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Role of greenhouse gases in climate change

Martin Hertzberg,[1] Alan Siddons[2] and Hans Schreuder[3]

Abstract

This study examines the concept of 'greenhouse gases' and various definitions of the phenomenon known as the 'Atmospheric Radiative Greenhouse Effect'. The six most quoted descriptions are as follows: (a) radiation trapped between the Earth's surface and its atmosphere; (b) the insulating blanket of the atmosphere that keeps the Earth warm; (c) back radiation from the atmosphere to the Earth's surface; (d) Infra Red absorbing gases that hinder radiative cooling and keep the surface warmer than it would otherwise be – known as 'otherwise radiation'; (e) differences between actual surface temperatures of the Earth (as also observed on Venus) and those based on calculations; (f) any gas that absorbs infrared radiation emitted from the Earth's surface towards free space. It is shown that none of the above descriptions can withstand the rigours of scientific scrutiny when the fundamental laws of physics and thermodynamics are applied to them.

Keywords

Anthropogenic climate change, greenhouse effect, meteorology, radiation, thermodynamics

Introduction

Draconian measures on 'carbon control' were recently introduced by the Unites States Government. The perceived need for the controls is predicated on three assumptions:

- recent measured increases in the atmospheric concentration of carbon dioxide (CO_2) are attributable to human emissions of the gas from combustion of fossil fuels such as coal, oil and natural gas.
- such increases are causing, or will be responsible for, dangerous global warming and climate change.
- CO_2 is a 'greenhouse gas' and is the cause of this warming and climate change by way of a 'greenhouse effect'.

[1]Pittsburgh, USA
[2]Boston, USA
[3]Ipswich, UK

Corresponding author:
Hans Schreuder, Flat 3, 336 Norwich Road, Ipswich IP1 4HD, UK.
Email: hans.schreuder@principia-scientific.org

It is said that continuing increases in CO_2 emissions will inevitably lead to dire consequences – the Anthropogenic Global Warming (AGW) theory advocated by the UN's Inter-Governmental Panel for Climate Change (IPCC). Governments, scientific societies, journal editors, newspapers editors, TV media journalists, environmental activists and many corporations, accept the IPCC theory/paradigm. Accordingly, a concerted effort is required to reduce human emissions, tax such emissions and replace fossil fuel combustion with alternative energy sources.

The totality of the data contradicting the first two of the above assumptions has been dealt with by Hertzberg and Schreuder[1] and others.[2–8] However, even among the scientists who challenge the validity of the overall IPCC paradigm and its conclusion that CO_2 is an existential threat to a future habitable earth, some do support the concept that CO_2 is a 'greenhouse gas' that impacts climate.

The Non-Governmental Independent Panel for Climate Change (NIPCC) in a recent report stated: 'Atmospheric Carbon Dioxide is a mild greenhouse gas...'[9] The statement is taken as given and neither the definition of the term 'greenhouse gas' nor a description of the physical processes by which the CO_2 presence in the atmosphere engenders global warming and climate change appears in the report.

A book entitled 'Slaying the Sky Dragon – Death of the Greenhouse Gas Theory' attempts to address the matter.[10] Alan Siddons compiled 19 definitions/descriptions of the 'greenhouse effect' presented by various Government Agencies, Universities, Scientific Institutes and others and prefaced the compilation with the caveat: 'Please note: none of what is described below actually occurs in reality'.[11] Gerlich and Tscheuschner, in their article, 'Falsification of the Atmospheric CO_2 Greenhouse Effects Within the Frame of Physics', conveyed a similar observation based on the fundamental laws of Physics.[12]

This study examines the various definitions of the greenhouse effect for compatibility with the laws of physics.

Greenhouse effect definitions and descriptions

Definition 1

A greenhouse is a glass/plastic enclosure, warmed by sunlight, facilitating plant growth. Several definitions argue that the effect in the atmosphere is analogous to a greenhouse. It is stated that sunlight transmitted into an enclosure through transparent glass warms the interior of the enclosure, increasing the Infra Red (IR) radiation. As glass is partly opaque to IR radiation, it cannot freely pass outward through the glass and is thus retained within the enclosure. Several definitions infer the radiation is being 'trapped' and it is argued that atmospheric gases such as CO_2 are analogous to the glass pane action of a greenhouse and this serves to 'trap' IR radiation within the atmosphere and obstruct radiative cooling.

An early test of the 'trapped' radiation theory was conducted by R. W. Wood.[13] He constructed two enclosures, one covered with a glass plate and the other covered with an IR transmitting rock salt plate. When adjusted so that both were exposed to the same solar input radiation, they both reached the same temperature of 55°C with 'scarcely a difference of one degree between the temperatures of the two enclosures'. His experiment clearly showed that it was the presence of the enclosure itself that enabled the warming. Therefore, it is the heat generated by absorbed sunlight that becomes 'trapped'. In the absence of an enclosure, the warmed air near the ground would rise by buoyancy and be replaced by cooler air from the surroundings thus cooling it. This natural convective cooling process is restricted and suppressed by the enclosure. It is the same process that generates a cooling, afternoon sea breeze on a beach with cooler air from the ocean replacing rising warmer air over land.

To argue that an open gaseous atmosphere confines in the way that the top and sides of a greenhouse enclosure does is not valid. To the contrary, a gaseous atmosphere is conducive to the convective cooling that occurs in the absence of an enclosure. It could be argued that CO_2 along with the other gaseous components of the atmosphere in fact helps to cool the Earth's surface.[14]

Definition 2

Another common theme among the various descriptions of the effect is that the 'greenhouse gases' serve as a 'blanket' keeping the earth warm. A simple experiment to test the validity of this argument is to appear naked outside on a cold evening and observe how long the blanket of 'greenhouse gases' in the atmosphere keeps you warm. Air warmed by body heat rises by buoyancy and is replaced by cooler air from the surroundings, causing rapid cooling down and shivering. An actual blanket is a flexible insulating enclosure that reduces the rate at which body heat is lost to the surroundings. Thus the atmosphere is more given to being an agent for cooling by way of natural convection.

Definition 3

A regular description of the 'greenhouse gas' heating mechanism is that referred to as 'back radiation'. Atmospheric gases such as CO_2, having a dipole moment, absorb some incoming solar radiation and some of the IR radiation the Earth's surface radiates toward free space. According to the Environmental Protection Agency, 're-radiated energy in the IR portion of the spectrum is trapped within the atmosphere keeping the surface temperature warm'. This 'trapping' is assumed to occur as the surface radiates to the atmosphere and the atmosphere radiates back to the surface.

The radiation emitted from the warmer surface absorbed by the colder atmosphere is readily detected by orbiting satellites. However, back radiation from the colder atmosphere to the warmer surface heating the surface further violates the Second Law of Thermodynamics. Shown in Figure 1 is a sketch of the radiation budget of the Earth's atmosphere as proposed by Trenberth and Kiehl.[15] It depicts an energy flow of 333 W/m^2 of down-welling back radiation from the atmosphere to the surface. This flux of energy is the amount a blackbody at the temperature of the lower regions of the atmosphere would emit to free space or any receptive absorber.

There are two problems with that amount of down-welling radiation: the atmosphere is not a blackbody with unit emissivity and equally, is not radiating toward a receptive absorber. Yet it is depicted as radiating heat downwards to the warmer Earth's surface in direct violation of the Second Law.

In order to clarify this question more satisfactorily, the fundamental physics of radiative energy transfer must be considered and applied in order to avoid an incorrect interpretation of the Stefan-Boltzmann equation in the down-welling radiation argument.

Take two flat, parallel surfaces each with unit emissivity facing each other. One surface is maintained at a higher temperature, T(h), while the other surface is maintained at a lower temperature, T(c). If the hotter surface faces a complete void at 0 K, the flux of radiant energy it would emit and the void would receive and absorb is $\sigma T(h)$,[4] where σ is the Stefan-Boltzmann constant.

Similarly, if the colder surface were facing a complete void (or surroundings at 0 K), the flux of radiant energy it would emit and the void receive is $\sigma T(c)$.[4] If neither of the surfaces is facing a void but are facing each other, the effective flux of radiation in the field between them is:

$$I(net) = \sigma\left[T(h)^4 - T(c)^4\right] \tag{1}$$

The flow of heat is always from the hotter surface to the colder surface as required by the Second Law of Thermodynamics.

Nowhere in the radiation field between the two surfaces is the flux of radiant energy equal to that which either surface would emit if they were facing a complete void. Thus, the simple use of the Stefan-Boltzmann term, σT^4 to characterize the emission from a source of radiation in the manner that depends only on the temperature of the source without considering the temperature of the surroundings receiving the radiation, is a misapplication of the equation and the notion that a colder source can transfer radiant energy to a warmer object is a misapplication of the Stefan-Boltzmann equation and a violation of the Second Law of Thermodynamics

It would therefore be clear that the application of the Stefan-Boltzmann term to simply characterize radiant energy being transferred from an object to its surroundings without reference to the conditions of the surroundings in radiative contact with that object is a misapplication of the equation.

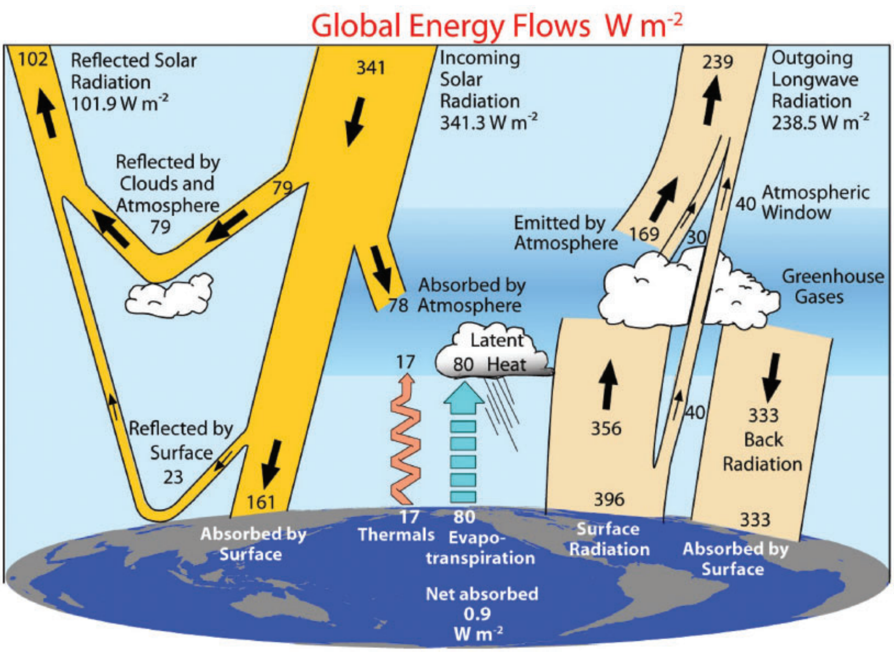

Figure 1. Earth radiation budget, Kiehl and Trenberth.[15]

The situation is analogous to a problem in mechanics. A 1 kg mass is sited on a frictionless table and subjected to a force of 10 Newtons from left to right and simultaneously subjected to a force of 7 Newtons from right to left. Calculate what the motion would be if only the 10 Newton force acted on the mass or calculate what the motion would be if only the 7 Newton mass operated on it. Neither of these calculations describes the real motion, which is that of a 3 Newton force acting from left to right. There is no motion to the left from the weaker force.

A definitive proof of the correctness of equation (1) is displayed in the line reversal method for determining the temperatures of flames. In the line reversal method, one looks at the flame emission from an excited spectral line (typically the Sodium D line that is obtained by seeding the flame with a small amount of a sodium salt). The flame is in the foreground and a blackbody in the background. A wire filament can also be used as the background. If the blackbody is not heated, it is not as bright as the flame and only the Sodium D emission line from the flame is observed. When the blackbody is heated and approaches the flame temperature, the emission line merges with the background and becomes indistinguishable from it. That is the 'point of reversal' at which the flame temperature is equal to the blackbody temperature. As the blackbody is heated to higher temperatures, the line reappears, but as a dark absorption line. Clearly, the point of reversal corresponds to the case where the first term in equation (1) is equal to the second term and there is no absorption or emission between the flame in the foreground and the blackbody in the background.

In the case where the flame is hotter than the background, the flame emission is seen as a bright line and the emission from that line is absorbed into the colder blackbody behind the flame. In the case where the blackbody is hotter than the flame, it emits radiation to the flame that is absorbed by the flame and the sodium D line is seen as a dark absorption line.

That line reversal is depicted below. In Figure 2 (upper), a dark absorption line is seen when the absorbing gas in front is colder than the blackbody in the background behind it. In Figure 2 (lower), a bright emission line is seen when the gas is hotter than the black body. When the temperatures are equal, nothing is seen at the line's wavelength and there is neither absorption nor emission between them.

Thus, the radiant transfer between the flame and the blackbody depends on both temperatures and is always from the high temperature source to the lower temperature sink.

Another proof would be the obvious failure of any attempt to measure the radiation from an object using a radiometer at a higher temperature than the object. That is one reason detectors used in the most sensitive IR telescopes are cooled with liquid helium to temperatures as low as 2 K.

For a higher temperature object with emissivity e(h) emitting to a lower temperature object with absorptivity a(c), the net transfer equation is:

$$I(net) = e(h)\, a(c)\, \sigma\left[T(h)^4 - T(c)^4\right] \tag{2}$$

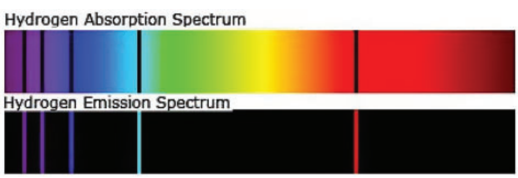

Figure 2. Absorption and emission lines of hydrogen.
Source: www.astronomyknowhow.com/hydrogen-alpha.htm

and is always from the hot object to the cold object regardless of the emissivities or absorptivities. Therefore, it would be incorrect to talk in terms of radiation exchanging, since transfer occurs only from warmer to cooler matter, from higher energy level to lower energy level.

Definition 4

A proposed new definition of the greenhouse theory to overcome the objections raised against warming by back radiation argues that IR absorbing 'greenhouse gases' hinder radiative transport from the Earth's surface upwards and aid to keep the surface warm and warmer than it would otherwise be in the absence of those gases. The definition ignores the fact that those gases themselves emit radiation to free space adding to radiation loss from the system.[15] Radiation loss to free space from the earth's surface and its atmosphere is essentially the same with or without presence of absorbing gases for the following reasons: the cooling by radiation to free space is a one-step process; in the presence of an atmosphere, it is a two-step process with the same loss, with or without, the absorbing and emitting gaseous atmosphere.

When talking about radiation, it is absorbed radiation or emitted radiation that is being considered. The above definition of a 'greenhouse gas' requires another form to be created – called 'otherwise radiation'. We analyse this as follows:

In the absence of an atmosphere, the radiation lost to space from the earth's surface is:

$$E\,\sigma\,T(E)^4 \tag{3}$$

where E is the Earth's surface emissivity, T(E) its temperature and space is essentially at 0 K (a perfect sink).

In the presence of an atmosphere, radiation from the surface that is absorbed by the atmosphere is given by:

$$E\,a\,\sigma\left[T(E)^4 - T(A)^4\right] \tag{4}$$

where a is the absorptivity of the atmosphere, and T(A) its temperature.

That same atmosphere radiates to free space at the rate:

$$e\,\sigma\,T(A)^4 \tag{5}$$

here e is the atmosphere's emissivity and $a = e$ (Kirchhoff's law).

The atmosphere is partially transparent with a transmissivity of $(1 - a)$, and the loss from the surface to space through that partially transparent atmosphere is:

$$(1 - a)\,E\,\sigma\,T(E)^4 \tag{6}$$

Adding equations (4), (5) and (6), one obtains the total loss to free space from both the surface and atmosphere. The positive and negative terms of the quantity $E\,a\,\sigma\,T(E)^4$ cancel each other to give the total loss as:

$$E\,\sigma\,T(E)^4 + (1 - E)\left[a\,\sigma\,T(A)^4\right] \tag{7}$$

Comparing equation (7) with equation (3) for the case when $E = 1$ shows that they are identical. Thus, the Earth with its atmosphere radiates as much to free space as it would without an atmosphere. Essentially, the same result is obtained approximately for non blackbodies with emissivities and absorptivities less than unity.

This analysis shows that if one looks at the totality of the radiative processes involved, the concept of 'otherwise radiation' is not supported.

Definition 5

In many of the various definitions, attempt is made to prove that 'greenhouse gases' in the atmosphere keep the Earth warm, warmer than it would otherwise be in the absence of an atmosphere as conveyed by the following quote:[17]

> This process (radiation trapping) makes the temperature rise in the atmosphere just as it does in the greenhouse. This is the Earth's natural greenhouse effect and keeps the Earth 33°C warmer than it would (otherwise) be without an atmosphere, at an average of 15°C.

Logically that argues that if the Earth had no atmosphere, its average temperature would be −18°C rather than its current temperature of 15°C.

Such a temperature is based on calculated ones, that is 'otherwise' ones. The calculations arise from several mistaken assumptions. The most obvious one diminishes the solar radiation input by 37% from the Earth's cloud albedo while simultaneously taking no account of any lessening of the IR radiation emitted to free space by the same blocking clouds. Equally, all IR radiating entities on the surface are assumed to be blackbodies with unit emissivity. The calculation that yields the −18°C temperature is obviously mistaken. The question is considered and covered in detail in the 'Cold Earth Fallacy'.[18]

Further argument used to illustrate the greenhouse effect of CO_2 is the atmosphere of Venus, which is almost entirely CO_2. Based upon its distance to the Sun relative to that of the Earth, and using the Earth's average temperature, Venus surface temperature should be about 280°C. Yet the measured value is about 465°C. This difference is attributed to the strong greenhouse effect of its higher CO_2 concentration. The difference is more correctly attributable to Venus' high surface pressure and the adiabatic compression of the atmosphere adjacent to its surface. Venus' surface temperature would be just as warm if its atmosphere consisted of any gas whose compressibility was the same as that of CO_2. The temperatures in the Mohave Desert and the Dead Sea are higher than the temperatures of surrounding areas at sea level. That is not a greenhouse effect but is caused by adiabatic compression of the higher pressures at their elevations below sea level.

Definition 6

All atmospheric gases that are believed to be 'greenhouse gases' absorb IR radiation emitted from the Earth's surface. Their absorption spectra are well known and it is relatively easy to calculate the radiation flux, those gases absorb from the Earth's IR emission. The problem arises when those radiation fluxes are translated into a resultant temperature rise while ignoring the fact that atmospheric gas is being simultaneously cooled by radiating to the unlimited sink of free space.

Epilogue

Joseph Priestley, Unitarian Minister and Scientist in whose name the American Chemical Society's highest award is given, identified CO_2 and other gases which he named 'airs'.

He called CO_2, which he collected from breweries, 'fixed air' and oxygen 'dephlogisticated air'. He, along with most 18th Century scientists, were adherents of the phlogiston theory, which posited that combustion involved the loss of a substance they called 'phlogiston'.

Antoine de Lavoisier, considered the father of modern Chemistry, conducted many outstanding experiments using the most sophisticated apparatus available at the time and demonstrated that combustion was a chemical reaction of a substance with oxygen and phlogiston became apocryphal.

At a time when the laws of thermodynamics had not yet been established, he coined the term 'caloric' to explain the heat generated by combustion and that also in time became discarded alongside phlogiston.

Both these scientists stored and used many labelled flasks and containers of gases, liquids and solids, but none were found labelled 'phlogiston' or 'caloric'.

In one of science's first 'thought experiments' Pierre Prévost (1751–1839) conjectured that a hot body absorbed less radiation from a cold body than the reverse, and that both would eventually reach the same temperature. Thus, the theory of radiant exchanges came into being, a view that predated the more thorough understanding of the Laws of Thermodynamics that came later. Yet it is noted that aspects of Prévost's 200-year-old theory continue to be applied in regard to 'net flow' of heat – a concept that radiation flows both downhill and uphill. The latter flow is a violation of the Second Law, which informs us that a hot body can absorb no radiation from a cold body to make it warmer still.[19]

Radiative greenhouse supporters have theorized a blackbody as an all-absorbing entity, capable of absorbing and retaining its own radiation to elevate its temperature and have used radiant exchanges in support of their arguments.

In the absence of definitive experiments to demonstrate the reality of the 'greenhouse effect', and in view of the failure of the previously enumerated definitions, the effect should join 'phlogiston' and 'caloric' in Science's Gallery of ancient constructs.

An added difficulty is that so far no way has been found to be able to readily transpose or correlate experiments conducted in the contained, static, isothermal and isobaric conditions of a laboratory to the great vastness of earth's atmosphere.

Conclusion

The various stated definitions of the greenhouse effect have been subjected to the rigorous scrutiny and application of the fundamental laws of physics and thermodynamics. They were found to be unreal, and unless some new definition can be put forward that satisfies and complies with those laws, it can only be concluded that the concept of a 'greenhouse gas' or a 'greenhouse effect' has not been demonstrated and is thus without merit.

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Martin Hertzberg was first trained as a meteorologist at the US Naval Postgraduate School and then served as a forecasting and research aerologist at the Fleet Weather Central in Washington DC. He subsequently obtained a PhD in Physical Chemistry at Stanford and later served as a Fulbright Professor. Hertzberg established and supervised the explosion testing laboratory at the U. S. Bureau of Mines facility in Pittsburgh (now NIOSH). Test equipment developed in that laboratory has been widely replicated and incorporated into ASTM standards. Published test results from that laboratory are used for the hazard evaluation of industrial dusts and gases. He is an internationally recognized expert on combustion, flames, explosions and fire research with over 100 publications in those areas. While with the Federal Government, he served as a consultant for several Government Agencies

(MSHA, DOE and NAS) and professional groups (such as EPRI). He is the author of two US patents: (a) Sub-micron Particulate Detectors and (b) Multi-channel Infra-red Pyrometers. He is also a long-time climate writer and, in recent years, his interests have returned to weather prediction and he is a well-published skeptic of anthropogenic global warming/climate change.

Alan Siddons is formerly a radio chemist and now a leading climate researcher and science writer. He has compiled several papers, essays and graphics commenting on errors underwritten by climate alarmists and realists alike. With clear examples, he illustrates the points at which urgent questions need to be asked and issues addressed.

Hans Schreuder trained as an analytical chemist in The Hague and spent 15 years working in that field, testing pharmaceutical products as well as researching the recycling of plastics and rubber. For another 15 years, he gained extensive experience as an international technical contractor, including writing quality control manuals whilst working in South Africa. He was accepted as a member of MENSA after passing the relevant tests. He has long been a staunch and studied critic of the greenhouse gas theory and is an outspoken commentator using his two websites as a publishing hub for fellow scientists critical of that theory. He has written many articles on the subject and in May 2009 submitted a 109-page report, supported by a 45-min spoken address, to the Northern Ireland Climate Change Committee.