THE GREENHOUSE REVISITED

by Vincent Gray

Climate Consultant. 75 Silverstream Road, Crofton Downs, Wellington New Zealand 6035. Email vinmary.gray@paradise.net.nz

ABSTRACT

The origins of the "Greenhouse Effect" which were reviewed in "The Greenhouse and its Effects"[1] . have been further reassessed.

The idea of the climate resembling the behaviour of a greenhouse originated from Fourier (1824). He considered that his belief that a greenhouse traps infra red rays could be applied to the climate, where infra radiation from the earth could be absorbed by water vapour This suggestion was supported by Pouillet and Tyndall. Arrhenius, who used Langley's calculations to measure the effect, attributed it to carbon dioxide instead, but he was unaware that absorption by carbon dioxide was not measured by Langley, so he inadvertently measured water vapour instead.

Callendar, and the current models favoured by the Intergovernmental Panel on Climate Change are based in the Fourier model but have repeated the error of Arrhenius in attributing it to carbon dioxide instead of water vapour. In contrast to Fourier, a real greenhouse depends on convection and latent heat transfer and so does the climate, with the addition of the outside climate ehich it excludes together with its chaotic behaviour. Fluctuations in this system are much greater than the claimed effects of greenhouse gases, which would therefore be undetectable

ORIGINS OF THE GREENHOUSE EFFECT

The "greenhouse effect" is claimed[2,3] to have originated in the opinions of Jean Baptiste Joseph Fourier. 1768 – 1830)[4] .

In his 1822 book *Théorie Analytique de chaleur*[5,6] he described the various forms of heat transfer and he postulated that heat transfer in solids varied according to a constant which became known as the thermal conductivity.

Fourier attempted to calculate the temperature of the earth in two publications[7,8]. Casey[9] has published the English translation of the 1824 paper by Burgess[10] and an edited version of the paper based on it[11]. He has also provided an edited English translation of the 1827 paper[12] and useful discussion of the errors and misconceptions which have arisen[13]

Fourier considered[10,11]

"1. The earth is heated by the solar rays; the unequal distribution of which causes diversities of climate.

2. It partakes of the common temperature of the planetary spaces; being exposed to the radiations from the innumerable stars which surround the solar system.

3.The solar system is situated in a region of the universe, every point of which has a common and constant temperature, determined by the rays of light and heat which proceed from the surrounding stars. This low temperature of the planetary space, is a little below that of the polar regions of the earth. The earth would have only the same temperature with the heavens, were it not for two causes which are concurring to heat it. One is the internal heat which it possessed at its formation, a part of which only is dissipated through the surface; the other is the continued action of the solar rays, which penetrate the whole mass, and produce at the surface, the diversities of climate".

"*The solar heat has accumulated in the interior of the globe, the state of which has become unchangeable. That which penetrates in the equatorial regions is exactly balanced by that which escapes at the parts around the poles. Thus the earth gives out to celestial space all the heat which it receives from the sun, and adds a part of what is peculiar to itself."*

Fourier thought that he could explain this extra heat from the experiments of his friend de Saussure with his solar heated "hot box", which was a miniature greenhouse[14,15]

He explained the "hot box as follows[11]:

"The theory of the instrument is easily understood. It is sufficient to remark, 1st, that the acquired heat is concentrated, because it is not dissipated immediately by renewing the air; 2nd, that the heat of the sun, has properties different from those of heat without light. The rays of that body are transmitted in considerable quantity through the glass plates into all the intervals, even to the bottom of the vessel. They heat the air and the partitions which contain it. Their heat thus communicated ceases to be luminous, and preserves only the properties of non-luminous radiating heat. In this state it cannot pass through the plates of glass covering the vessel. It is accumulated more and more in the interval which is surrounded by substances of small conducting power, and the temperature rises till the heat flowing in, shall exactly equal that which is dissipated".

Fourier would not have been aware of the discovery in 1850 by Melloni[16] that glass absorbs most low temperature infrared radiation.

He applied his interpretation of the "hot box" to the atmosphere as follows:

"In short, if all the strata of air of which the atmosphere is formed, preserved their density with their transparency, and lost only the mobility which is peculiar to them, this mass of air, thus become solid, on being exposed to the rays of the sun, would produce an effect the same in kind with that we have just described. The heat,

coming in the state of light to the solid earth, would lose all at once, and almost entirely, its power of passing through transparent solids: it would accumulate in the lower strata of the atmosphere, which would thus acquire very high temperatures.

"*All the terrestrial effects of solar heat are modified by the interposition of the atmosphere and the presence of water. The great motions of these fluids render the distribution more uniform. The transparency of the waters appears to concur with that of the air in augmenting the degree of heat already acquired, because luminous heat flowing in, penetrates, with little difficulty, the interior of the mass, and non-luminous heat has more difficulty in finding a way out in a contrary direction."*

He thus regards water vapour as "augmenting the degree of heat already acquired". which means absorption of radiation from the earth itself..

This view of Fourier was supported by Claude Pouillet and John Tyndall, both of whom also believed the extra heat came from absorption by water vapour and from a warm ether.

POUILLET

Claude Servais Mathias Pouillet[17] (1791-1868), professor of physics at the Sorbonne and member of the French Academy of Science, was the inventor of the pyrheliometer, an instrument that measured the quantity of heat received by the sun. He made early estimates of the thermal equivalent of solar radiation outside of the atmosphere, or the so-called solar constant, and provided the first estimates of the role of water vapour in the greenhouse effect.

Pouillet[18, 19] compared the atmosphere to experiments he had done on solid and liquid diathermanous screens, for example, panes of glass and layers of water, concluding that "the atmospheric stratum acts in the manner of screens of this kind, and exercises a greater absorption upon the terrestrial than on the solar rays." He called this the "effect of diathermanous envelopes."

Pouillet accepted the view of Fourier that the earth was warmed above the temperature of the ether by the absorption of the radiation from the earth by water vapour in the atmosphere. However, by this time, his friend Poisson (the famous statistical mathematician) had calculated that the upper regions of the atmosphere were much cooler than the ether. He carried out experiments at night with an actinometer, an instrument for measuring radiation and from the results calculated that the temperature of space was -142ºC. Despite this low figure he still believed that the earth received more heat from space than from the sun.

TYNDALL

John Tyndall (1820-1893)[20] was an Irish-born physicist and mathematician who studied in Germany and from 1853 to 1887 was Director of the Royal Institution in London as the immediate successor of Michael Faraday. For 12 years from 1859 he carried out a series of studies on the passage of low temperature radiation through a number of gases and vapours.

Tyndall's Bakerian lecture of 1861[21,22] gives details. It is also part of his book "Heat as Mode of Motion".[23]

Tyndall's equipment was a copper cubic container full of water kept boiling by a flame underneath. The front was coated with lampblack and the radiation passes though a rock salt window and through a brass tube cooled with water. The radiation passed out through another rock salt window and to a double conical device with a thermopile inside it connected to a galvanometer. The tube was evacuated to give a zero reading for the galvanometer and filled with a gas or vapour to different pressures. Water was circulated around the rock salt to keep it cool. A compensating radiation source was at the far end to enable setting the zero on the galvanometer. He measured the loss of radiation from putting the various gases in the tube.

It has been pointed out by Casey[12,13] that this arrangement does not measure *absorption,* a term repeatedly used by Tyndall. It measures relative *opacity* which is the proportion of radiation passing through the gas. He did not understand that the gas would re-radiate part of the heat as radiation in all directions, some being absorbed by the sides of the tube and some radiating backwards. He seemed to have a rudimentary knowledge of spectroscopy, but his belief in the ether led him to believe in a linear relationship between absorption and concentration. The actual relationship is close to logarithmic.

Tyndall's biographical memoir[24] has the following passage:

"*he was able to determine the position of aqueous vapour, which, on account of condensation, could not be experimented on directly. Experiments made with dry and humid air corroborated the inference that, as water transcends all other liquids. so aqueous vapour is powerful above all other vapours as a radiator and absorber*"

Tyndall wrote[22]

"*Air sent through the system of drying-tubes and through the caustic-potash tube produced an absorption of about 1.*

Air direct from the laboratory, containing therefore its carbonic acid and aqueous vapour, produced an absorption of about 15.

Deducting the effect of the gaseous acids, it was found that the quantity of aqueous vapour diffused through the atmosphere on the day in question, produced an absorption at least equal to thirteen times that of the atmosphere itself.

It is exceedingly probable that the absorption of the solar rays by the atmosphere, as established by M. Pouillet, is mainly due to the watery vapour contained in the air. The vast difference between the temperature of the sun at midday and in the evening is also probably due in the main to that comparatively shallow stratum of aqueous vapour which lies close to the earth. At noon the depth of it pierced by the sunbeams is very small; in the evening very great in comparison.

The intense heat of the sun's direct rays on high mountains is not, I believe, due to

his beams having to penetrate only a small depth of air, but to the comparative absence of aqueous vapour at those great elevations.

But this aqueous vapour, which exercises such a destructive action on the obscure rays, is comparatively transparent to the rays of light. Hence the differential action, as regards the heat coming from the sun to the earth and that radiated from the earth into space, is vastly augmented by the aqueous vapour of the atmosphere".

He also wrote[21,22]

"*De Saussure, Fourier, M. Pouillet, and Mr. Hopkins regard this interception of terrestrial rays as exercising the most important influence on climate*".

ARRHENIUS

Svante August Arrhenius (859 1927)[25] was a Swedish scientist, originally a physicist, and one of the founders of the science of physical chemistry. The Arrhenius equation, lunar crater Arrhenius, and the Arrhenius Labs at Stockholm University are named after him. He received the Nobel Prize in Chemistry in 1903 for his discovery of ions in aqueous salt solutions. He played a prominent part in the selection of subsequent winners of the award.

He published several articles on the effects of carbon dioxide on the atmosphere. That published in English in 1896 was the most influential[26].

He made very few measurements himself and the paper depended entirely on his calculations from the measurements by Langley and Very[27].

Langley's bolometer[28] was an absorptive element, such as a thin layer of metal, connected to a heat sink (a body of constant temperature) through a thermal link. The result is that any radiation impinging on the absorptive element raises its temperature above that of the heat sink. It was attached to the thermopile and was able to measure intensity of narrow emission bands in a spectrum that had been obtained with a rock salt prism.

Langley made a series of measurements of the full moon's radiation with this instrument at the Alleghany observatory in 1897. He made measurements at different angles with the moon.

Arrhenius had the idea that by finding out the difference he got from different angles he could calculate the absorption of the moon's radiation by the earth's atmosphere. By assuming that the radiation from the moon was approximately the same as that of the earth he could calculate the absorption of the earth's atmosphere by the trace absorbent gases, water vapour and carbon dioxide.

Erren[29] has shown that Langley's measurements used by Arrhenius were preliminary and had serious errors. They became less accurate as they approached the region used by Arrhenius, the measurements were exaggerated, and did not reach far enough to include the major absorption frequency of carbon dioxide, so they were

actually measurements of water vapour, not carbon dioxide

Arrhenius published many subsequent publications[30-34], parts of which are available from Erren[29,35-40], who provides modern information on the moon spectrum[35,36], which show that Arrhenius' values were exaggerated[37,38] and that he did not subsequently amend them. Erren[39] disagrees with Weart[2] who claimed that the 1901 and 1908 Arrhenius papers lowered his original numbers

He also gives an account of the paper by K Angstrom[40] which wrongly criticized Arrhenius

On his first page[26] Arrhenius states:

"*Fourier maintained that the atmosphere acts like the glass of a hothouse because it lets through the light rays from the sun but retains the dark rays from the ground*

.Arrhenius assumed that the ratio of carbon dioxide (K) to water vapor (W) in the earth's atmosphere was K/W where K is 1.5 and W is 0.88, a ratio of 1.7.

The concentration of carbon dioxide in the earth's atmosphere is now thought to be 0.039%. The average concentration of water vapour is not known. Since it varies from place to place from 0 to 4% and we take 2% as typical, this means that the ratio of water vapour and carbon dioxide is about 50 to 1.

So, about 98% of Arrhenius' figures and calculations, even if soundly based, apply to water vapour and not to carbon dioxide.

Arrhenius no longer believed in the ether when he says "Empty space may be regarded as having a temperature of absolute zero".

He included this basic model of the climate

"*All authors agree in the view that there prevails an equilibrium in the temperature of the earth and of its atmosphere. The atmosphere must, therefore, radiate as much heat to space as it gains, partly from absorption of the sun's rays, partly through the radiation from the hotter surface of the earth and by means of the ascending currents of air heated by contact with the ground. On the other hand the earth loses just as much heat by radiation into space and to the atmosphere as it gains by absorption of the sun's rays. If we consider a given place in the atmosphere or on the ground, we must also take into consideration the quantities of heat that are carried to this place by means of oceanic or atmospheric currents".*

CALLENDAR

Guy Stewart Callendar (1898 -1964) was an English steam engineer and inventor who published many studies and articles which revived the claim by Arrhenius that increased atmospheric carbon dioxide heated the earth. He measured the absorption

spectrum of water vapour and carbon dioxide and that of the sky. He ignored water vapour and even believed that radiation was the only form of energy transfer. In his 1938 paper[41] he stated

"*If the whole surface of the earth is considered as a unit upon which a certain amount of heat falls every day, it is obvious that the mean temperature will depend upon the rate at which heat can escape by radiation, because no other type of heat exchange is possible".*

He seemed to be unaware of the existence of conduction, convection, and evaporation and condensation as possible mechanisms of heat transfer.

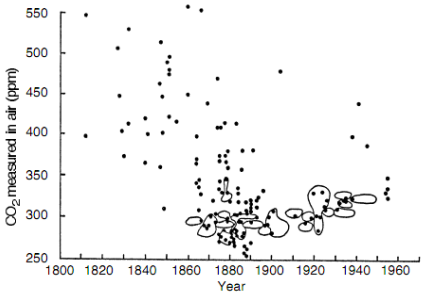


Figure 1
AVERAGE ATMOSPHERIC CO_2 CONCENTRATIONS MEASURED IN THE 19TH AND 20TH CENTURIES
The values that G.S. Callendar chose to use are shown encircled. He rejected both higher and lower values, to arrive at a figure that backed up his hypothesis.

Source: Adapted from S. Fonselius, et al., 1956. *Tellus*, Vol. 8, p. 176

Jaworowski[42] has claimed that he chose only those figures for carbon dioxide that suited his theory from the many available.

Sir George Simpson, the eminent meteorologist, who was, at that time, Director of the UK Meteorological Office, in commenting on this paper[41] said

"*It is not sufficiently realised by non-meteorologists who come for the first time to help the Society in its study that it was impossible to solve the temperature distribution in the atmosphere by working out the radiation. The atmosphere was not in a state of radiative equilibrium, and it also received heat by transfer from one part to another. In the second place, one had to remember that the temperature distribution in the atmosphere was determined almost entirely by the movement of air up and down. This forced the atmosphere into a temperature distribution which was quite out of balance with the radiation. One could not, therefore, calculate the effect of changing any one factor in the atmosphere, and he felt that the actual numerical results which Mr Callendar had obtained could not be used to give a definite indication of the order of magnitude of the effect."*

These remarks have been comprehensively ignored ever since

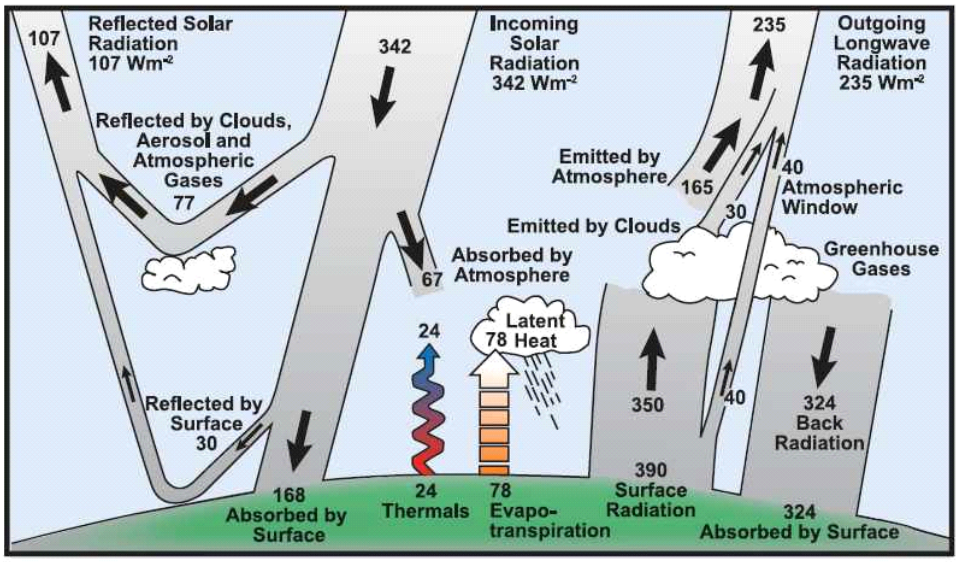
MODERN DEVELOPMENTS

Since the 1980s, considerable effort has been spent on developing the theory originated by Fourier modified by Arrhenius and Callendar, that the energy of the climate is primarily controlled by absorption of the earth's radiation by carbon dioxide and other minor trace gases, merely enhanced by water vapour when the water vapour is the main effect. It has been reviewed thoroughly by Weart[2].

The Intergovernmental Panel on Climate Change[43-46] was set up in order to prove this theory, and despite their four major reports and several minor ones they have

failed to do so[47-50]. They have persisted in claiming that all energy changes in our atmosphere are dominated by radiation alone

The 1997 version of Kiehl and Trenberth[51] (KT97) was the most important first basic concept at that time.



FAQ 1.1, Figure 1. *Estimate of the Earth's annual and global mean energy balance. Over the long term, the amount of incoming solar radiation absorbed by the Earth and atmosphere is balanced by the Earth and atmosphere releasing the same amount of outgoing longwave radiation. About half of the incoming solar radiation is absorbed by the Earth's surface. This energy is transferred to the atmosphere by warming the air in contact with the surface (thermals), by evapotranspiration and by longwave radiation that is absorbed by clouds and greenhouse gases. The atmosphere in turn radiates longwave energy back to Earth as well as out to space. Source: Kiehl and Trenberth (1997).*

This has recently been revised by Trenberth, Fasulla and Kiehl[52] (TFK09)

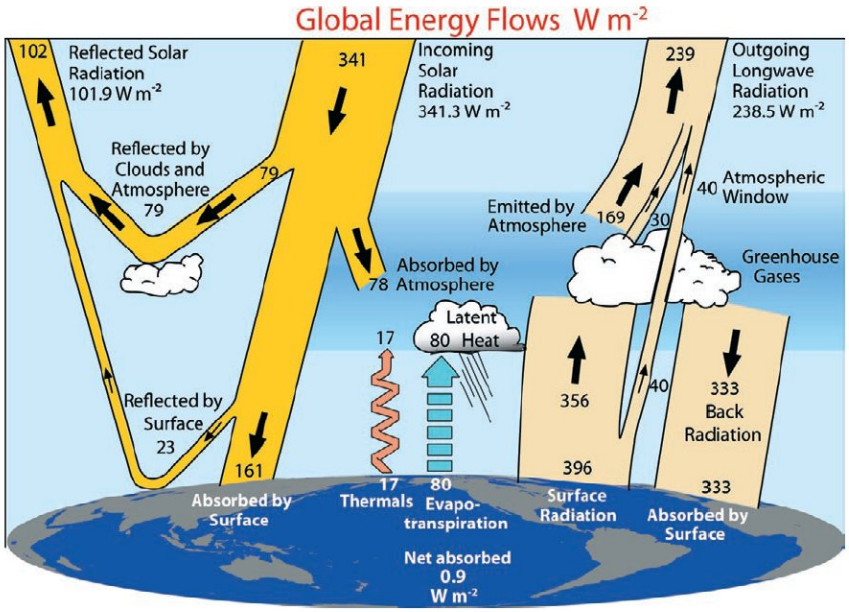


FIG. 1. The global annual mean Earth's energy budget for the Mar 2000 to May 2004 period (W m^{-2}). The broad arrows indicate the schematic flow of energy in proportion to their importance.

TK97 covers the ERBE (Earth Radiation Budget Experiment) period from February 1985 to April 1989, which measured the external radiation from the earth but provided only an average and not the difference between day and night.

TFK09 covers the CERES (Clouds and the Earth's Radiant Energy System) period from March 2000 to May 2004.

The details of both results are given in TFK09.

There are two items in both graphs representing heat loss from the earth labelled “Thermals” (presumably convection) and “Latent Heat”.

Latent Heat is calculated from the total annual precipitation. TK97 chose 78 W/msq which is less than any of the other calculations they list (80.2. 82.3 and 85.1 W/msq).

TFK09 chose 80.0 W/msq, which is again less than the other values listed (83.1 and 90.2 W/msq)

The other item, called ”Sensible Heat" in their tables and "Thermals" in the graphs, is the heat loss from convection.

TK97 chose 24 W/msq for this quantity although the other authorities quoted have much smaller values (15.3, 15.3 and 18.8 W/msq). They needed the extra in order to "balance" the budget.

TFK09 chose 17 W/msq for "Sensible Heat, where other authorities had found 15.6. 19.4 and 17 W/msq. They had evidently abandoned all hope of "balancing" their budget, and they came out with a surplus of 0.9 W/msq.

Both papers give separate estimates of “Sensible Heat” for "Land" and "Ocean"

TK97 has figures from other authorities of 27.1, 25.8 and 27.5 W/msq for "Land" and 11.0, 11.5, 15.8, 9.5 and 14.0 W/msq for "Ocean" but no figures were chosen by the authors.

TFK09 chose a “Sensible Heat” figure of 27 W/msq for "Land" with other authorities giving 36.3 and 27,4 W/msq. They chose 12 W/msq for "Ocean" where the other authorities gave 11.7, 16.6, 14.6 and 10.8 W/msq.

There is much greater heat loss to the atmosphere over land than ocean. This is because of the greater turbulence caused by the irregular surface profile and greater vertical temperatures

The difference is slightly greater because of the lower albedo over land which gives a lower solar absorption.

It should be noted that the figures for “Thermals” and Latent Heat are much greater than the claimed increase in radiative forcing[46] supposedly caused by carbon dioxide between 1750 and 2005 of only $1.8 Wm^{-2,}$ is much less than the differences between the different figures, swamped by the chaotic fluctuations, and unlikely to be

detectable

TK97 quoted Global albedo values between 28.1-33.8%, "Land" between 30.8 and 35.8%, and “Ocean” is 27.1-33.3% but did not make a choice itself.

TFK90 quoted figures for Global albedo of 27.9-34.2% and chose 29.8%, "Land" 30.6-35.2%, and chose 34.4%, "Ocean", 27.0-33.9% and chose 28.3%.

They therefore now consider that there is a difference of 6.1% between the albedo of "Land" and "Ocean"

All the figures are given as if they were known to an exact amount, when they actually represent averages of quantities that are very inaccurately known, or even just guessed. No estimates of uncertainty are give for any of them. For the supposed surface radiation from the earth it would be necessary not just to have a figure for the average temperature but for the average of the fourth power of the absolute temperature. Neither of these quantities are known.

It is not possible to average day and night. The climate by day is a quite different problem from the climate at night. By day the earth has a constantly varying supply of energy aspiring to a constantly varying equilibrium. By night, without the sun, it would tend to an equilibrium of absolute zero.

The claim that energy received is instantaneously emitted is immediately destroyed when they admit the existence of conduction, convection and latent heat transfer (as they do) you immediately make it possible to store part of the energy. This may merely be the time it takes for heat stored by the earth in the daytime to lose it by night , the process of condensation of clouds and their circulation before precipitation of rain or snow or by warming the ocean or melting ice or show.

But this is for a dead world. No energy is used for chemical change or work. There are no living creatures, no storage of fossil fuels, no concrete or steel. There is no place for the work done by the climate in modifying the surface, or for building mountains.

The climate is a heat engine which receives low entropy energy from the Sun, and eventually exhausts higher entropy energy to space, thus complying with the Second Law of Thermodynamics. It is perfectly capable of using its energy during this process to decrease entropy, similarly to a refrigerator which uses external energy to transfer heat from a cold place (the refrigerator) to a warm place (the heat exchanger). All living organisms also decrease entropy.

Several people[53-56] who have failed to understand this have claimed that the system presented is wrong as the presence of radiation from the atmosphere involves heat being transferred from a cool atmosphere back to the earth (‘back radiation”) which violates the Second Law of Thermodynamics.

Gerlich and Tscheuscher[55,56] try to argue that the climate cannot be regarded as equivalent to a heat pump because the external energy to a heat pump is work instead of solar radiation. They give as references for the view that external energy

has to be work by two publications by Clausius[57.58] The English translation[56] at least, does not support this view . which is, however, supported by some textbooks (e.g. Smith and Cooper 1964[59]). It cannot be right because it would involve violation of the Stefan/ Boltzmann and Planck's laws of radiation.

The entire climate is ignored by the IPCC models, which are based on only a part of it which they wrongly term the "Climate System". They neglect to study the entire system which includes the sun, the earth and outer space.

THE REAL GREENHOUSE

One of the first people to point out that Fourier's theory for the action of a greenhouse is wrong was **Robert Williams Wood** (1868–1955) an American physicist and inventor. He wrote a standard textbook on "Physical Optics"[60].He presented a theory of the operation of a greenhouse in the Philosophical Magazine in 1909[61]

"XXIV. Note on the Theory of the Greenhouse

By Professor R. W. Wood (Communicated by the Author)

There appears to be a widespread belief that the comparatively high temperature produced within a closed space covered with glass, and exposed to solar radiation, results from a transformation of wave-length, that is, that the heat waves from the sun, which are able to penetrate the glass, fall upon the walls of the enclosure and raise its temperature: the heat energy is re-emitted by the walls in the form of much longer waves, which are unable to penetrate the glass, the greenhouse acting as a radiation trap. I have always felt some doubt as to whether this action played any very large part in the elevation of temperature. It appeared much more probable that the part played by the glass was the prevention of the escape of the warm air heated by the ground within the enclosure. If we open the doors of a greenhouse on a cold and windy day, the trapping of radiation appears to lose much of its efficacy. As a matter of fact I am of the opinion that a greenhouse made of a glass transparent to waves of every possible length would show a temperature nearly, if not quite, as high as that observed in a glass house. The transparent screen allows the solar radiation to warm the ground, and the ground in turn warms the air, but only the limited amount within the enclosure. In the "open," the ground is continually brought into contact with cold air by convection currents.

To test the matter I constructed two enclosures of dead black cardboard, one covered with a glass plate, the other with a plate of rock-salt of equal thickness. The bulb of a thermometer was inserted in each enclosure and the whole packed in cotton, with the exception of the transparent plates which were exposed. When exposed to sunlight the temperature rose gradually to 65ºC., the enclosure covered with the salt plate keeping a little ahead of the other, owing to the fact that it transmitted the longer waves from the sun, which were stopped by the glass. In order to eliminate this action the sunlight was first passed through a glass plate.

There was now scarcely a difference of one degree between the temperatures of the two enclosures. The maximum temperature reached was about 55ºC. From what we

know about the distribution of energy in the spectrum of the radiation emitted by a body at 55º, it is clear that the rock-salt plate is capable of transmitting practically all of it, while the glass plate stops it entirely. This shows us that the loss of temperature of the ground by radiation is very small in comparison to the loss by convection, in other words that we gain very little from the circumstance that the radiation is trapped. Is it therefore necessary to pay attention to trapped radiation in deducing the temperature of a planet as affected by its atmosphere?

The solar rays penetrate the atmosphere, warm the ground which in turn warms the atmosphere by contact and by convection currents. The heat received is thus stored up in the atmosphere, remaining there on account of the very low radiating power of a gas. It seems to me very doubtful if the atmosphere is warmed to any great extent by absorbing the radiation from the ground, even under the most favourable conditions.

I do not pretend to have gone very deeply into the matter, and publish this note merely to draw attention to the fact that trapped radiation appears to play but a very small part in the actual cases with which we are familiar

A greenhouse has, as a main function, the protection of the interior from loss of heat absorbed from the sun by the outside weather, from wind, and rain

When the sun is shining, its radiation passes through any panes of glass with minimal absorption and is absorbed, mainly by the base, where plants are present, but also by any part of the structure it encounters, raising their temperature.

The air within the greenhouse which is in contact with any heated surface receives heat by conduction. As heated air becomes lighter, it rises, and is replaced by cooler air. The warmer air rises to the upper surface but cannot leave, until the entire greenhouse has become warmer than the air outside the greenhouse. This process is called convection and it cools the surfaces that have been heated by the sun to a temperature which is almost uniform within, but is higher than the outside climate.

The energy received from the sun is absorbed by chlorophyll in the plants, and is used to convert the carbon dioxide in the atmosphere to plant material. Sometimes extra carbon dioxide is supplied to enhance growth. There is no evidence that the air is influenced by absorbed infra red by water vapour or carbon dioxide..

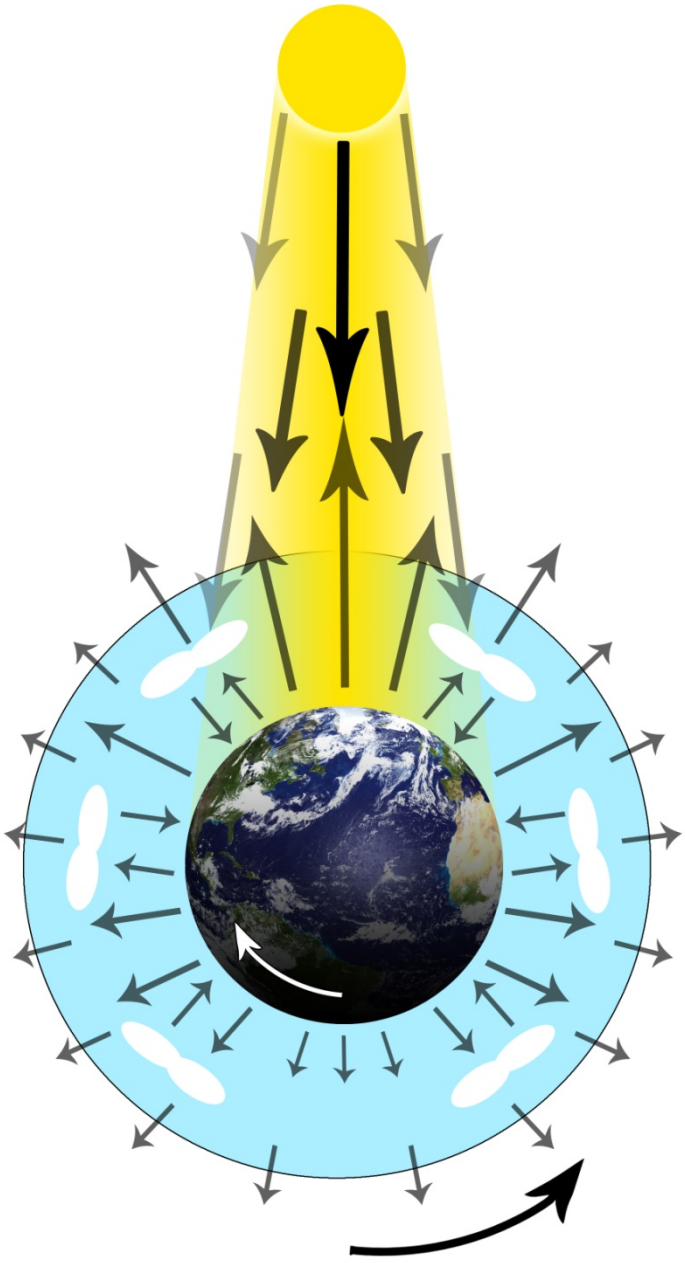
When the sun shines, the air in the greenhouse cools the heated greenhouse base and distributes the heat to give a uniform internal temperature which is greater than the outside.walls, If the air in a greenhouse is heated by convection from the heated base and sides, it is therefore carrying out a cooling function. Also, for any water or moist surface the sun's rays will evaporate water, and this will also cool the heated surface and establish a more moist atmosphere.

All the surfaces, both external and internal, as well as the air inside, will radiate in the infrared according to their temperature but as Wood believed, this is probably small. All the internal radiation will be absorbed by the sides and roof. The entire structure will largely be cooled from outside by external convection and radiation.

It is all different at night, or even when the sun is not shining. Then, the loss of heat by radiation and convection by the whole structure and its contents is reduced by the heat which is stored by the interior air. In addition the extra moisture in the air is deposited, releasing latent heat.

THE REAL GREENHOUSE EFFECT

The Real Greenhouse Effect is the behaviour of the earth's atmosphere in a similar way as in a greenhouse plus the outside climate from which it protects its interior .



THE REAL CLIMATE.

THE REAL CLIMATE

The diagram shows radiation received and emitted by the real climate. Energy is received only by day. The most important emissions are from the daytime heated surfaces, plus the warmed atmosphere, but contributions also come for the rest of each day. From the cooling earth and atmosphere.

It might be noted that radiation from the warmed atmosphere would have a downwards component because of the radiation laws.

The climate is a heat engine where the sun provides the energy input and outer space the exhaust, after energy has been absorbed by doing work, or stored for a shorter or longer period. The work includes support for all living organisms plus changes in the earth's surface carried out by the climate. Some energy is stored for small or large periods, Storage of fossil fuels could occur for millions of years

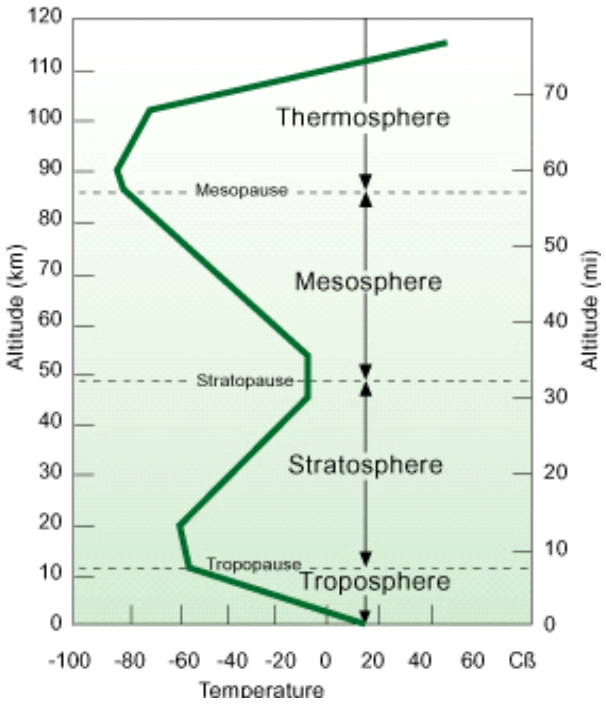
The atmosphere is held in place by gravity, so the top of the troposphere performs a similar function as the glass ceiling of a greenhouse, as it prevents loss of air heated by convection. The sun's rays are absorbed by the earth only by day.

If there were no atmosphere the temperature would rise to a higher level by day and fall to a lower level at night because when there is an atmosphere the daytime warmed atmosphere and oceans circulate heat..

The average daytime temperature of the moon is 107ºC and at night -153ºC, but the time of rotation of the moon is 27 days, so the earth without an atmosphere would not reach such extreme values. However, the temperature would be much higher during the day and lower at night if it were not for the atmosphere.

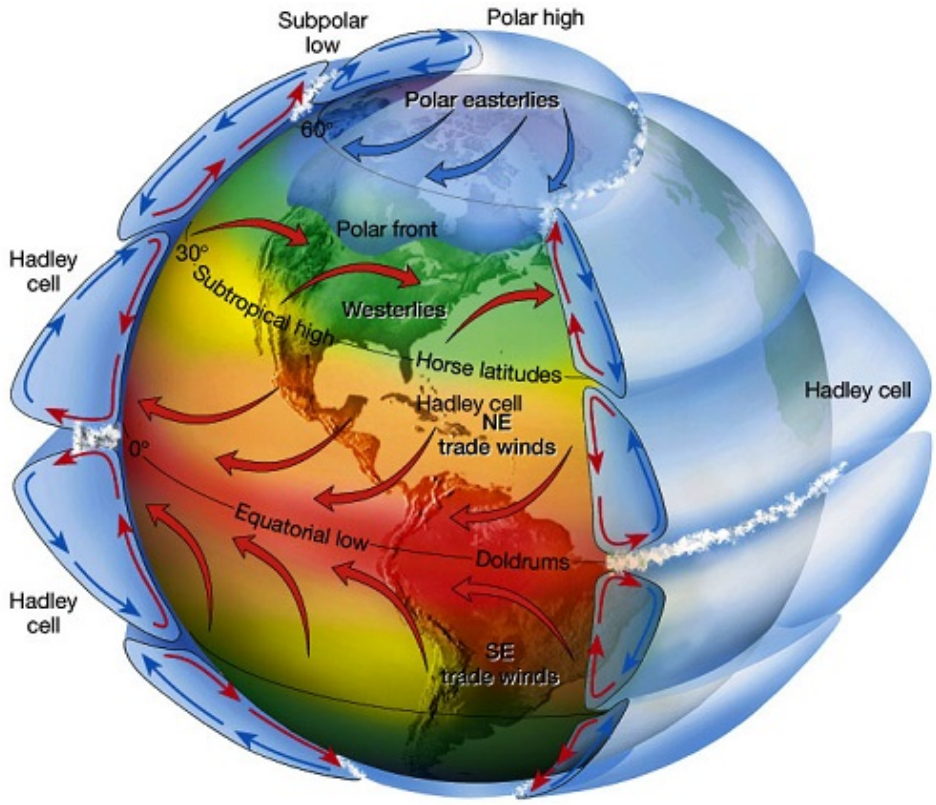
The atmosphere in contact with the surface removes heat by convection so that, to start with, its temperature is similar. Its temperature steadily falls with height until it reaches the tropopause . It is radiating all the time, some returning to the earth. It has the function of radiating outwards part of the heat absorbed from the sun, which falls with height as it cools and becomes less dense.

This process can be seen in the temperature change with height. At the tropopause most of the heat has gone but then there is a temperature increase from the reaction of ultraviolet with ozone in the stratosphere.

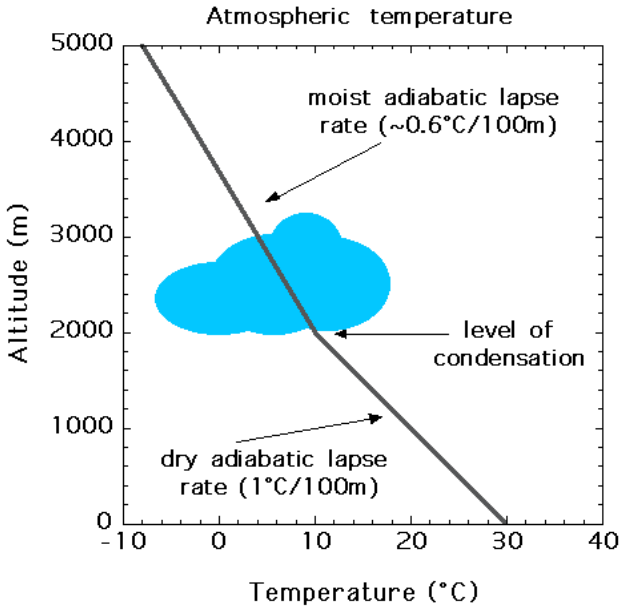


AIR CIRCULATION

Convected air circulates around the earth in a complex sytem of wind patterns



At the surface, the earth is also cooled by evaporation of water, extracting latent heat. The moister atmosphere deposits the water higher us as clouds, releasing the heat. Precipitation sets up a cycle of this process. The change in temperature with height is called the “lapse rate” Wheh the water vapour reaches a temperature above the dew point it forms clouds, and these may result in precipitation of rain or snow. The rain or snow usually causes additional cooling when it is colder than the receivimg surface. The water vapour is circulaled with the rest of the atmosphere.



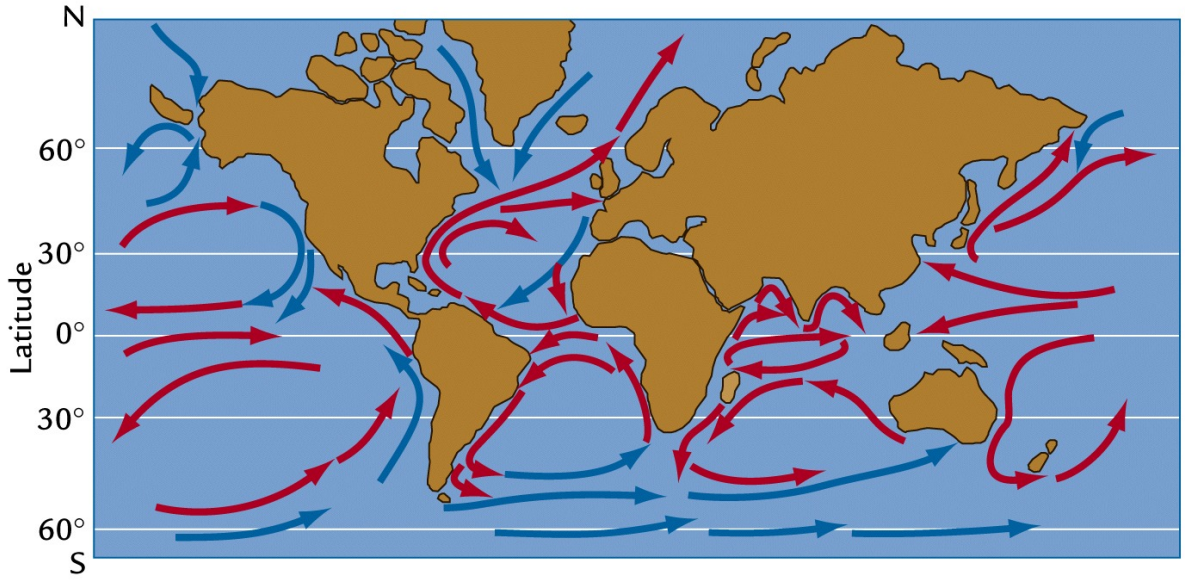
In the earth’s atmosphere both the heat and the moisture in the air are distributed around the world by wind, enhanced by turbulence, which is highest over the land. Some of the heat absorbed by the ocean is distributed by surface ocean currents.

Without the sun, the nigh time earth cools by radiation but is warmed by the previously heated air and by deposition of moisture as dew or frost. The turbulence from winds is greater on land than on the ocean and it enhances air and moisture movement. On a calm day the earth is warmer. On a calm night it is cooler but

deposition of dew and frost reduce the surface cooling.

OCEAN CIRCULATION

Warmer and cooler ocean currents follow established but constantly varying patterns which are monitored by measurements of sea surface temperature and by sensors at various depths.



The oceans also experience several established oscillations of varying frequency..The El Niño Southern Oscillation (ENSO); the Pacific Decadal Oscillation (PDO) Atlantic Multi Decadal Oscillation (AMO) the Indian Ocean Oscillation (UOO) are amongst the many that have been identified

THE EFFECTS OF CHAOS

The IPCC[46] claims

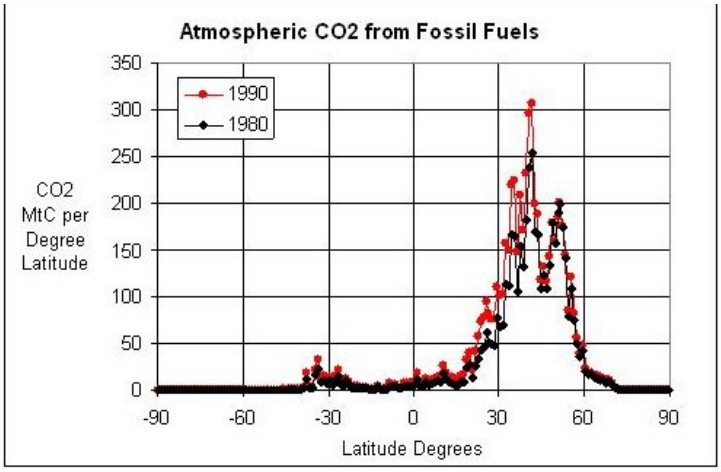
"*The chaotic nature of the weather makes it unpredictable beyond a few days. Projecting changes in climate (i.e long-term average weather) due to changes in atmospheric composition or other factors is a very different and much more manageable issue*"

The claim to have "managed" chaos is clearly untrue. Convection ("Thermals") and Latent Heat ("Evapotransportation") are undoubtedly subject to the same chaotic behaviour which afflicts weather forecasting. Their total 97Wm^{-2} of energy will be subject to a chaotic variability which is much greater than the claimed global warming from the absorption of infra red radiation by trace gases, which, when calculated from the TFK model is a mere 1.6 Wm^{-2} since 1700[58]. Any contribution the carbon dioxide greenhouse effect would therefore be undetectable. And the greenhouse model would be no better in predicting future climate than is now claimed for weather forecasting.

A greenhouse, by preventing natural convection, reduces the extent of outside cooling by day and warms at night. All buildings act in the same fashion as a greenhouse. Shelter belts and wind barriers reduce heat loss by day. Changes in albedo which reduce the surface from darker to lighter also are warming devices by day and cooling devices at night. Forests have a higher albedo than farmland, concrete roads and airport runways. The extra heat helps to maintain human llife and welfare

Devices that capture part of the natural heat loss such as windmills or solar panels actually cause global warming, for they remove part of the heat that would otherwise be removed by convection, and so inhibit cooling. Inhibition of daytime cooling is caused by urbanisation and land use change giving an upwards bias to temperature readings by weather stations.

I have pointed out in my "Greenhouse Delusion"[47] that the average 0.02 W/msq of heat which is generated by humans is very unevenly distributed and there are some industrial areas where the amount generated exceeds that attributed to the supposed greenhouse effect of 1.6W/Msq since 1700 by almost 100 times. The attached graph (from Tom Quirk[62]) shows how this heat is predominantly emitted between 30-60 degrees N. It is obvious that temperature measurements which are predominantly collected from these regions will give an upwardly biased view of global temperature as they concentrate on those areas most likely to warm from urban change. Measurements of carbon dioxide concentration which do not include these areas are likely to be downwardly biased.



CONCLUSIONS

1. Fourier, Pouillet and Tyndall believed the earth was warmed by the ether and by absorption of radiation from the earth by water vapour. There was no net warming from the sun's rays or work done by the heat absorbed They believed that this behaviour was similar to the action of a greenhouse where they thought infra red radiation was trapped by glass.

Arrhenius first claimed absorption of radiation from the earth by carbon dioxide but he did not realize that he was actually measuring water vapour.

Callendar launched the carbon dioxide greenhouse effect despite the objections of Sir George Simpson who considered he had ignored air movement.

R W Wood was the first to show that the air in a greenhouse is mainly heated by

convection not by trapped infra red. A real green house also transfers latent heat

The behaviour of the real climate resembles a real greenhouse but has air and ocean movement in addition, which means its future predictability is limited by their chaotic behaviour. Convection and evaporation cool the earth by day and warm air circulation and deposition of water or frost help to reduce night time cooling. For the whole earth the movement and circulation of the atmosphere and of the oceans has to be added, together with their chaotic behaviour to the basic greenhouse model.

Human attempts to interfere with convection and evaporation are a far more likely cause of possible global warming than changes in trace gases in the atmosphere.

REFERENCES

1. **Gray, V.R. The Greenhouse and its Effects.** **http://nzclimatescience.net/images/PDFs/the%20greenhousexxx.pdf**
2. **Weart S** 1997, The Discovery of the Risk of Global Warming. *Physics Today* January 34-43.
3. **Weart S** 2011, The Carbon Dioxide Greenhouse Effect. http://www.aip.org/history/climate/co2.htm#S1. http://www.aip.org/history/climate/co2.htm
4. **Joseph Fourier** 2011, http://en.wikipedia.org/wiki/Joseph_Fourier
5. Fourier J.1822 Théorie Analytique de Chaleur. Chez Firmin Didot, père et fils. http://www.archive.org/details/thorieanalytiqu00fourgoog
6. F**reeman A** 1952, Theory of Heat. Translation of “Fourier J B 1922, Théorie Analytique de Chaleur” in *Great Books of the Western World, Vol. 45.* Encyclopedia Britannica.
7. **Fourier J B J** 1824, "Remarques Générales Sur Les Températures Du Globe Terrestre Et Des Espaces Planétaires.", *Annales de Chimie et de Physique*, Vol. 27, pp. 136–167. http://books.google.com/books?id=1Jg5AAAAcAAJ&dq=Annales+de+chimie+et+de+physique+volume+27&
8. **Fourier J B J** 1827, "Memoire sur les temperatures du globe terrestre et des espaces planetaires", *Memoires de l'Académie Royale des Sciences*, Vol. 7, pp. 569-604. http://gallica.bnf.fr/ark:/12148/bpt6k32227.image.f808.tableDesMatieres.langEN
9. Casey T 2011, Text of E. Burgess' 1837 Translation of Fourier (1824)’ **http://burgess1837.geologist-1011.mobi/**
10. **Burgess E** 1837, "General Remarks on the Temperature of the Terrestrial Globe and the Planetary Spaces; by Baron Fourier", *American Journal of Science*, Vol 32, pp. 1-20. Translation from the French, of Fourier J B J 1824, "Remarques Générales Sur Les Températures Du Globe Terrestre Et Des Espaces Planétaires", *Annales de Chimie et de Physique*, Vol. 27, pp. 136–167

http://nsdl.org/archives/onramp/classic_articles/issue1_global_warming/n1Fourier_1824corrected.pdf

11. **Casey T** 2011, Fourier (1824) Repaginated with Corrections from Burgess (1837). **http://fourier1824.geologist-1011.mobi/**

12,Casey T 2011, English Translation of Fourier (1827). **http://fourier1827.geologist-1011.mobi/C**

13 Casey T 2011, The Most Misquoted and Most Misunderstood Science Papers in the Public Domain. **http://geologist-1011.mobi/**

14 Horace De Saussure and his hot boxes 2011, http://www.solarcooking.org/saussure.htm.

15 **Horace de Saussure** 2011, **http://en.wikipedia.org/wiki/HoraceB%C3%A9n%C3%A9dict_de_Saussure**
16 **Melloni M** 1850, La Thermochrose, Part 1: Sur La Coloration Calorifique.
17 **Claude Pouillet** 2011, http://en.wikipedia.org/wiki/Claude_Pouillet
18 **Pouillet C** 1838, Mémoire sur la chaleur solaire, sur les pouvoirs rayonnants et absorbants de l'air atmosphérique et sur la température de l'espace. *Comptes Rendus des Scéances de l'Academie des Sciences* July 9th.
19 **Pouillet C** 1838, translated by F W Taylor. http://nsdl.org/archives/onramp/classic_articles/issue1_global_warming/n2-Poulliet_1837corrected.pdf
20 **Tyndall J** 2011, http://en.wikipedia.org/wiki/John_Tyndall
21 **Tyndall J** 1861, "On the Absorption and Radiation of Heat by Gases and Vapours, and on the Physical Connexion of Radiation, Absorption, Conduction.-The Bakerian Lecture", *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science*, Series 4, Vol. 22, pp. 169-194, 273-285. http://nsdl.org/archives/onramp/classic_articles/issue1_global_warming/n3.Tyndall_1861corrected.pdf.
22 **Casey T** 2011, http://tyndall1861.geologist-1011.mobi/ ;
23 **Tyndall J** 1868, J Heat as a Mode of Motion http://www.archive.org/details/heatamodemotion03tyndgoog
24 **Tyndall J** 1903, Biographical Memoir in *Lectures and Essays*. Watts and Co
25 **Svante Arrhenius** 2011, http://en.wikipedia.org/wiki/Svante_Arrhenius

26. Arrhenius S 1896, On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground, *London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science (fifth series*), April 1896. vol 41, pages 237–275.

27 Langley S P (and Frank W. Very)1890 , The Temperature of the Moon, *Memoir of the National Academy of Sciences, vol. iv. 9th mem.* 193pp .
28 Langley S P 2011, http://en.wikipedia.org/wiki/Samuel_Pierpont_Langley
29 Erren H 2011, Langley Revisited. http://members.casema.nl/errenwijlens/co2/langleyrevdraft2.htm
30 Arrhenius S 1901a, Ueber die Wärmeabsorption durch Kohlensäure, *Annalen der Physik,* Vol 4, 1901, pages 690–705.
***31* Arrhenius S** 1901b, Über Die Wärmeabsorption Durch Kohlensäure Und

Ihren Einfluss Auf Die Temperatur Der Erdoberfläche. *Abstract of the proceedings of the Royal Academy of Science,* **58**, 25–58.

32 Arrhenius 1903, *Lehrbuch der Kosmischen Physik,* Vol I and II, S. Hirschel publishing house, Leipzig, 1026 pages.

33 Arrhenius S 1906, Die vermutliche Ursache der Klimaschwankungen, *Meddelanden från K. Vetenskapsakademiens Nobelinstitut,* Vol 1 No 2, pages 1–10.

34 Arrhenius S 1908, *Das Werden der Welten*, Academic Publishing House, Leipzig, 208 pages.

35 Erren H 2011, Scanned pages from Arrhenius 1901 http://members.casema.nl/errenwijlens/co2/arrhenius1901/index.html

36 Erren H 2011, Scanned pages from Arrhenius Textbook of Cosmic Physics 1903 and Arrhenius 1908 "Becoming the Worlds" http://members.casema.nl/errenwijlens/co2/arrhenius0308/index.html

37 Erren H 2011, Arrhenius was wrong. http://members.casema.nl/errenwijlens/co2/arrhrev.htm

38 Erren H 2011 Summary graphs of Arrhenius' errors http://members.casema.nl/errenwijlens/co2/arrhenius.html

39 Erren H 2011, Reply to Weart[2] http://members.casema.nl/errenwijlens/co2/arrhweart.htm

40 Erren H 2011, Knut Angstrom's measurements. http://members.casema

41 Callendar G S1938, The Artificial Production of Carbon Dioxide and Its Influence on Climate, *Quarterly Journal of the Royal Meteorology Society*, 64, pps. 223-240.

42 Jaworowski Z 1997, Ice Core Dat show no Carbon Dioxide Increase *21st Century Spring 1997* 44-52.

***43* Houghton, J T , G J Jenkins , & J J Ephraums**, (Eds) 1990. *Climate Change : The IPCC Scientific Assessment*. Cambridge University Press. Henceforth referred to as *Climate Change 90*

***44* Houghton, J T , L G Meira Filho, B A Callander, N Harris, A Kattenberg & K Maskel**l. 1996.. *Climate Change 1995 : The Science of Climate Change*. Cambridge University Press Henceforth referred to as *Climate Change 95.*

***45* Houghton J T , Y Ding, D J Griggs, M Noguer, P J Van der Linden, X Dai, K Maskell, & C A Johnson** (Eds). 2001. *Climate Change 2001: The Scientif Basis.* Cambridge University Press. Henceforth referred to as *Climate Change 01.*

46 Solomon, S., D Qin, M. R. Manning, M. Marquis, K. Averyt, M. H Tignor, H. L. Miller, and Z. Chin. (Eds.). Climate Change 2007: The Physical Science Basis (IPCC), Cambridge University Press.

47 Gray V R 2002, The Greenhouse Delusion: A Critique of Climate Change 2001. *Multi-Science Publishers UK.*

48 Gray, V R 2007, Spinning the Climate. http://nzclimatescience.net/images/PDFs/gray2.ipcc%20spin.pdf

49 Gray V R 2008, The Global Warming Scam. http://nzclimatescience.net/index.php?option=com_content&task=view&id=369&Itemid=32

50 Gray V R 2009, The Triumph of Doublespeak. http://nzclimatescience.net/index.php?option=com_content&task=view&id=483&Itemid=3

51 Kiehl J. T. and Trenberth K E 1997, "Earth's Annual Global Mean Energy Budget" *Bull. Amer. Meteor. Soc.*, **78**, 197-208.

52 **Trenberth K E, J T Fasullo and J. Kiehl** (2009), Earth's Global Energy Budget. *Bull. Amer. Meteor. Soc*., **90**, 311-323.
53 **Multiple Authors** 2011, Slaying the Sky Dragon. Stairway Press Mt Vernon WA USA
54 **Casey T** 2011, Not So Apologetic. http://geologist-1011.net/
55 **Gerlich**, G., & **Tscheuschner**, R. D., **2007**, "Falsification Of The Atmospheric CO2 Greenhouse Effects Within The Frame Of Physics", arXiv:0707.1161v1 [physics.ao-ph].
56 **Gerlich** G & **Tscheuschner R. D** 2009, "Falsification Of The Atmospheric CO2 Greenhouse Effects Within The Frame Of Physics", *International Journal of Modern Physics*, Vol. B23, pp.275-364, arXiv:0707.1161v4 [physics.ao-ph], DOI: 10.1142/S021797920904984X
57 **Clausius R** 1887, *Die Mechanische Wärmetheorie.* Druck und Verlag Friedrich Vieweg, Germany, 3. Auflage
58 **Clausius R** 1987, *Mechanical Theory of Heat.* John van Voorst, London. http://www:humanthermodynamics.com/Clausius.html
59 **Smith, A W and J N Cooper** 1964 *Elements of Physics* McGraw Hill Book Company.
60 **Wood R W** 1934, *Physical Optics*. Dover publications New York 1967
61 **Wood R W** 1909, Note on the Theory of the Greenhouse. *Philosophical magazine* vol 17, p319-320
62 **Quirk T** 2008 Private Communication.

25th March 2013

Vincent R. Gray , M.A,Ph.D, F.N.Z.I.C. Climate Consultant **75**
Silverstream Road Crofton Downs
Wellington 6035, New Zealand
Phone (064) (04) 9735939
Email vinmary.gray@paradise.net.nz