A Discussion on the Absence of a Measurable Greenhouse Effect

Joseph E Postma, M.Sc. Astronomy

October 22, 2012

An Original Publication of Principia Scientific International

PRINCIPIA SCIENTIFIC INTERNATIONAL

Abstract:

A contextual flaw underlying the interpretation of a back-radiative greenhouse effect is identified. Real-time empirical data from a climate measurement station is used to observe the influence of the "greenhouse effect" on the temperature profiles. The conservation of heat energy ordinary differential equation with the inclusion of the "greenhouse effect" is developed, which informs us of the temperature profile we expect to see when a "greenhouse effect" is present. No "greenhouse effect" is observed in the measured data. The latent heats of H_2O *are identified as the only real heat-trapping phenomenon and are modelled. A discussion on the existence of universal principles is used to explain why simplistic arguments cannot be used as justification for the greenhouse effect.*

Table of Contents:

1. Introduction to the GHE

1.1. The problem, and truth, of the albedo

A well-known attempt at a theoretical disproof of the postulate of an "atmospheric greenhouse effect" (GHE) was found in Gerlich & Tscheuschner's [1] "Falsification of the Atmospheric CO2 Greenhouse Effects Within the Frame of Physics". One of the rebuttals to this paper was Smith's [2] "Proof of the Atmospheric Greenhouse Effect". A fault can be levelled at both of those papers in that no true empirical tests were made of either's claims, no matter how well-established the physical principles might have seemed to be in either's assessments. Generally, the inference of an atmospheric GHE is made by comparing the Earth's near-surface-air average temperature to its global effective blackbody radiative temperature calculated from the absorbed energy from the Sun – there is a difference of 33K.

There exists a simple contextual flaw in this inference because the average terrestrial albedo is much higher than the true surface albedo due to the presence of clouds in the atmosphere, resulting in a terrestrial albedo of approximately 0.3, while the true surface albedo is actually much less at only 0.04 [3]. That is, without greenhouse gases, the albedo would not still be 0.3, but 0.04. The physical surface is not where the average terrestrial albedo of 0.3 is found, and so the direct comparison of related temperatures using the same albedo is unfounded, because one system is being compared to a qualitatively different system with different absorptive (and presumably emissive) properties. But for a common example, in this [4] online textbook, we read:

> "*The temperature of the surface of the Earth without these greenhouse gases would be 255 K. With these greenhouse gases the average temperature of the surface of the earth is 288 K. Our total of greenhouse warming is 33 K.*"

However, without greenhouse gases, the albedo would not be 0.3, which thus leads to the 255K value. The albedo would actually be 0.04. Therefore a valid comparison is actually found in the theoretical temperature of the Earth-ensemble without greenhouse gases (GHG's) and with a *correctly* corresponding albedo, to that with greenhouse gases with their corresponding albedo. In this physically meaningful comparison, the difference in temperature between the theoretical ground surface, and the observed surface with an atmosphere and GHG's on top, is only 12K, reducing the inferred strength of the GHE by almost two-thirds. That is, the average global surface temperature without GHG's, calculated using the usual method of the Stefan-Boltzmann Law with conservation of energy given the known solar input and the surface-specific albedo, results in a value of 276K. The observed average surface temperature with GHG's present is actually 288K (15C), and so the "greenhouse effect" should actually be thought to only provide 12K worth of additional temperature, not the 33K which is always incorrectly cited.

It should be noted that the much higher albedo, with GHG's present, is caused by the presence of clouds from droplet-condensation of the GHG water vapour. This reduces the amount of sunlight absorbed by the system and thereby must reduce the temperature, in spite of the warming effect of the GHE from water vapour's own presence. In light of that one may ask: What would be the theoretical temperature of the surface of the Earth, with GHG's including water vapour present, but when no clouds form? Without knowing (as yet in this paper) the mechanism of the GHE and how to account for it, we can't directly answer the question, but it should be at least 276K, as above, given that the albedo isn't reduced from clouds. However, the answer can simply and easily be tested empirically on days where there are no clouds. This will be done later in this report. Without the albedo-increasing cooling effect of clouds (they prevent heating from solar insolation) above the surface, the GHE should manifest much more clearly. We must also acknowledge the fact that since the bulk portion of the terrestrial albedo is caused by cloud-tops, at altitude, we still cannot directly infer that the resulting 255K terrestrial temperature with clouds present should be found at the physical ground surface, whether or not there is a GHE, because the radiative surface with albedo equal to 0.3 does not reside with the ground surface. There is a vertical dimension which affects the interpretation and must be taken into consideration. Martin Hertzberg adds additional detail [5], with the point being that treating the emissivity as unity such as to arrive at the "Cold Earth Fallacy" is also unjustified:

"*Since most of the albedo is caused by cloud cover, it is impossible for Earth to radiate out into Space with unit emissivity if 37% of that radiation is reflected back to Earth, or absorbed by the bottom of those same clouds. Even for those portions of Earth that are not covered with clouds, the assumption that the ocean surface, land surfaces, or ice and snow cover would all have blackbody emissivities of unity, is unreasonable. This unrealistic* *set of assumptions - leading to sub-zero average temperatures for Earth - is shown in Fig.1; and it is referred to there as the "Cold Earth Fallacy"*."

A second and related ambiguity is that the 33K "GHE" value is a comparison of a calculated effective blackbody radiative temperature as should only be observed from outside the system (from space), via an integrated emission spectrum, to a specific kinetic temperature measured at only a single depth-position inside the thermodynamic and radiative ensemble. That is, the average radiating emission altitude of outgoing energy from the terrestrial ensemble is actually between 5 and 6 km [6], and this is where the kinetic temperature of 255K is found. In terms of radiation, the ground surface of the Earth is not the radiating surface, and therefore we shouldn't expect the ground surface to have that temperature. In terms of the radiating surface, the temperature of the Earth as an integrated thermal ensemble inherently including the atmosphere, as seen from space, is exactly the same value as the theoretically-calculated effective blackbody temperature. The Earth, in terms of its only means of exchanging energy – radiation – is exactly the temperature it is supposed to be. But for most natural radiating gaseous systems with central gravity, such as stars, there will be a generally fixed effective blackbody temperature, while the kinetic temperature of the gas typically follows a distribution, in the main radiating layers, which increases in temperature with depth; see Gray [7], Table 9.2, for example. This is true for stars because the source of energy is below the radiating layers; however, the same is true for the terrestrial atmosphere because the bulk source of heat energy, similarly, comes from solar radiation generating heat at the bottom-most layer of the atmosphere, at the surface-atmosphere boundary. (Some solar radiation is absorbed directly into the atmosphere via absorptive extinction; see [8] and [9] for example.) And so, because the ground surface is where the solar heat is (mainly) initially deposited, which then works its way through the atmosphere conductively and radiatively, the surface and lower layers should be expected to be warmer than the integrated average layer and upper layers. This fact is particularly relevant when we consider the actual maximum heating potential of sunlight under the solar zenith: considering a surface albedo of, say, 15%, and no clouds in the way, the real-time insolation temperature works out to ~378K or 105^0C, via the Stefan-Boltzmann Law. As a matter of fact, the instantaneous average heating potential of sunlight over the sun-facing hemisphere, assuming an integrated albedo of 0.3, has a hemispherically integrated average value of 322K or $+49^0$C. Note that the bi-hemispherical average temperature at the surface is actually only $+15^0$C. Because this energy is initially deposited by sunlight within the first few millimeters of land surface (for the ocean most sunlight is absorbed within 200m depth), and this is therefore the only (main) place where the insolation is converted to heat, we find much justification for finding said surface to be warmer than the integrated average of the entire atmospheric thermodynamic ensemble above the surface conducting heat away from it, similar to the classical problem of a bar heated at one end. The effective blackbody radiating temperature, being an integrated sum of the emission from all wavelengths and points along the optical (i.e. physical) depth of the atmosphere, necessarily requires that higher kinetic temperatures than said radiative average will be found below the depth of average radiative emission, essentially by the mathematical definition of what an integrated average is, and independent of any "GHE".

1.2. The lapse and cloud-height forcing

So to be clear, the commonly cited 33K GHE value is a comparison between the integrated average effective blackbody radiative temperature of the Earth which is radiatively observed from space and kinetically found between 5 and 6 km on average, to the specific kinetic temperature found at another point in the emission-column located just above the surface of the Earth at a typical altitude of 1.5 m, or approximately 5 – 6 km beneath the average altitude of emission.

Hansen (*et al.*) [10] described this in their Equation 3:

$$T_s \sim T_e + \Gamma H \tag{1}$$

where T_S is the surface temperature, T_e is the effective blackbody radiative temperature, H is the flux-weighted mean radiating altitude, and Γ the mean temperature gradient or lapse rate in the atmosphere. They (*ibid.*) state: "The excess, T_S - T_e [equal to ΓH], is the greenhouse effect of gases and clouds, which cause the mean radiating level to be above the surface. An estimate of the greenhouse warming is [Equation (1)]." Unfortunately, Hansen (*et al.*) (*ibid.*) do not state the actual mechanism by which ΓH arises, nor were any references made for such, but it is apparent they considered it (ΓH) to be representative of the GHE itself.

The lapse rate Γ (both dry and wet values of it, as we will see) can be derived from first principles. A parcel of gas of mass *m* at temperature *T* and at altitude *h* will have a total energy content *U* made up of both thermal and gravitational energies. Considering Local Thermodynamic Equilibrium, this quantity of energy will be constant, and so:

$$\begin{gathered} U = mC_pT + mgh \\ dU = mC_p \cdot dT + mg \cdot dh = 0 \\ \frac{dT}{dh} = -\frac{g}{C_p} = \Gamma \end{gathered} \tag{2}$$

Dry air has a specific thermal capacity of C_p = 1006 J/kg/K, and the gravitational constant is 9.8 m/s^2, and so the lapse rate for dry air is :

$$\Gamma_{dry} = -9.74 \ K/km \tag{3}$$

Equations (2) and (3) cannot be related to a "greenhouse effect" categorically dependent upon "greenhouse gases" (GHG's), because the majority contribution to the weighted-mean thermal capacity is given by molecular nitrogen and oxygen which constitute ~99% of the atmosphere. Of course, the specific mechanism of the GHE is something else, which we will discuss ahead, but it should be clear that whatever the GHE mechanism is, it is not the temperature gradient Γ itself. The GHE must be related only to H, the mean altitude of the radiating surface. So there can be little discussion of the effects of "GHG's" based on the lapse rate and Equations (2) and (3) since GHG's do not factor in a meaningful, and particularly not in a radiative way, to them.

The wet, or more commonly known as the "normal" or globally averaged lapse rate, can be derived from the result of Equation (3) and the value of the average atmospheric water vapour concentration at the surface of the Earth. Water vapour concentration at the surface of the Earth varies between 1% and 4% by volume [11], so an average value for the volume concentration can be taken as $\chi_v^{H_2O} = 2.5\%$. For an ideal gas, the molar concentration is the same as the volume concentration, and so the mass percentage of water vapour is:

$$\chi_m^{H_2O} = \chi_v^{H_2O} \cdot \frac{m_{H_2O}}{M} \tag{4}$$

where m_{H2O} is the molar mass of H_2O (18.02 g/mol), and M is the average molar mass of air at STP (28.57 g/mol). This results in a mass percentage of 1.58%; that is, at the surface at STP, the mass fraction of water vapour of a parcel of atmosphere is 0.0158. If we consider a cubic meter of atmosphere at the surface, which has a density of 1.225 kg/m^3, then the internal mass from water vapour is 0.0194 kg. The region of atmosphere where the lapse rate is constant and the temperature decreases essentially linearly with altitude extends to about 10 km in altitude from the surface [12]. At the top of the troposphere the concentration of water vapour is essentially negligible as compared to its surface value, and because the lapse rate is constant, we can linearly interpolate the rate of condensation per meter, as the air parcel rises, at 1.94 x 10^{-6} kg/m.

Now, water vapour has a latent heat of vaporization of 2,257,000 J/kg, and so the rate of energy input from the loss of latent heat in this kg of air due to condensation is 4.38 J/m. With a specific heat capacity of about 1006 J/kg/K, the heat input from condensation in this 1.225 kg mass of air will reduce the rate of temperature decrease by 0.0035 K/m. Given that the dry lapse rate is -0.00974 K/m, the wet rate will then be -0.00624 K/m or -6.24 K/km. The average observed global lapse rate is -6.5 K/km, and so this estimate and derivation is satisfactory given the average values used. Alternatively, the calculation can be performed "in reverse" starting from the observed environmental lapse rate, in which case the average mass percentage of water vapour at the surface turns out to be $\chi_m^{H_2O} = 1.44\%$ and the volume percentage $\chi_v^{H_2O} = 2.29\%$, which is of course well within the observed range.

If we combine the above result of the natural temperature distribution (lapse rate) of the atmosphere due to gravity, thermal heat capacity, and water vapor condensation, with the fact that the average radiating layer and temperature is found at ~5 km in altitude, we find that

$$\Gamma H \approx 33\ K \tag{5}$$

from Equation (1). In this formulation of the GHE (there is another, as we will see) it is clear that the mechanism of the GHE is found in setting the radiative height *H*. In this formulation, the GHE doesn't specifically have anything to do with actual heating of GHG's or heating caused by back-radiation from GHG's *per se*, but is only about setting the radiative scale height *H*. However, with increasing global surface temperature and increasing CO2 concentration (not necessarily causally-related *a priori*), no increase in the temperature scale height of the atmosphere has actually been observed [13], thus putting into question the GHE postulate itself, and the source of the warming. Why increasing CO2 concentration hasn't led to an increase in the temperature scale height of the atmosphere thus requires explanation, which may possibly be found in Miskolczi's "Saturated Greenhouse Theory" [14] which has an excellent summary here [15].

We may also note once again that the mean altitude of radiative equilibrium *H*, in addition to the plain mathematical requirement of the definition of what an average is, must be risen off of the physical ground surface independent of any radiative GHE mechanism because the surface of the net terrestrial albedo, which is used to calculate the equilibrium, is found at altitude, on the cloud-tops, and not at the physical ground/sea surface. The net terrestrial albedo of 0.3, which value originates largely by the presence of cloud-tops, is thus actually found at cloud-top heights which range up to 20 km in altitude [16], and which average (by judging from the colour-altitude plots from the current reference) anywhere between 4 km to 8 km. A globally and temporally averaged effective cloud-top height was unable to be discovered by this author, and it would be a good number to know. These facts are particularly relevant because "the decadal change in radiative forcing from CO_2 is equal in magnitude (~0.28 W/m^2) to a change in effective cloud height of +19m" [17], indicating that the global effective cloud height does indeed affect the surface temperature of its own accord via the mechanism basically described in Equations (1) to (3) (and Hansen (*et al)* Equation 3). If the cited cloud-height-forcing were linear, which we might expect from Equations (1) to (3), then as an approximation an effective cloud height of only 2.24 km would correspond to the 33K "forcing" of the GHE, without needing to refer to any additional back-radiative heating mechanism.

No additional radiative GHE heating mechanism is thus necessarily required to explain the near-surface air temperature because the average cloud-top height is what is principally responsible for determining the altitude of the surface of 0.3 albedo; the resulting near-surface-air temperature is then exclusively due to the lapse rate/cloud-height-forcing alone. The correlation here to the situation on Venus is thus relevant and obvious: it has a cloud-top deck at approximately 70 km [18] which reflects 67% of the insolation [19], and has an effective blackbody temperature less than the Earth's at -25^{0}C. But we certainly would not say that Venus' physical surface would have an average temperature of -25^{0}C if it had no atmosphere and no GHE, because its real surface "soil" albedo will be *much less* than 0.67. So the case of Venus makes it very clear how incorrect such a comparison is, as it is for the Earth. With a cloud deck so high in altitude, and a lapse rate of 10.74 K/km, there's more than enough depth between the radiative/cloud-top surface and ground surface to reach a near-surface-air temperature of 462^{0}C on Venus without any need for a heat-amplifying GHE. The same physics can be expected to occur on the Earth, but to lesser extent given the more rarefied and shallow atmosphere.

Although we have highlighted a type of mechanism and a definition for the GHE based on a very common reference for it, we now turn to an alternative characterization of the mechanism of GHE heating based on widely-recognized and prevalent references.

2. Development of the GHE via Conservation of Energy Heat Flow Mechanics

2.1. The conservation of heat energy ordinary differential equation

The word equation for heat flow and conservation of energy which establishes the ordinary differential equation which describes this is [20, pg. 19]:

"The rate of change of heat energy = heat energy flowing across the boundaries + heat generated inside"

This equation forms the basis of all physical heat-flow modelling with energy conservation, and in generality it forms the most fundamental physical ordinary differential equation that exists. The general statement of the equation would be: the rate of change of a metric is proportional to the difference between the current value of that metric, and the value of whatever forcing influences exist, of the appropriate dimensionality, that is causing said metric to change. Mathematically, the general relation is

$$\begin{aligned} \dot{F}(t) &\propto I(t) - F(t) \\ \dot{F}(t) &= c \cdot \left(I(t) - F(t) \right) \\ \tau \dot{F}(t) &= I(t) - F(t) \end{aligned} \tag{6}$$

where $\dot{F}(t)$ is the rate of change of the metric, $I(t)$ is the input, and $F(t)$ is the current value for the system. We place the constant of proportionality 'c' with the rate of change term, and re-denote it as 'τ', and we will see that it represents a time-lag constant which incorporates several fundamental physical properties of the system. This constant also provides for a dimensional difference between the specific rate-of-change-term and the current-value terms for input and output. The equation is a fundamental formula found in many fields of physics, describing such things as the electrical voltage in a resistance-capacitance circuit, or the temperature of a cup of coffee, for example. The solution to the equation typically involves a power function of the natural logarithmic constant.

2.2. The ordinary differential equation developed for a real system

If we would like to apply the fundamental heat flow equation to the Earth, we have to figure out what metric is appropriate to model, and we also need to define where and to what that metric applies. To solve the heat flow problem, we first note that heat energy is defined in units of Joules, and that the amount of heat energy held within a system is equal to

$$q = m \cdot C_p \cdot T \quad (J) \tag{7}$$

where q is the system heat energy, C_p is the thermal capacity in units of J/kg/K, and T is the system temperature. It is obvious that if the number of Joules inside the system increases, then the system temperature increases as well. Or, as a time differential

$$\frac{dq}{dt} = m \cdot C_p \cdot \frac{dT}{dt} \quad (J/s) \tag{8}$$

assuming the mass and specific heat capacity are constant. This equation has units of Wattage, so that is, the Wattage leaving or entering the system is proportional to the rate of change in temperature of the system, as we would expect. This heat flow is completely independent of the nature of the transport of the energy: it could be by radiation, or conduction, but the energy which goes into or out of the system represents a net flow of Joules of energy over a time period, which is Wattage. One could also factor in the surface area of the system, i.e. the boundary layer which defines the system, and then we would have units of Watts per square meter (W/m^2), which is cross-sectional energy flux density, or simply surface flux. This is convenient because the forcing from solar insolation is typically quantified in these units. In that case, what we can model is a particular square-meter of Earth's surface and establish a heat-flow model for that location in order to assess the heat energy flows.

Since dq/dt = flux, the temperature will change when there is an inequality between the rate of energy entering vs. that leaving the system through the surface, and so

$$flux_{in} - flux_{out} = m \cdot C_p \cdot \frac{dT}{dt} \quad (W/m^2) \tag{9}$$

That is, if there is more energy coming in than is leaving, then the temperature will increase, and vice-versa. Equilibrium is found when the input and output flux are equal. For the radiative analysis, the surface output flux is that given by the current temperature via the Stephan-Boltzmann equation and emissivity (*e*), and the input flux can be an arbitrary function (which in our case would be the solar insolation), so:

$$\tau \cdot \frac{dT}{dt} = F_{in} - e \cdot \sigma \cdot T^4 \quad (W/m^2) \tag{10}$$

where the time constant is easily identified as $\tau = m \cdot C_p$. We may note that, while the mass of the system would not be expected to change, the thermal capacity of the system can change due to phase changes of H_2O; but for now, we can leave tau as a constant.

Equation (10) can be generalized to

$$\tau \cdot \frac{dT}{dt} = F_{in} + C(t) - e \cdot \sigma \cdot T^4 \quad (W/m^2) \tag{11}$$

where C(t) is literally a climate term which could be either positive or negative (adding heat or taking heat away) in total, or composed of several unique contributions depending on if there is an additional heat source such as the "greenhouse effect", or chemical and geologic sources etc., or an active cooling mechanism such as that caused by wind. It can also be a scalar or a function of time or temperature. Equation (11) is not solvable analytically due to the fourth-power dependence of the output flux on temperature, but the topology of the solution retains the power function decay that can be derived if the relationships were all linear. For example, if the relationship to temperature was linear and the input a scalar, then the solution would simply be:

$$T(t) = \frac{F_{in}}{e\sigma} + c_1 \cdot \exp\left(\frac{e\sigma t}{\tau}\right) \tag{12}$$

when F_{in} is a constant, C(t) = 0, and c_1 is the constant of integration. However, the transcendental nonlinear solution with T^4 is actually, using "Wolfram Alpha" [21]:

$$c_1 + \frac{t}{\tau} = \frac{\ln\left(\sqrt[4]{F} + T(t)\cdot\sqrt[4]{e\sigma}\right) - \ln\left(\sqrt[4]{F} - T(t)\cdot\sqrt[4]{e\sigma}\right) + 2\tan^{-1}\left(\frac{T(t)\cdot\sqrt[4]{e\sigma}}{\sqrt[4]{F}}\right)}{4\sqrt[4]{e\sigma}\cdot F^{3/4}} \tag{13}$$

The nonlinear solution for dT/dt is easily handled by a numerical integration routine, and we will utilize those as available in Matlab [22] for this paper. Numerical routines also make it extremely simple to allow for all parameters to be modelled with time and temperature dependence, such as thermal capacity.

In the case of a location on the planet's surface, the insolation forcing function F_{in} is generally only the positive-half (upper half) of a sinusoid, and the general solution if $F_{in}(t) = a\cdot\sin(b\cdot t)$, and if the temperature dependence was linear, is:

$$T(t) = c_1 \exp\left(\frac{e\sigma t}{\tau}\right) + \frac{a\left(e\sigma\sin(bt) - b\tau\cos(bt)\right)}{b^2\tau^2 + e^2\sigma^2} \tag{14}$$

The sin and cosine term is important to understand here because it signifies a time lag between the forcing input function and the response of the solution. We can see this analytically in the linear solution here, but such would not be obvious if looking at the nonlinear T^4 solution (if one is even writable in this case…Wolfram Alpha "timed-out" before a solution could be found). However, topologically, the effect of the time-lag is similar in the linear and nonlinear solutions in that it manifests in the same way in both, as we will see ahead. Because '*b*' is simply a unit scaling term for the trigonometric argument, we see that the degree of phase lag of the solution to the input forcing will be a function of $\tau = m\cdot C_p$; that is, larger mass and/or larger thermal capacity will cause a longer phase lag, and vice-versa. Appendix A shows the Matlab script for numerically solving Equation (11), where $F_{in} = a\cdot\sin(b\cdot t)$ is valid only for positive values, and $F_{in} = 0$ otherwise, thus simulating day-time solar forcing followed by night-time cooling (C(t) is ignored and will be explored later). The results are plotted for two different values of τ so that its effect on the solution can be observed, as seen in Figure 1 below. The τ values therein would correspond, if modeling a sandy surface and soil of specific heat C_p = 800 J/kg/K [23], to masses of 6.25kg and 500kg, which equate to square-meter soil columns of approximately 4mm and 31cm deep, given a soil density of 1600 kg/m^3 [23].

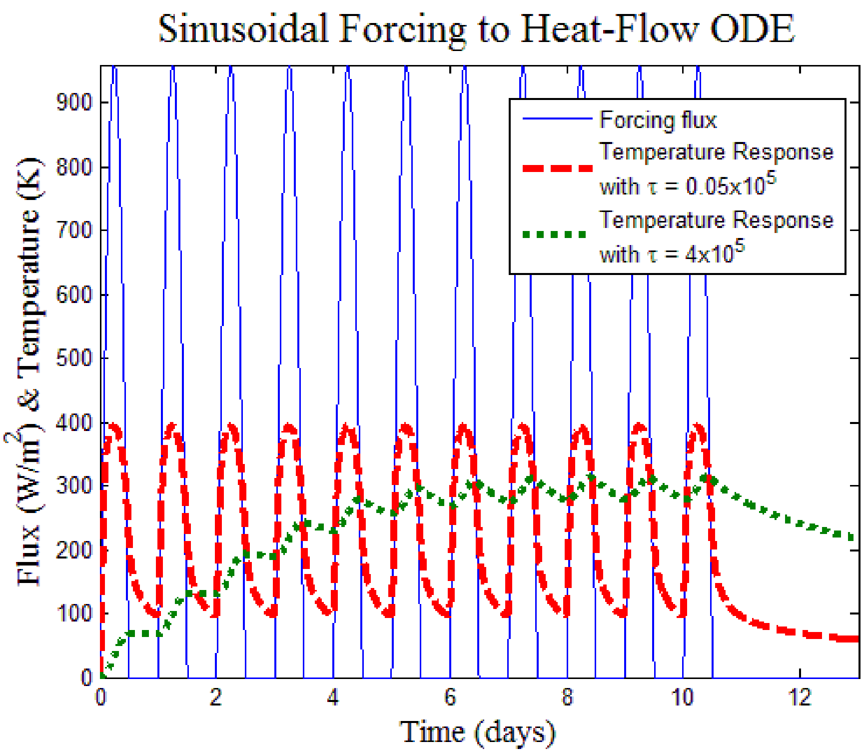


Figure 1: Temperature response in the heat-flow differential equation for two different values of time constant.

If we were modeling a system with constant thermal heat capacity, then it is readily apparent that increased mass equates to a longer lag-time between the peak of the insolation forcing and the peak of the temperature response (the same is true if the thermal capacity is increased). For very small mass, the peak temperature coincides essentially identically with the peak insolation, but as the mass increases, the peak response temperature begins to significantly lag the time of peak insolation. In the example of the plot, the high-mass lag is approximately 4.75 hours. The physical relevance of the fundamental heat-flow equation and Figure 1 is that it provides a direct insight into the cause of the well-known diurnal and seasonal temperature lags to that of the solar insolation. Day-time-high air temperatures are typically observed approximately 3 hours after the solar noon, and the highest summer-time air temperatures are seen approximately 4 weeks after the summer solstice. The physical origin of the lag arises in the fact that the solar insolation is much higher ("hotter") than the near-surface air temperature, and so the air temperature will continue rising, trying to "catch-up" to match the surface temperature generated by the insolation, to achieve thermal equilibrium, until the surface insolation drops back below the surface output in the afternoon. The natural cooling effects of the air due to convection and wind, which is driven by the temperature generated upon the ground, also make it more difficult for the air temperature to come to equilibrium with the surface.

In other words, the inflection points of the thermal response occur when the input and output fluxes cross each other, as seen in Figure 2.

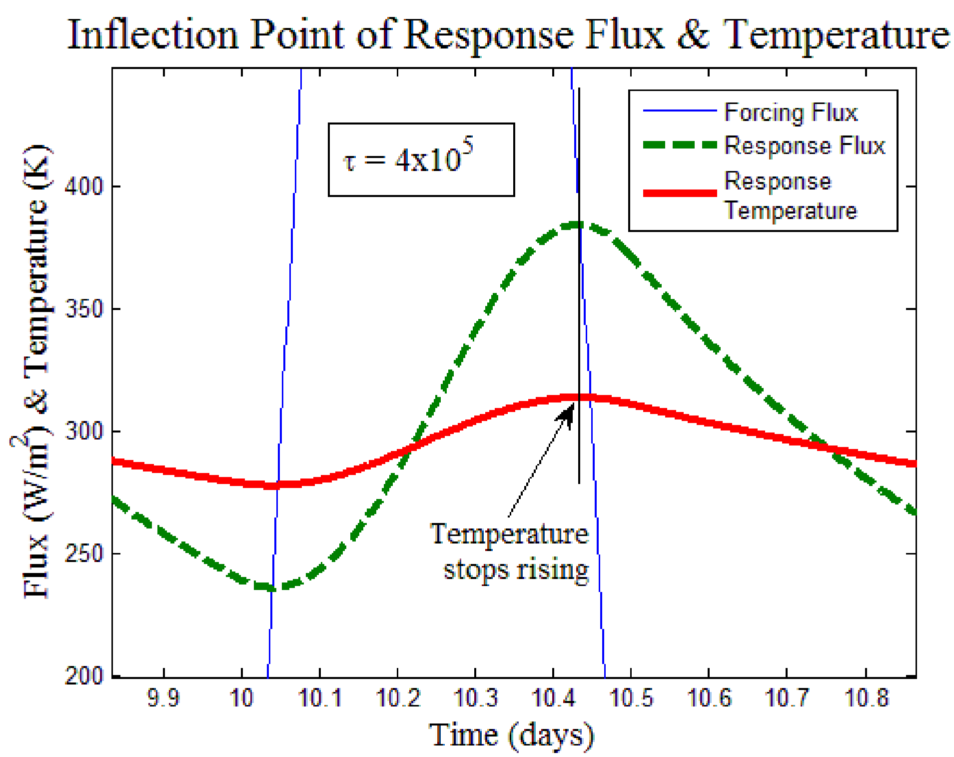


Figure 2: Temperature stops rising when input forcing flux drops below output flux (and vice-versa).

Because the diurnal and seasonal forcing is from the same source (the Sun), but there are two unique lag-times to the forcing (~3 hours and ~4 weeks), this indicates that there are two bulk systems, say a first-order and a second-order, which respond uniquely to said forcing thus giving rise to the daily and seasonal response lags. That is, daily short-wave insolation acts immediately upon the first few millimeters of the ground surface resulting in the large daily rise and fall in temperature with its associated low-mass lag time, but there must also be a much larger system being affected by the lower-order seasonal variation in insolation as well, which necessarily has a much longer time-lag to it. Solar forcing acts directly only on the top few millimeters of surface soil itself (the penetration depth is larger for ocean water and some heating occurs directly in the atmosphere via extinction), and this is where the incoming short wave radiant energy performs work and raises the temperature. This heat energy will then conduct its way down into the subsurface until it merges with the geothermal temperature at a depth of somewhere around, say, 5 to 10 meters and temperature of approximately 5^0C to 10^0C (the author has not been able to find reliable data to reference these values, but, scanning the results of an internet search typically provide shallower depths and significantly higher temperature, so, these values here should be a good conservative estimate), and this much larger thermal-mass system will respond much more slowly, in aggregate, to the solar variation. This low-frequency aggregate response will provide a baseline upon which the daily variations will oscillate at the top few centimeters of surface. There is of course a way to model that, which will be discussed later.

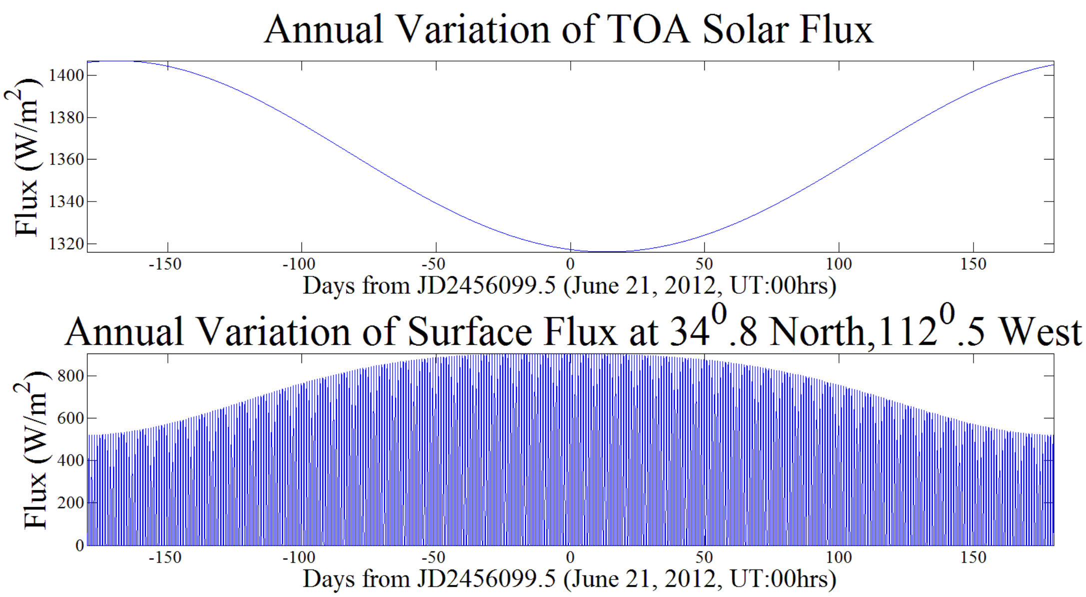


Figure 3: Annual variation of solar flux at TOA and at a Northern Hemisphere location. (Appearance of lower plot is due to Moiré pattern caused by closely-spaced daily cycles, but the annual profile is valid.)

In Figure 3 we plot the annual variation of the solar constant and the associated surface flux for a specified location in the Northern Hemisphere. See Appendix B and C for the Matlab scripts. The plot makes very clear the fact that "summer-time" occurs, for the northern hemisphere, when the planet is furthest from the Sun due to the orbital eccentricity. The annual variation of input flux just from eccentricity alone is about 100 W/m^2, and given the larger area of land surface vs. ocean surface for the Northern Hemisphere, it would be interesting to try to predict what the global climatic response would be when the two curves move into phase with each other as the pole precesses, which of course would be a Milankovitch cycle. By modelling a much larger bulk mass of soil, equivalent to 15625kg or a 9.75m deep square-meter column, we reproduce the seasonal lag time of approximately 30 days, as shown in Figure 4; see Appendix D for the Matlab script.

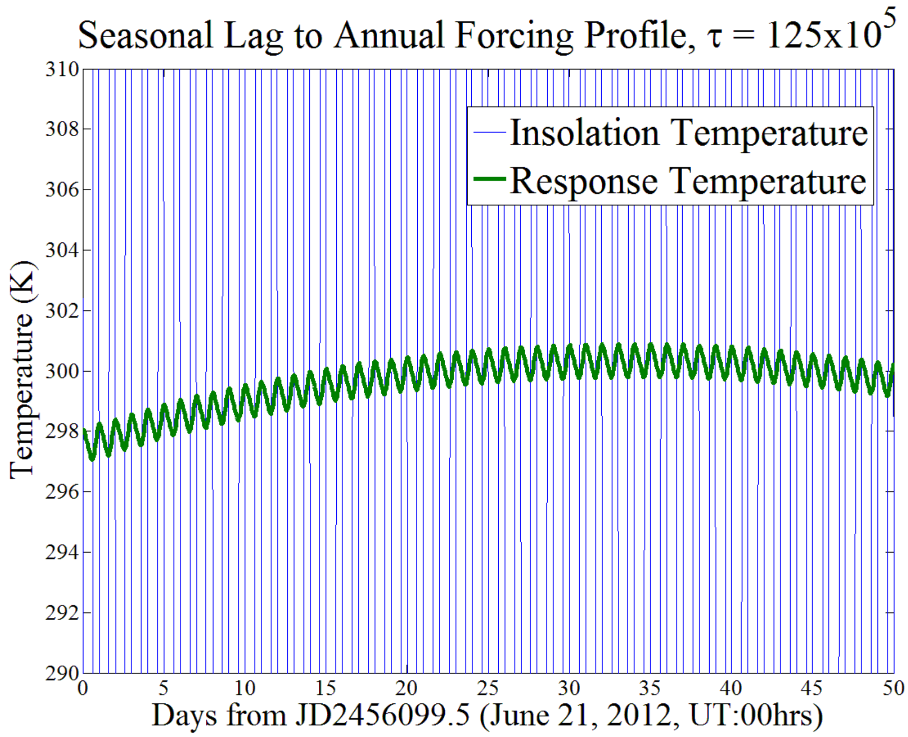


Figure 4: The seasonal temperature lag to the solar insolation. An entire year was run in the model but this plot focuses on the time-frame & scale as indicated.

2.3. The conservation of heat-energy ODE and the greenhouse effect

We note that, in typical treatments of the mechanism and physics of the GHE, "greenhouse warming" is proportional to the surface output flux because some fraction of that flux is absorbed into the atmosphere and then emitted and/or scattered back to the surface, which thus causes further heating. This is the so-called "back-radiation" formulation (see Appendix H for a sample list of quotation references adhering to the back-radiation mechanism of the GHE), and it is functionally distinct from the formulation discussed earlier in this report. So if from Equation (11) $C(t) = \gamma \cdot e \cdot \sigma \cdot T^4$, where γ is the fraction of output flux which is kept from exiting the system and/or returned to the surface thus causing the "greenhouse effect", we can just write

$$\tau \cdot \frac{dT}{dt} = F_{in} + C(t) - (1-\gamma)e \cdot \sigma \cdot T^4 \quad (W/m^2) \tag{15}$$

and where C(t) is no longer a term which can represent the "greenhouse effect", but is kept for generality. In this formulation, the "greenhouse effect" as the gamma term has the same effect as emissivity. However, the bulk of the atmosphere is actually very stable in temperature, so the $(1-\gamma)$ term could be removed and another constant term such as "G_0" could be added to represent "greenhouse effect" heating. While there are functional differences, we will see that it actually doesn't really matter which way we choose to represent the "greenhouse effect" in this analysis, because the physical effect on the resulting temperature profile is topologically similar with whichever parameterization we choose. The exact solution will be informed by real-world empirical data itself. The main point is, we are now modelling the "greenhouse effect" with a physically valid heat-flow equation, based on the standard and widely accepted back-radiation mechanism of heat trapping, as distinct from the formulation discussed at the beginning of this report. So let us just write

$$\tau \cdot \frac{dT}{dt} = F_{in} + G_0 - (1-\gamma)e \cdot \sigma \cdot T^4 \quad (W/m^2) \tag{16}$$

and then we can explore the effects of using either G_0 or γ in a numerical solution to get an idea of how the "greenhouse effect" affects the heat flow balance.

Smith [2] wrote a paper developing a version of Equation (16) as a rebuttal to Gerlich & Tscheuschner's [1] "Falsification of the [GHE]…", and called it "Proof of the Atmospheric Greenhouse Effect". While G&T's paper was certainly much more elaborate, both G&T and Smith suffer from not having actually proved anything at all, other than that they are capable of writing down equations. As any physicist knows, or even a pure mathematician, or any scientist for that matter should, there are a far, far….far greater number of equations to be written down that are wrong, than those that are correct. The ratio is probably infinite…perhaps a mathematician can check. For a physicist, a correct equation is tentatively confirmed by empirical data; one might not need empirical data to creatively develop an equation, but one must, at some point, check with reality to see if the implications of the equation are valid in fact. This is what will be accomplished in this paper. This is an important distinction to make because we read in the U.S. Climate Change Science Program's "Climate Models: An Assessment of Strengths and Limitations" [24] that:

> *"One goal of climate modeling is to decrease empiricism and base models as much as possible on well-established physical principles."*

This is problematic if not outright dangerous. For example, consider the theory of General Relativity: the physical principles which underlie it are very well established. But we also know something is wrong with them, because they're not compatible with the number zero, or quantum mechanics. Or consider aerospace engineering which deals with chaotic nonlinear air-flow problems which are just as difficult as the climate analysis: test pilots have died by the hundreds when the "well-established physical principles" are suddenly and catastrophically found to have been incorrect. We always suffer the possibility that some new insight or measurement or regime of reality will change how we understand some physics. Modeling should *always* be based on empiricism for their ultimate reference, and assumptions should be avoided, especially contestable ones. The question is: What is the desired (n.b., it was stated *as a goal*) limit to the degree of separation between climate models and real-world empirical data? This author would have assumed the desired limit to be zero, but apparently the opposite is the case. This paper will be filling in this gap in relation to the "greenhouse effect".

Appendix E shows the Matlab script for numerically solving Equation (16), and the next two figures display the effect the GHE has on the temperature profiles, relative to if there were no GHE at all.

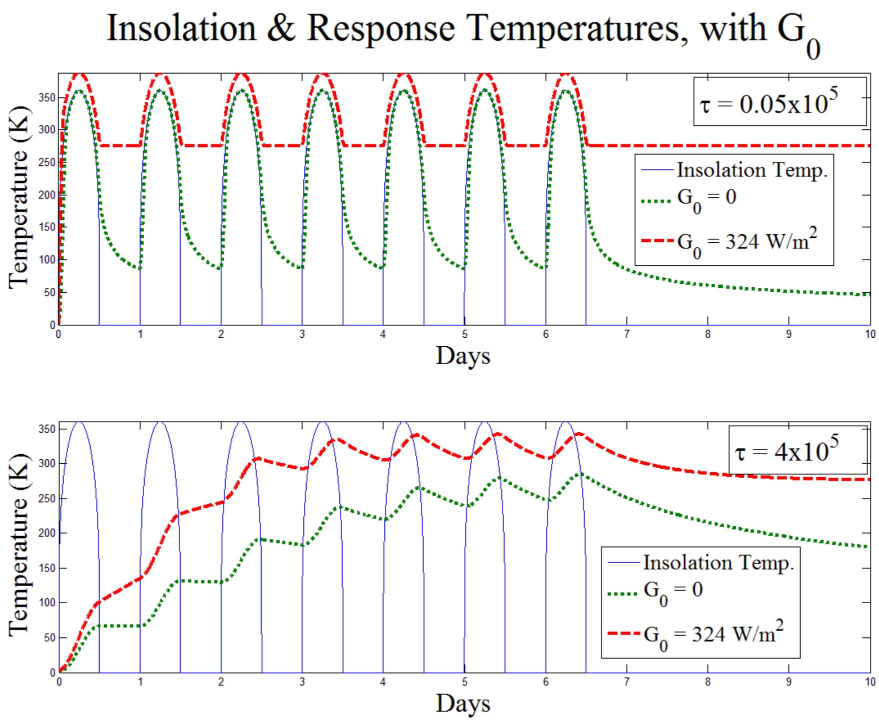


Figure 5: Temperature responses with and without "G_0" term for two values of tau. The value for G_0 is explained in the text.

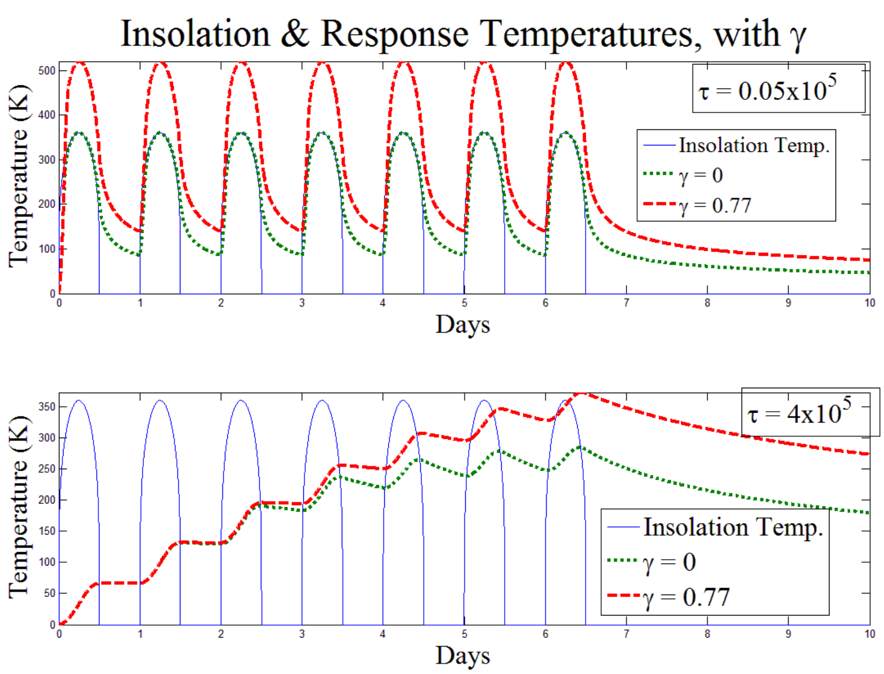


Figure 6: Temperature responses with and without "gamma" term for two values of tau. The value for γ is explained in the text.

In Figure 5 we use the constant-value "G_0" for the back-radiation greenhouse effect term as taken from Kiehl & Trenberth's [25] global mean energy budget. As can be seen for the low-mass scenario, the response temperature always peaks in-phase with the insolation; without a GHE it reaches the same temperature as the insolation, while with a GHE it reaches approximately 30^0C above the peak insolation. For the high-mass scenario, the response temperature with the GHE doesn't quite reach above the insolation, although it certainly would if the back-radiation were larger, but the response with the GHE is approximately 50^0C higher than without and in both cases the peak response is lagged to the peak insolation forcing.

In Figure 6 we have the response behaviour when using "gamma", with the value for that as indicated in Jacob's textbook [26, sxn. 7.3.2] on atmospheric chemistry. Again, for low-mass, the peak response is always in-phase with the insolation, and with a GHE present reaches approximately 150^0C above the peak insolation. For larger mass, the responses are lagged to the insolation and the response with the GHE reaches above the temperature of the forcing. In both of these figures the topological response with a GHE present is similar, and particularly obvious for the low-mass case in that the temperature response exceeds the temperature forcing from insolation; this latter is, of course, the central tenet of the atmospheric greenhouse effect.

3. Discussion of Data and Collection

3.1. Raw data

Carl Brehmer has constructed his own climate monitoring station near Chino Valley, Arizona, at latitude 34.8^0 N, longitude 112.5^0 W, at an elevation of 4701 ft. The setup consists of a homemade Stevenson Screen [27] with an air temperature and humidity data logger (EasyLog model EL-USB-2); a thermocouple for the ground surface attached to a data logger (EasyLog model EL-USB-1); and a pyranometer (Apogee model MP-200) for measuring the solar insolation. The air temperature and humidity logger with the Stevenson Screen was positioned 1.5 meters off of the ground and set to record measurements every thirty minutes starting at 00hrs local time. The thermocouple was placed on top of the soil (described as "sandy soil") in a shade-free area and set to record the specific surface temperature at the same cadence as the air temperature logger. The pyranometer was set to record the solar insolation in Watts per square meter (W/m^2) also at the same cadence. This data set for two sequential cloud-free days on June 21 and 22, 2012, can be found in Appendix F. A plot of the insolation and temperatures is shown in Figure 7.

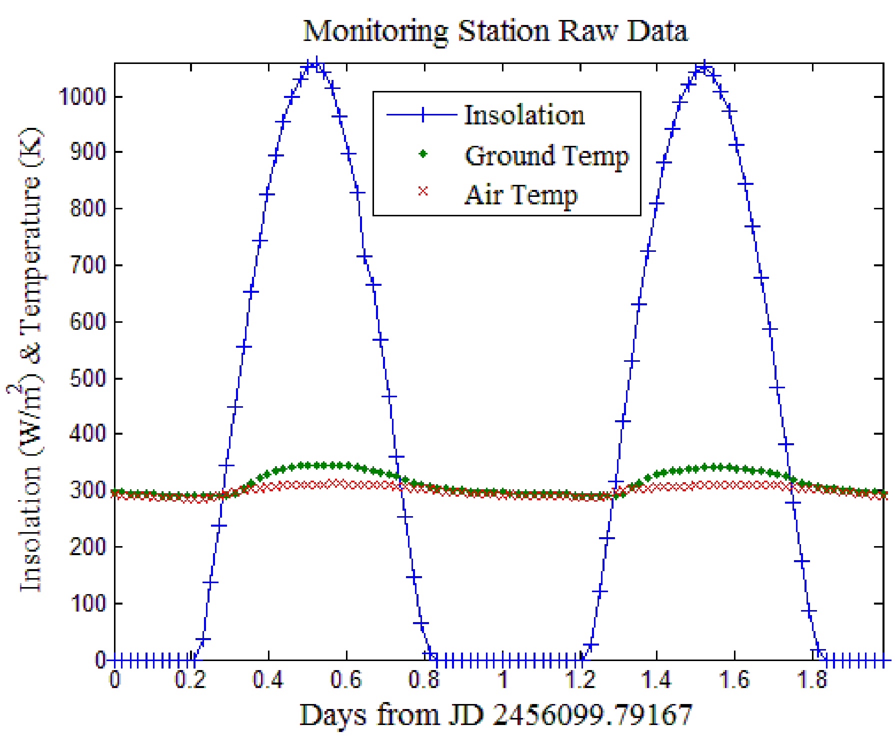


Figure 7: Plot of raw measurement data of insolation and ground and air temperatures. Data analysis is found in a later section.

3.2. Preliminary data analysis

By calculating the raw top-of-atmosphere (TOA) insolation and comparing it to the measured surface insolation, we make an estimate for the degree of atmospheric extinction of the Sun's rays. See Appendix B for the Matlab code for calculating (see The Astronomical Almanac [28]) the local solar altitude, local solar airmass, and the solar distance, and also Appendix C for the short script which calculates the TOA insolation, factored for incidence angle. The measured maximum insolations from day 1 and 2 were 1060 W/m^2 and 1052 W/m^2, respectively, while the calculated TOA flux was 1291 W/m^2 for both days. These values are simply the maximum-point values taken from the measurements, and the TOA calculated values for the matching times; fitting the peak with some curve and finding its maximum would likely yield slightly higher values for all of them, but this would be a very minor percentage change in the subsequent ratio as follows. Averaging the maximum flux values results in an extinction of

$$\varepsilon = 1 - \frac{1060 + 1052}{2 * 1291} = 0.182 \tag{17}$$

or 18.2%. The calculated TOA flux was then linearly scaled down to reflect this value, and the comparison to the measured insolation is seen in Figure 8, below.

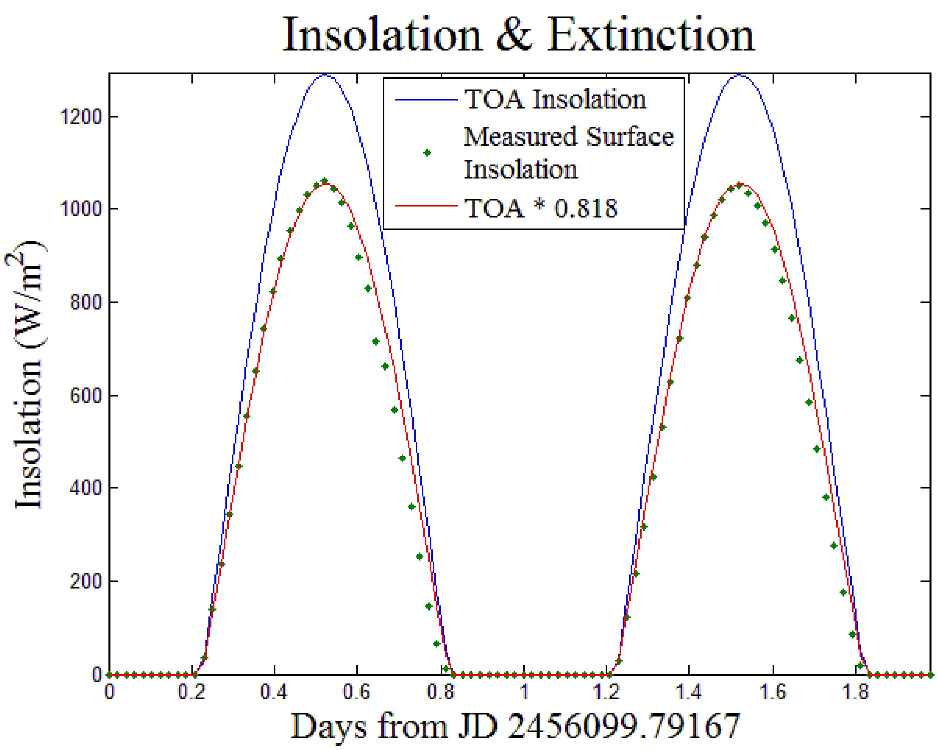


Figure 8: Plot of calculated & measured insolation curves, showing extinction.

Because the calculated flux is simply linearly scaled by the solar-noon extinction value of 81.8% (18.2% extinction), it was surprising to find that there is not more extinction in the morning when the Sun's rays are passing through more airmass to get to the target. The measured curve should fall below the linearly-scaled calculated curve in the morning due to the dependence of extinction on airmass; see "Challenges of Astronomy", Chapter 19, for example [29]. This does happen in the afternoon; however, the extinction there appears constant, not differential with airmass. Asymmetric differential extinction about the solar zenith is likely due to the increased opacity of the atmosphere from morning-convection currents which have "polluted" the air with dust particles and aerosols by the time the afternoon sets in.

In regards to the general lack of signal for airmass-dependant extinction, we postulated that such a signal is countered by the solar short-wave illumination provided by scattering from all the other paths not along the line of sight from the observer to the source. See "Challenges" [29] Figure 19.10, for example. Of course, this is not a consideration which would be taken in general observational astronomy. That is, the daytime clear sky is blue because short wave solar insolation is being scattered towards the observer from all angles, and this illumination begins significantly before direct insolation actually begins when the Sun rises proper. This short-wave insolation will register on a solar pyrometer just as readily as the "direct" insolation, since the wavelengths are commensurate. Carl Brehmer tested this hypothesis by blocking the direct solar insolation to the pyrometer with his hand at a distance, putting the pyrometer in the shadow of direct sunlight but still able to register the rest of the blue sky. The pyranometer still registered approximately 75 W/m^2. The sky appears blue, therefore that short-wave radiation is making it to the surface. And because it is making it to the surface, it will also be absorbed there. While real-time empirical data of the scattered short-wave intensity would be an interesting study, it is also likely calculable to some extent in theory, but we leave this exercise to some astronomer.

In "Photospheres" [7] (pg. 96), Gray explains that total extinction is the result of two separate processes: 1) absorption of the photon along the line of sight, where its energy actually becomes thermalized; and 2) scattering of the photon to vectors outside of the line of sight and thus not thermalized. Gray was speaking in reference to stellar atmospheres but the same physics holds for the terrestrial atmosphere. In the first case we find the example of the telluric absorption spectrum of solar insolation due mainly to water vapour where direct heating of the vapour does occur, while the second case is responsible for the colour of the blue sky, i.e. Rayleigh Scattering, which does not cause direct heat generation in the atmosphere. Rayleigh scattering is not known to contribute to an absorption spectrum, but molecular or atomic scattering may do so and without thermalization. In [8] and [9] calculations were made for the heating effect due to extinction, but it was not clear if scattering is considered a heating effect within the atmosphere (which it should not be).

If we wish to know how much heating is developed by the insolation, so that we can differentiate that from how much heat is caused by the greenhouse effect, we must have a measurement of the surface albedo where the temperature is being monitored. Carl Brehmer measured the surface reflectivity over 12 hours on June 13, 2012, by turning the pyranometer upside-down and registering the value of reflected short-wave radiation; the results can be found in Appendix G, and are plotted in Figure 9 and Figure 10, and the measurements have an average value of $\alpha \cong 0.26$.

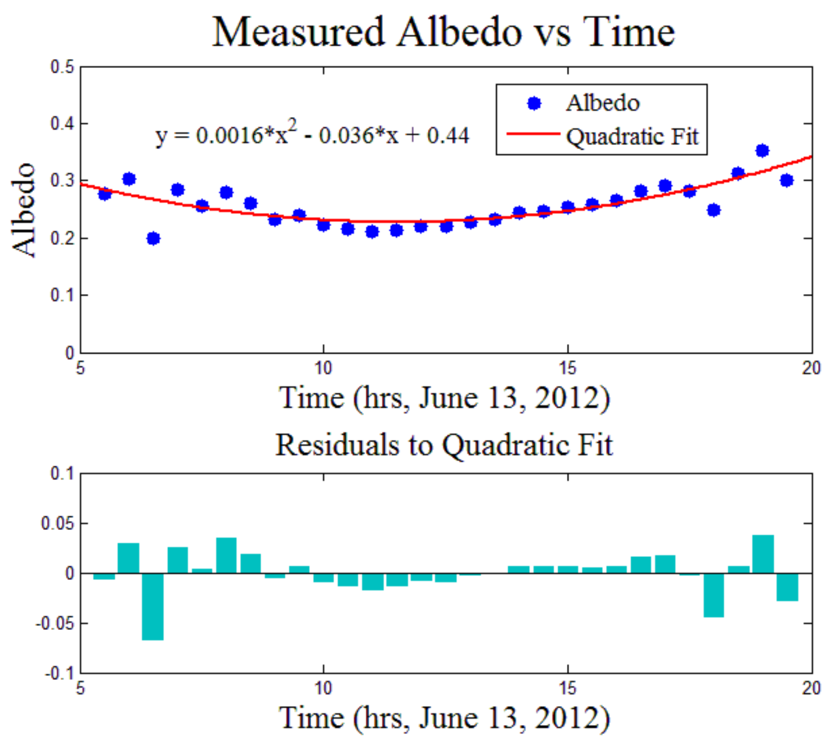


Figure 9: Plot of albedo over the course of one day. Percentage measurement error become large when the insolation is very small.

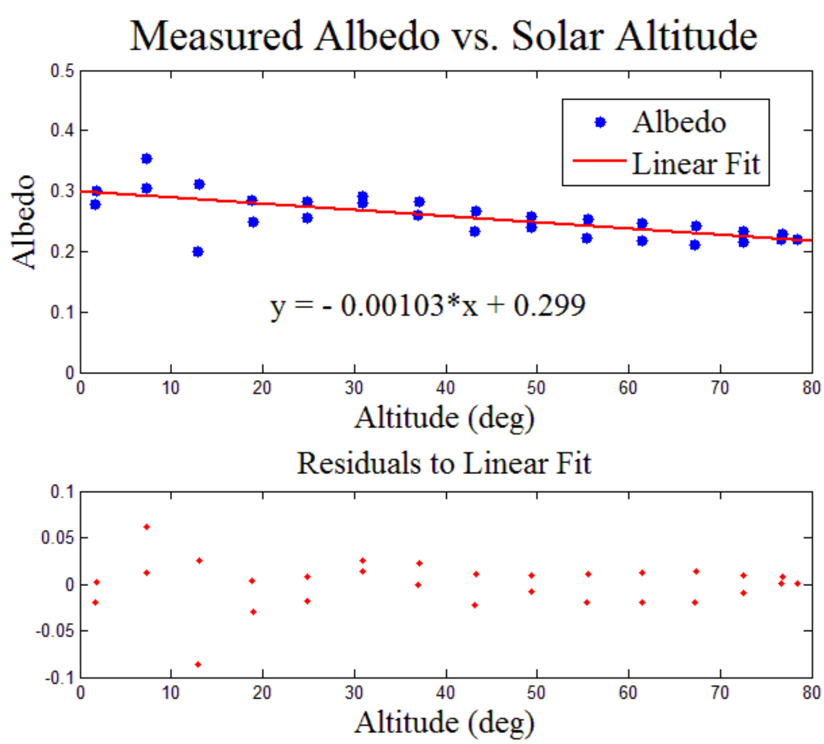


Figure 10: Plot of albedo vs. Solar altitude angle.

3.3. Comparison of the postulate of the "greenhouse effect" to empirical data

Whether the radiation is short-wave solar insolation or long-wave atmospheric emission, both are absorbed directly at the solid surface of the ground, aside from that portion lost to albedo. That is, heat is generated by the action of absorbed radiation directly at the surface, within the first few millimeters or so of soil, as radiation obviously does not penetrate any further than this. The primary source for heating insolation is from the Sun, but under the context of the GHE there is an additional active heating component added by atmospheric radiation. (In fact, in K&T's energy budget diagram [25], atmospheric radiation is approximately twice as strong as solar radiation which therefore makes the atmosphere responsible for the majority of the temperature at the surface.) The depth of soil in which radiative energy converts to heat constitutes a very small amount of mass and so the temperature generated directly at the surface should not lag nor fall significantly below the temperature of the insolation forcing. The near-surface air and deeper subsurface soil then responds to that. As we have seen, the basic mechanism of the greenhouse effect is to add additional radiation to the forcing balance, thus driving a higher temperature to be achieved than just from solar insolation alone. This is expressed in Equation (16), by Smith [2], K&T [25], etc., and in the sample list of references found in Appendix H. Our surface thermocouple was attached directly to the ground surface and measured the rise and fall in its temperature throughout the day; if the greenhouse effect is present and the sky clear so that there are no confounding factors from clouds etc. - all you have is the pure insolation and straight greenhouse effect - then the temperature generated upon the surface *has* to rise above that provided by solar insolation alone, otherwise we lose the basis for the "greenhouse effect" postulate in the first place. In the next section we discuss an even easier way to test for this, but see Figure 11 below.

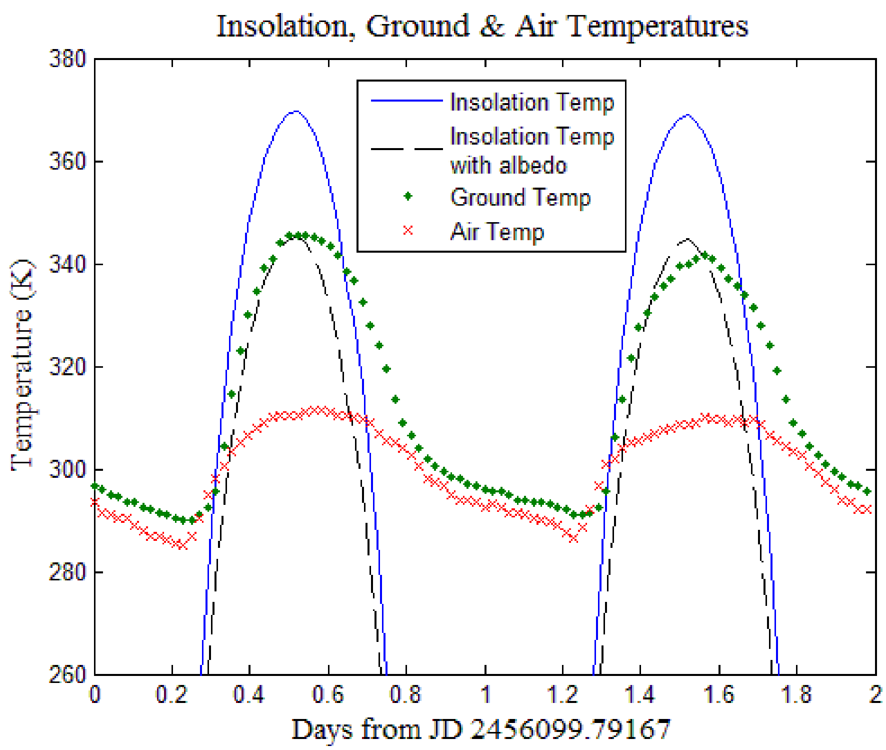


Figure 11: No "greenhouse effect" is observed in empirical data.

In Figure 11, we have taken the measured solar insolation values and converted them to their temperature-forcing value (factored for albedo), and plotted that against the ground temperature and air temperature. As can be seen, the ground temperature does not exceed the temperature of the solar insolation. This is impossible given the conditions of Equation (16) with either formulation of the "greenhouse effect" heating term, and the various references we have seen supporting the postulate, because the peak temperature response coincides with the peak insolation (on day one), which confirms that a very small mass is instantaneously responding to the insolation forcing. Another test can be performed in this regard and is discussed in the next section. Day two is interesting in that it shows how the surface temperature will drop only after the solar forcing temperature drops below it. This is an easily-reproducible experiment (and see the next section) who's equipment requirements are inexpensive, and we ask for it to be confirmed. It would be a good experiment for senior high-school level and undergraduate physics, going forward. Why not demonstrate the validity (or lack thereof) of the greenhouse effect ODE to undergraduate physicists learning ODE's for the first time, and the rules of thermodynamics?

Although the amount of mass a few millimeters deep, where radiative forcing is converted into thermal energy, represents a very small "tau" value, and this mass responds essentially instantly to the forcing, we would not expect said surface to rapidly drop in temperature with removal of the solar forcing. This first layer of soil is in contact with the soil beneath it (and with the atmosphere as well). Carl Brehmer has more recently investigated the variation in temperature of the soil going down to a depth of one meter, and at that depth (84 cm to be precise) the soil temperature averaged 25^0C (as of August 28, 2012) and had a diurnal range of only 0.11^0C. Reports of similar values can easily be found by an internet search. Clearly, a very large amount of thermal energy is efficiently stored in subsoil and at a relatively very high temperature, and this energy will conduct to the surface and keep it from cooling as fast as it might without it; while not a GHE in the usual parlance, this is still clearly an effect that will keep the average temperature at the very surface warmer than it would be otherwise. This occurs because the top surface does drop below the temperature of the subsoil overnight, and then the deeper heat does the natural thing and transfers to the cooler surface, thus keeping the surface warmer.

In fact, another alternative description of the GHE that can be argued is that the atmosphere keeps the surface from cooling overnight as much as it might with without it…a so-called insulating effect which results in a higher diurnal average (see Appendix I for quotation references). While the atmosphere is generally actually cooler than the ground, as can be seen in the previous figure, and humans build physical greenhouses to prevent the open-atmosphere's natural cooling effects, and for which we expect the direction of heat transfer to be from the surface to the atmosphere, nevertheless it might be argued that the heat transfer is said to be slowed because of back-radiation from the atmosphere, and therefore the diurnal average surface-air temperature is warmer than otherwise, compared to if there were just conductive transfer alone. However, the mass of a one-square meter column of air is about 10,000kg, and if it has an average temperature of 255K, has a total energy content of about 10000kg*255K*1006J/kg/K = 2.56×10^9 J. With a TOA output around 240 W/m^2, the column will lose 10.4MJ of heat overnight, which would correspond to an aggregate temperature reduction of 0.4% or 1^0C. As can be seen from real-world data, the ground surface and near-surface-air drop in temperature by about ten-times that amount overnight, which means that most of the cooling of the column actually occurs at the surface, and thus cooling there is actually enhanced relative to the rest of the column, rather than impeded.

One option for describing and modelling the entire thermal situation of the column, starting from a soil depth at which the annual temperature variation is arbitrarily small (i.e. effectively an infinite heat sink at constant temperature), passing through the surface, and extending up to, say, the top of the troposphere where the temperature is again constant, and based on standard heat-flow mechanics with energy conservation, is the extension of the one-dimensional (i.e., time) word equation found earlier in this report into the space dimension. Such is what the entire rest of the cited textbook is about, and we leave in-depth discussion of this for future work. However, the basic equation is [20, pg. 8]

$$c\rho\frac{\partial u}{\partial t}=\frac{\partial}{\partial x}\left(K_0\frac{\partial u}{\partial x}\right)+Q \tag{18}$$

where we find all the familiar terms: 'c ' is the specific heat capacity per unit mass; 'ρ' is the mass density per unit volume; 'u ' is temperature, 'K_0' is the thermal conductivity, 't ' is the time dependence and 'x ' for space, and 'Q' is the heat input term but in general you may add on whatever heating and cooling terms you wish. In a general application the thermal coefficients can all be functions of space and time and obviously the heat input will be as well. This equation would allow for full quantification of the surface-heat "insulating effect" caused by the significant temperature of the subsoil, for example. As we have discussed, subsoil efficiently retains significant temperature and thermal energy and this is because of its high specific heat capacity and high mass density. However, in terms of the specific surface itself where heat is actually generated by insolation, the time-dimensional conservation equation we have discussed in this report is sufficient for describing whether or not atmospheric backradiation causes additional heating on top of the solar contribution.

3.4. The back-radiation/glass greenhouse justification for the GHE

Please see Appendix H for a sample list of quotation references adhering to the back-radiation mechanism of the GHE. All the references and quotations therein conform to the "back-radiation model" of the GHE, which is based on a comparison with actual greenhouses made of glass. The problem is that this well-known comparison is incorrect. Like anything else, the interior surfaces of a greenhouse warm up by absorbing sunlight. But what the glass enclosure then does is trap the surface-heated air, acting as a physically rigid barrier to convective heat dissipation. This is why a greenhouse gets warmer than the outside air. This fact can be verified by alternately opening two small panels of the greenhouse: first, open a wall panel at ground level. No significant temperature decrease will be observed. Next, open a roof panel; the temperature will drop noticeably and quickly.

Now, if trapped radiation were involved, radiation would escape equally well from either the base or the top when an escape hatch appears. The fact that the greenhouse only cools when a roof panel is opened indicates that the increased warmth comes about only because heated air has been trapped. Thus, the premise that radiation-trapping in the atmosphere is analogous to radiation-trapping in a real greenhouse, is unsound. Yet this analogy is consistently used to justify an atmospheric form of the GHE. Although the glass in a real greenhouse does not cause additional warming by trapping radiation, we are told that trace gases do perform this task - by virtue of a comparison to something that does not actually occur! Greenhouses were invented by human beings to protect a pocket of air against the cooling forces in the atmosphere; i.e., they do the opposite thing that the atmosphere actually does, so to compare the atmosphere to a physical greenhouse is unsound. We are not without remit to state that this line of justification or reasoning is obfuscatory at best, or outright fraudulent at worst.

If back-radiation augments the warming that sunlight provides, as alleged in the references and quotations in Appendix H and by the heat-flow equation developed earlier in this report, then the atmospheric GHE should be able to generate higher temperature than real-time insolation can provide, even at its maximum. To this author's knowledge, however, this has never been demonstrated for a greenhouse, let alone the actual atmosphere.

An easier way to test for back-radiation enhanced heating is to use a simple sheet of black construction paper or "Bristol board". Its albedo could be measured using the same technique Carl

Brehmer used to measure that for his ground surface. Simply place the sheet flat and horizontal on the surface (a stack of sheets would help insulate against the surface contact, or perhaps the sheet could be suspended in the air only with atmosphere around it blocked for wind), and measure its temperature with a calibrated surface thermocouple throughout a clear sunny day. With a negligible mass, insolative forcing will be instantaneous, and the heating contribution from GHE backradiation from the atmosphere should clearly force the temperature response of the sheet to be much warmer than what the solar insolation readings alone suggest.

Care might need to be made for the emissivity of the paper. Emissivity represents a surface's "inability" to radiate as fully as a blackbody would at a given temperature and at specific wavelengths. Kirchhoff's Law states that emissivity and absorptivity will be equal at the same wavelengths when an object is in thermal equilibrium; however, this is not practically always the case because absorption and emission generally occur at different wavelengths. For example, these ESA tables [30 (http://www.tak2000.com/data/Satellite_TC.pdf)] show that when the absorptivity-to-emissivity ratio is low, that higher temperatures than the radiative forcing will result. This is not a GHE from backradiation or insulation, but is due to a surface's inability to radiate. It could be said the atmospheric GHE is similarly caused by GHG's which prevent the ground surface from radiating directly out into space, causing a pseudo-emissivity effect; however, the same result should then be seen that a higher temperature than the solar insolation is achieved; of course as we have seen it is not, and so it would be incorrect to say that.

It might also be argued that a sensible-cooling term in the equation and in reality in the form of $C(t) = -k \cdot (T_{Surf} - T_{Atm})$ is what prevents the GHE from being observed. However, that would require that the cooling term to be conveniently always exactly equal to the GHE term for every single location and for all time, which is a dubious position. So, just shield the paper/board from wind at the sides, and see if the backradiation from the atmosphere adds with the real-time insolation and induces a higher maximum temperature than just the insolation alone is expected to produce…the effect should be instantaneous due to the tiny time-constant of the system.

With the sensible-transfer term, Equation (16) becomes

$$\tau \cdot \frac{dT}{dt} = F_{in} + G_0 - (1-\gamma)e \cdot \sigma \cdot T^4 - k(T_{Surf} - T_{Atm}) \quad (W/m^2) \tag{19}$$

where the sensible term is negatory when the surface is warmer than the atmosphere, and vice-versa. For Carl Brehmer's stations' location, the ground surface is almost always warmer than the atmosphere and so the term is almost always a cooling one. Now, it is interesting to note that physics has never considered a back-heating term from back-conduction, in that the heat from the atmosphere, being of a cooler temperature but having been gained from the surface originally, is never thought to sensibly return to the surface again and thus further increase its temperature, or alternatively, to cause an increase in temperature due to the "conductive resistance" from the atmosphere. This is only a scheme that adherents of the GHE seem to propose for radiation when they suggest that back-radiative heating, or alternatively sometimes called back-radiative resistance, does cause such a temperature increase, with their necessary justification being postulated that radiation doesn't need to follow the Laws of Thermodynamics in the same way we expect of sensible transfer. This is of course rather doubtful.

4. The Sun and Global Energy

4.1. The sun heats the Earth?

Is it possible that the Sun can heat the Earth all by itself, or does the atmosphere provide twice as much heating energy as the Sun provides as per the K&T "Global Energy Budget" [25] as supported by the IPCC and believed by all supporters of the GHE? The nonlinear ordinary differential equation of heat flow with conservation of energy should be able to provide a theoretical answer to the question, and we can attempt this by modelling something representative of the terrestrial system. The planet is covered by approximately 70% ocean water, so let us model an actual square meter of ocean water of various mass and explore the results. Appendix J shows the Matlab script for simulating solar heating upon H_2O starting from a solid block of ice at -100^{0}C. The specific heat capacity of H_2O is a function of temperature, but data for ice [31] was found only down to -100^{0}C; data for liquid H_2O is found here [32] and the latent heat of melting is 334,000 J/kg. (Most H_2O on this planet would not have started off as ice, but we can model from that point in any case.)

For large mass (greater than 100 kg), the equilibrium response temperature was found to asymptote at 13.4^{0}C and at 1000 kg has a negligible diurnal variation. However, a very interesting consequence was found due to the presence of latent heat for smaller masses: at less than 100kg, H_2O is held at higher average temperatures than compared to if no latent heat plateau were present. The maximum of this effect is found near 17kg and is +16.2^{0}C in effect (Figure 12 and Figure 13), resulting in a diurnal average at +1.8^{0}C as opposed to -14.4^{0}C; at 25kg the effect is +14^{0}C giving a diurnal average of +10^{0}C as opposed to -4^{0}C (Appendix K). In Figure 14 we plot a comparison of the heating and cooling profiles over a period of five days with and without inclusion of the latent heat plateau; the effect of the latent heat phase is to reduce the maximum and minimum temperatures. This represents a clear negative feedback to temperature change, but it is a feedback which has a net-positive aggregate response because it "pins" the temperature oscillation about a higher average. Figure 15 shows the response function for large mass.

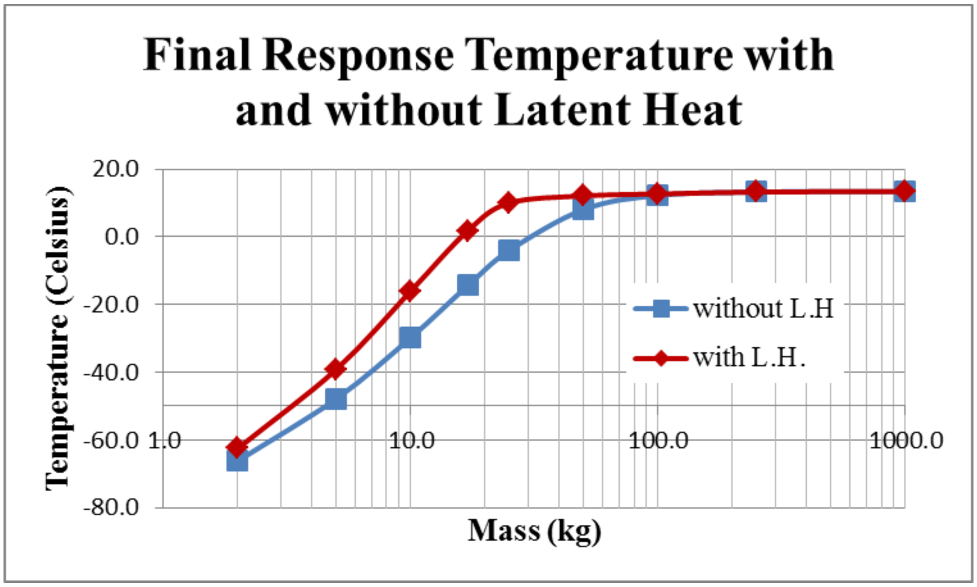


Figure 12: Final equilibrium temperature with and without latent heat.

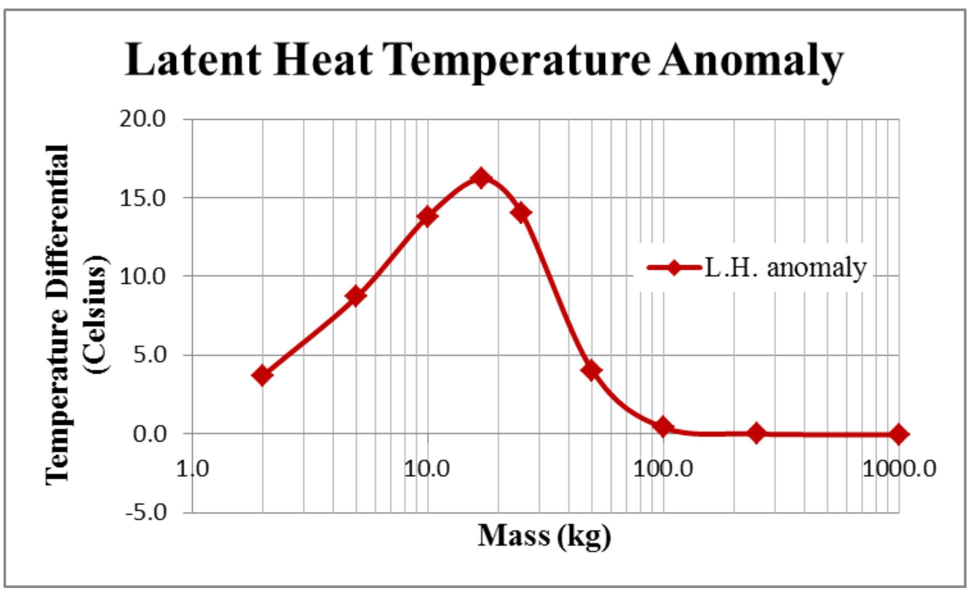


Figure 13: Difference between equilibrium temperatures with and without latent heat.

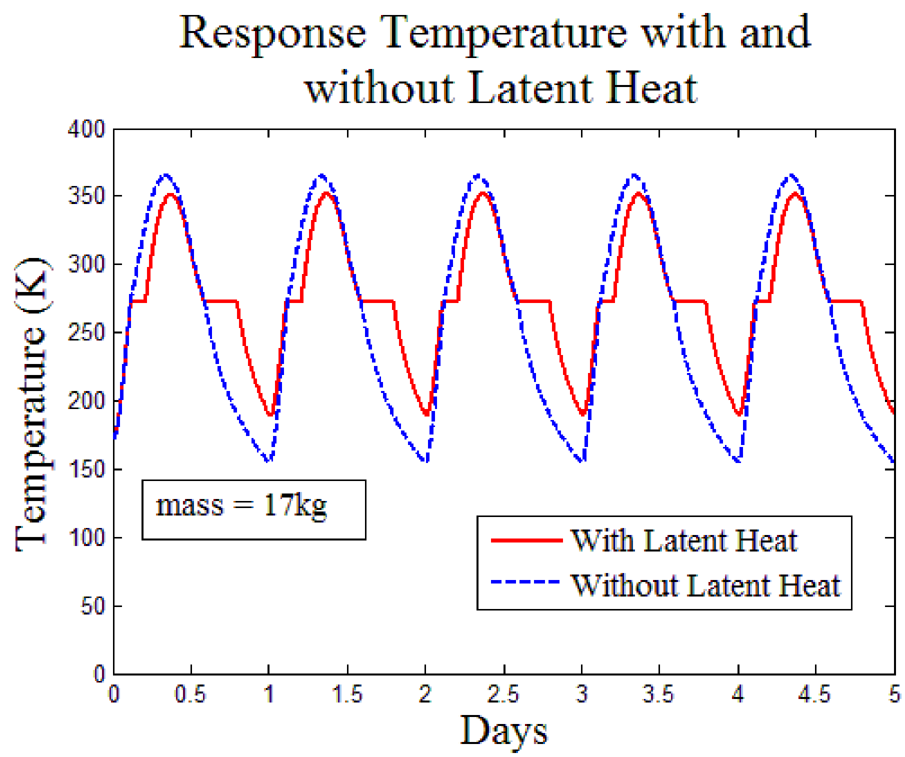


Figure 14: Example of heating and cooling profiles with and without latent heat.

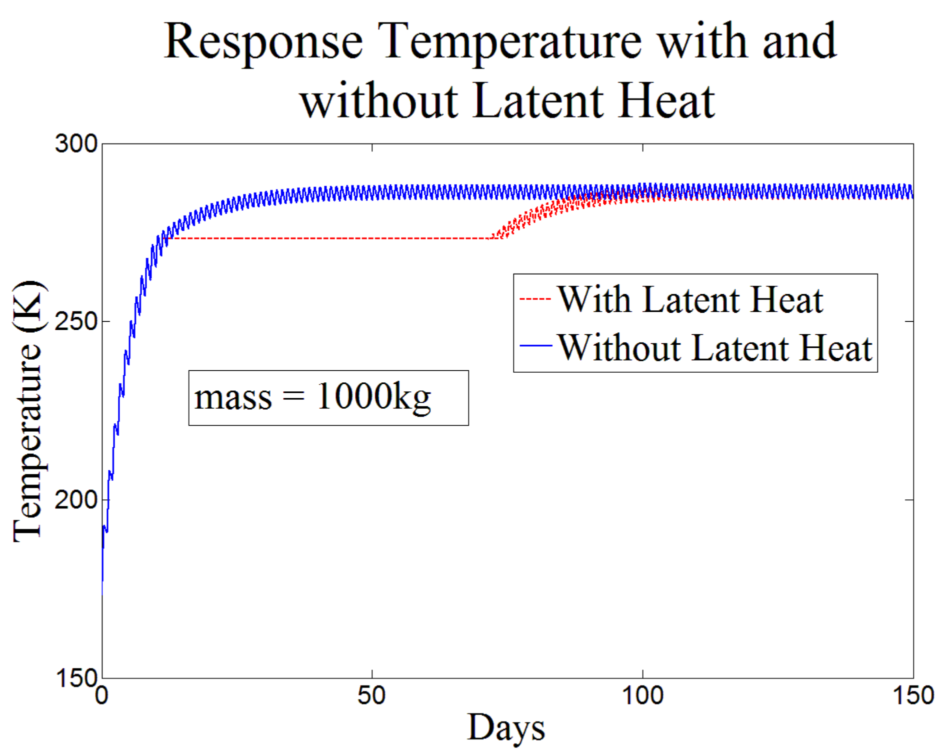


Figure 15: Temperature response curves for large mass.

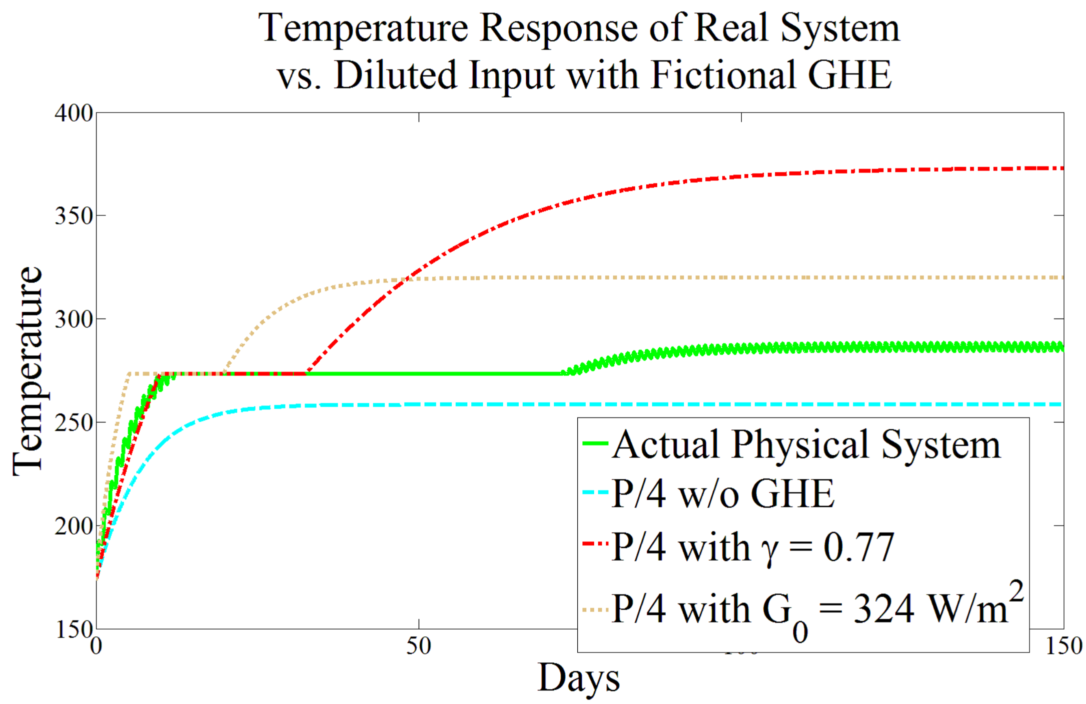


Figure 16: Comparison of temperature response curves between a physically realistic system and three fictional systems based on the IPCC framework for climate science.

In Figure 16 above we plot a comparison of the temperature response functions for several considerations of a system. The first curve in the legend is a repeat as that from the previous figure, where an actual cubic meter of ice is heated by a physically-realistically modeled solar input. The second curve in the legend shows the response when a constant input of 240 W/m^2 is used. This relates to the so-called "P/4 issue" where the usual approach of climate science is to average the solar input over the entire globe rather than model the actual input in real-time. This author has written on the problems we can expect of this approach previously [33] [34] [35]. In a physical dynamic system with discontinuities, you cannot dilute the real-time power into an average power and expect the same physical response. For getting some mathematical average, fine, but you must be very careful about how you interpret that number; i.e., that number should no longer be thought of as an input, but only as an output, and this is not a trivial or unphysical distinction, as discussed in the previous two references. The physical system has a non-linear discontinuity at 0^{0}C where energy disappears without causing an increase in temperature. It takes energy of a specific power to overcome this physical discontinuity, this barrier. The density of radiant energy of 240 W/m^2, or -18^{0}C, cannot overcome this discontinuity, let alone approach it. But a physically realistic and real-time power density, varying as a sinusoid, *can* overcome that discontinuity. Once you are over it, you now have the opposite problem. When you are underneath the required power density, the problem is getting over the barrier; when you overcome that barrier because you naturally have the input power to do so, the problem then becomes getting back beneath that barrier because the system can keep radiating energy without decreasing in temperature below 0^0C, because of the hidden energy of latent heat. And then the sun returns and reheats the system before too much cooling takes place. The point being, if you model the input with a diluted and unrealistically cold power density, *of course* the result is that you need to invent a mechanism to self-amplify the input, in order to save the appearances of that initial assumption.

Solar heating on the ocean extends to about 200m in depth, and the Pacific and Atlantic circulation patterns are parallel with the equator for most of their width [36], allowing lots of time to absorb the relevant amount of solar energy. When continental obstacles get in the way, the circulation patterns divert north or south and eventually run through the polar regions and then back again to the equator. The amount of internal heat of a 1kg block of ice at 13^0C is approximately 600,000 J (evaluated by numerically solving the H_2O problem with temperature-dependant specific heat and the latent heat plateau) with about half of that being latent heat. And so 200m deep of a 1 square meter column is about 120 GJ of thermal energy. Given an equatorial average solar input to the ocean of approximately 31 MJ per day for a square meter under the solar zenith, this column of water holds about 3,871 days or 10.5 years' worth of solar heating. Given that, relative to the scale of a square meter, the hemispherical surface is approximately flat for several million square kilometers under the solar zenith (and one square kilometer = one million square meters), there is clearly a tremendous amount of stored solar energy in this system which will take from centuries to many millennia to cool as equatorial water sheds its heat in the north and south as it circulates through. If you take the entire mass of ocean at $1.4x10^{21}$ kg, and if most of it is liquid, and the latent heat of fusion of ice is 334,000 J/kg, then this is $4.67x10^{26}$ J of stored "hidden" energy. Given that the global absorbed solar insolation is $1x10^{22}$ J per day, that's about 121 years' worth of solar energy stored in the latent heat. The latent heat component being on the order of half of the total energy for water at 13^0C, means that there will be a significant barrier to cooling below 0^0C as the current circulates through the poles, keeping these regions much warmer than they would otherwise be. This of course will skew-high the characterization of the average global surface temperature and thus provide an "interpreted appearance" of a GHE when there actually is none.

4.2. The significance of latent heat

In addition to the tremendous amount of energy stored in latent heat in liquid water, we can return to the beginning of this report and calculate the total latent heat of vaporization stored in a square meter column of atmosphere. Given that the mass of water vapour in a cubic meter at the surface is, on average, 0.01764 kg, and this decreases to zero in increments of 0.01764/10000 to 10,000 meters, the total mass of water vapour in the column is roughly 88 kg. Water vapour has a latent heat of vaporization of 2,257,000 J/kg, and so this column of atmosphere has 198 MJ of stored "hidden" energy, which is about 6.4 days' worth of solar input for a square meter under the zenith. Given the total surface area of the Earth is 5.1×10^{14} square meters, the global latent heat of vaporization stored in the atmosphere would be about ten days' worth of global solar input. In terms of thermal physics, heat is simply *held* within the very large mass and specific heat capacity of the system; the only place you might correctly think of heat energy being "trapped" is within latent heat. It is only within latent heat where heat energy disappears without causing a change in temperature, and from which heat energy can be spontaneously shared and also emitted without a decrease in temperature. Only latent heat actually traps energy. The rest of the systems only hold heat as a simple function of their mass and thermal capacity, and this energy is free to be emitted, while latent heat will only be emitted at the relevant phase change if the temperature is low enough, at which point this energy prevents further decrease in temperature.

In Figure 3.16 of "Fundamentals of Physical Geography" [37], we see an energy budget plot presenting the point of "Zero-Energy Balance" (ZEB) which is the latitude where the average incoming and outgoing radiant energies are actually equal; the plot has been copied in Figure 17 below. Effectively, what we see is input radiant energy "going missing" in the equatorial regions, and then, energy "appearing from nowhere" in the polar regions. It is highly likely and you can probably assume that this dearth and excess of energy balance each other out perfectly over the long run. The problem is that you need a mechanism for transporting that energy from the equator to the poles without showing up as actual temperature radiation until it is required. If there was ever a concept that needed to be invented to help us out, nature has created one to fit the bill for us in latent heat. What could be more efficient? Both the oceans and atmosphere circulate to the polar regions and bring with them an enormous amount of stored solar energy collected from the equatorial region.

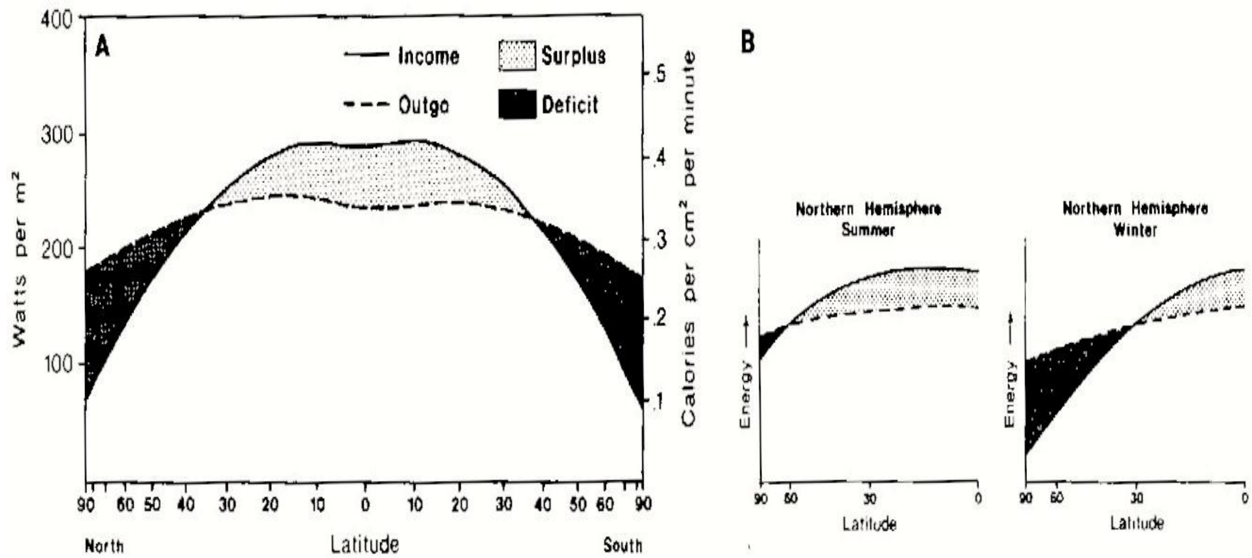


Figure 3.16 (a) Mean latitudinal distribution of the earth's radiation. Note the points of balance where the lines cross, that is, where incoming and outgoing radiation are equal. This is known as the point of zero balance. (b) The point of energy balance for summer and winter in the northern hemisphere. The point moves with the seasonal migration of the sun and is generally coincident with the Arctic Front

Figure 17: Zero-Energy-Balance plot from Briggs, Smithson, and Ball [37] showing the energy balance between the equator and the poles. Copied with permission.

If we return to the example of modelling 1000 kg of water, and, after it has achieved thermal equilibrium on about day 125, let it cool either with or without latent heat, then by the time the latent "barrier" is breached to below 0^0C on the model run which includes it, the one which did not include it is 88 Kelvin degrees *lower* in temperature.

4.3. A global energy budget

In the K&T Energy Budget [25], the atmosphere provides twice as much heating power as the Sun. Essentially, the energy input and output sequence in such a flat-earth model is as follows:

1) The Sun heats the Earth uniformly and globally
2) The atmosphere gets heated by the surface
3) The atmosphere then heats the surface some more even though it is colder than the surface
4) The surface then heats the atmosphere some more
5) Energy leaves the Earth at the same rate it comes in

The above points 3 and 4 are obviously in violation of the laws of thermodynamics, but this scheme is forced into existence due to the set-up for point number one, where the input power of Sunshine is diluted to only -18^{0}C to satisfy the assumption a flat Earth receiving global illumination, rather than a realistic hemispherical projection over a globe with day and night. The actual sequence of energy input and output is as follows:

1) The Sun heats the Earth non-uniformly over a hemisphere continuously
2) The system & atmosphere reacts to this heating, producing the climate
3) Energy leaves the Earth, the same amount leaving over two hemispheres what comes in over a single hemisphere

Only the model presented in Figure 6, pg. 34, of [34], represents this reality and is amenable to differential calculus for real-time characterization. The model is reproduced below with updates for the integrated average power of Sunlight (vs. the linearly averaged power in [34]), and a modification to the cooling profile to reflect the hidden latent heat energy retention; see Figure 18 below. There are certainly many improvements which can be made on this model, but the fundamental point is to use a graphical model to represent something of the reality of the system, and the scientist's mind should automatically be queued towards differential calculus as the correct approach to assessing heat-flows in the system, rather than flat-earth "physics" which by the necessity of its fiction must violate the Laws of Thermodynamics.

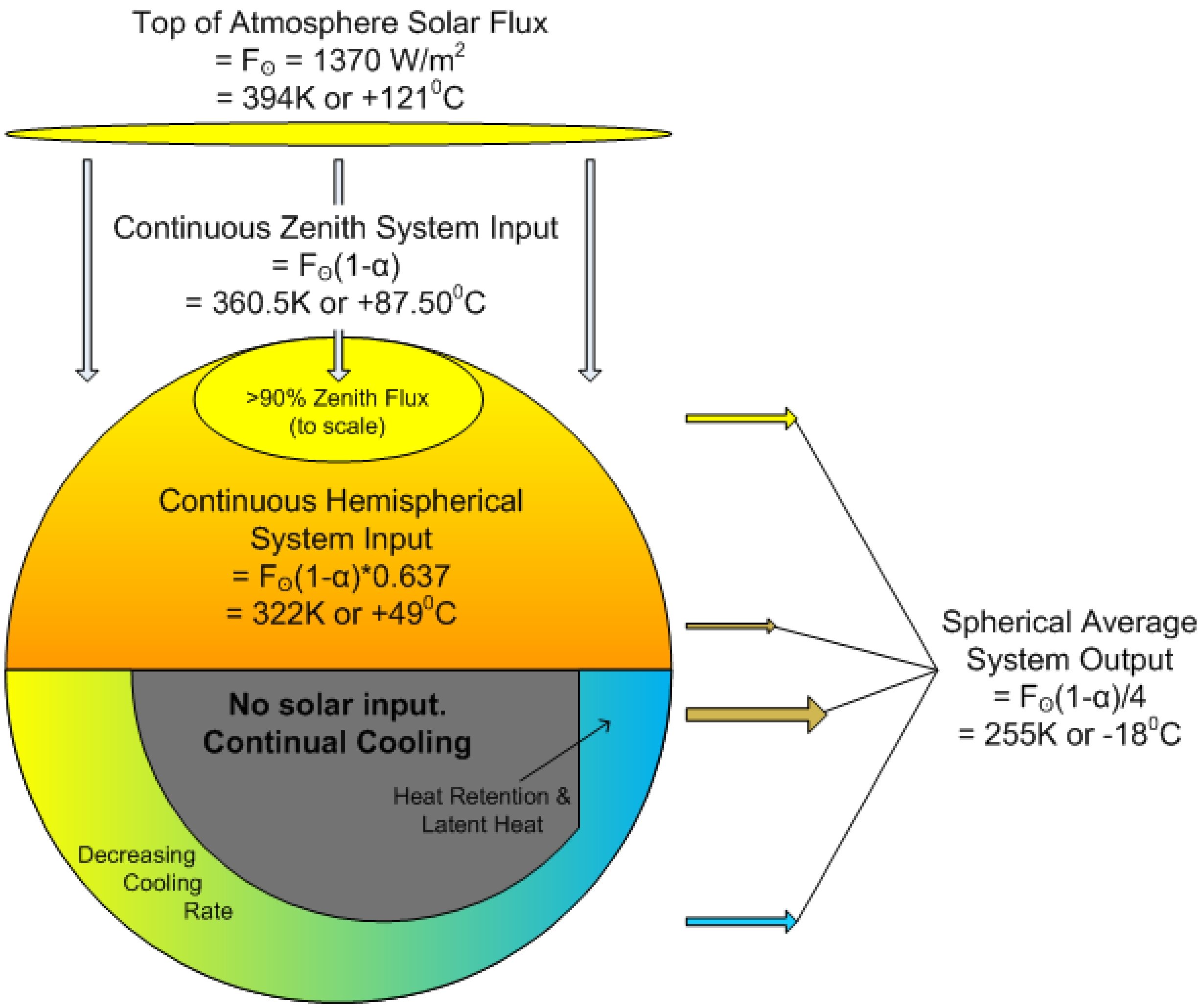


Figure 18: Spherical model for the energy input and output sequence. This model necessitates differential calculus which is a much more fundamental approach to characterizing heat-flow.

5. Conclusion

5.1. The fraud of simple-minded mathematics and sense-perception

What is the originating error of the GHE, the assumption which underlies everything that follows? In addition to the error of associating the terrestrial albedo with the ground surface, it is the error of averaging the input power temperature of sunlight over the entire globe. If you average the input power of sunlight over the entire globe it makes it appear as though sunlight can only provide -18^{0}C worth of heating at the surface. But you have to look at the units of the metric you are dealing with here: W/m^2 or J/s/m^2. Units mean something…you need to pay attention to what they mean. The units pose the question: what is the energy, in one second, over a square meter? These all have to occur together, simultaneously. The time and space in which incoming solar energy also impinges the night-side of the planet simply does not physically exist. It is only an imaginary mathematical trick that does not actually occur. What does occur in one second, and in the square meters where sunlight actually impinges, is illumination of a hemisphere with an intensity projection factor that goes as the function of the cosine from the zenith. If you integrate to the average projection factor and combine this with the Stefan-Boltzmann Law and terrestrial albedo, then the real-time instantaneous heat input is *constantly* +49^{0}C. At the zenith it has a maximum of +121^{0}C, constantly, when the albedo is zero.

Modern physics is patently not based on the simple type of linear averaging mathematics as seen in climate science; rather, it is based on calculus, i.e., Leibniz' greatest mathematical achievement of all time. Calculus is what breathes life into modern physics and allows us to characterize dynamic physical systems in detail. This simple type of linear algebraic manipulation we see underlying models and energy budgets in climate science, of what should be real-time dynamic quantities, cannot possibly provide a valid scientific basis for insight into a dynamic non-linear system. Such an attempt is patently invalid, and it should have been obvious when this scheme concluded that sunshine is freezing cold at -18^{0}C, and that the atmosphere provided, with no actual chemical or nuclear source of radiant energy, twice as much heating power as the Sun itself. The intrinsically defective concept of backradiation heating was thus created to cover this mathematical blunder up.

Why can't you average-out the power density? The answer, both physically and mathematically, couldn't be any more simple: you cannot linearly average the power density because the system is non-linear. It is that simple. The system is non-linear for at least three fundamental reasons: 1) heating and cooling is a function of insolation and temperature to the *fourth* power; 2) the input heating occurs non-uniformly over a hemisphere, not uniformly over a plane or a globe; 3) a large fraction the system is itself physically non-linear, due to the presence of H_2O, which has completely discontinuous responses to energy input at its triple-point. The heat capacity of H_2O changes between its phases, and at the discontinuity point of the phase change, has latent heat which absorbs or releases energy without any change in temperature. The amount of internal heat of a 1kg block of ice at 0^0C is approximately 200,000 J (evaluated by numerically solving the ice problem with temperature-dependant specific heat). But the latent heat of fusion of ice (to turn ice into water, taking in energy without changing the temperature) is 334,000 J/kg, which is entirely 167% of the energy it took just to get the ice block to 0C. Given that the power of sunshine can intrinsically overcome this latent heat barrier and induce even much higher temperatures - as opposed to the IPCC belief that the atmosphere needs to provide twice as much power as the Sun without actually having any source of energy - then the system naturally has a significant obstacle to cooling below this threshold and therefore the average temperature will be higher, as we have seen. Combine that with the even more energy-dense latent heat of vaporization which allows heat to be transported relatively quickly from the equator to the poles. This presents a substantial negative-feedback to temperature change in general but in combination with our distance from the Sun and the related radiant power, prevents excess cooling specifically.

There is a 3-way problem here between the mathematical ontologists, the mental idealists, and the scientific materialists. Take a universal principle, such as the principle of least action/time. The indication that the solution to the relevant physics problem did not originate from the mathematics itself; rather, the solution was only arrived at by insight of the mind identifying a unique principle which governs all of universal reality. The materialist contributes nothing more to this discussion than providing basic sense perception…so perhaps we can actually leave them out of the problem after they've finished staring at things. How do you get a universal principle out of an arche of ontological mathematics? Ontological mathematics may be a universal principle itself and indicate certain real things such as a Riemannian space-time and antimatter, and perhaps it is even the basis principle from which all else follows; however, it is the mind which identifies it as such, so which came first? Mathematically, one *can* write out a system where output is re-added or back-added to the input (as with backradiation), and mathematically this results in a gain on top of the raw input, so, what is the ontological mathematic error in doing so? Where does pure ontological mathematics indicate that this is an error? Sense-perception indicates that this gain doesn't actually occur and the mind has discovered intuitive and logical principles to justify the restrictions known as the Laws of Thermodynamics.

What we thus seek is a resolution between the mathematical ontologists and the mental idealists…and perhaps the only one available is unification, a sort of wave-particle duality concept but as occurring for the arche itself – the arche is both mentally ideal and mathematically ontological, and these are different aspects of the same underlying principle of reality (not that reality is a third thing...it is one thing with two appearances, like any quantum particle is a single thing with two appearances, as opposed to a third thing with two appearances, and the one thing is energy, i.e. a monad, which is a perfectly abstract concept). Of course, the mathematical ontologists can say that it comes first, and mind is a result which can become aware of its own underlying nature. However, the mental idealists can also say the mind is fundamental since it is the only thing that is actually knowably absolute, i.e., "I think therefore I am" - the only thing that is absolutely known is that I am thinking, therefore all that can be, is mind. A position can be had for the absolute abstractedness of mathematic ontology because it meshes with the absolute abstractness of the underlying physics of reality, i.e. energy. However, it does not seem capable of explaining how the mind can intuitively discover universal principles that mathematics is incapable of indicating on its own, without acknowledging that the mind has some form of primacy in and of itself. If you merge them into a contextual duality, a possible solution is found. In some sense then, the arche must count itself. Number is all that can exist as Pythagoras said, but number can only exist if counted, which is an action necessitating mind. "I count, therefore I am both number and mind", or some variation of such. They have to occur together. Perhaps this is the fundamental "strange loop" [38] of existence. In any case, back-input is materialistically known to be erroneous…it simply doesn't occur. There is some independent principle which limits what we can get out of a system: the "no free lunch principle", i.e., the 1st and 2nd Laws of Thermodynamics.

That space-time is Riemannian and antimatter exists should have been enough reason for any materialist scientist to accept that mathematics is ontological…the label of "imaginary" for the relevant field of numbers does not and was never meant to mean that they are actually mentally imaginary, as so many mistakenly believe today (a much better moniker is "complex"). The existence of universal principle should also have been enough reason for any materialist to accept that absolute logic is ontological. Mathematics is ontological, but there are also independent ordering principles which give structure to the arche which only the mind can discover and comprehend. What this author prefers could be called "ontological absolute logic", because mathematics is a necessary derivative of logic. I would place a great logical orator such as Socrates or Plato as fundamental to the evolution and development of thought and most closely mimicking the arche in cognition. It is logic which creates mathematics and it is logic which gives the arche structure in the form of Universal Principles. So, perhaps the mental idealists are correct after all.

The only attempt at a mathematical physics explanation for radiation obeying the laws of thermodynamics that this author is aware of is found in Claes Johnson's work on the subject [39]. This work needs to be considered because we are now in a position of knowing that we have to solve the relevant problem and limitations of such of heat flow, as Johnson has always been aware. The two-way net transfer postulate simply cannot work because it leads to the possibility that radiation from a colder source can warm up a warmer object. The GHE advocates have desperately tried to protect the two-way transfer postulate because they require it for their backradiation heating or radiative-resistance heating, but now that that whole scheme has been discarded and shown as fraudulent, we can start making more progress on a real understanding.

The most common criticism of Johnson's result for heat flow is that it is one-way, with critics charging that Johnson implies that photons from a cold source of radiation do not travel at all to a hotter source of radiation. The question is posed as criticism and it is almost always asked this way: "How does a radiant photon 'know' not to travel from cold to hot?" However, this is not what Johnson actually says; he explains that EM waves/photons are two-way, but the heat transfer mediated by EM waves/photons is one-way. The problem with the materialist objections is that they think of photons as busy little balls of energy which have to deposit their energy as heat into whatever they interact with, whereas a photon is actually a quantum particle that obeys wave mechanics. They are not tiny little balls of heat that have to do something that you think you would feel with sense perception…there are higher principles governing things.

As Doug Cotton has explained of Johnson's work in "Radiated Energy and the Second Law of Thermodynamics" [40] and summarized in personal correspondence with this author,

> *"The only (one way) heat transfer between, say, two parallel plates at different temperatures, corresponds to the energy in the radiation represented by the area between the two Planck curves. The Planck curve for the warmer body always envelopes that for the cooler body – i.e., the area under the cooler body's Planck curve is a subset of that for the warmer body. So each body radiates all the*

frequencies represented by the area under the Planck curve for the cooler body. However, the radiation represented by the area under the cooler body's curve, for both bodies, radiated in each direction, merely resonates in each body and is thus scattered. There is no associated heat transfer. This is how and why the 2nd Law of Thermodynamics works for radiation. There can be no other explanation, because if heat were transferred each way there would be no necessity for it to come back via radiation. For example, if radiation from a cooler atmosphere transferred heat to a warmer lake, that energy could return to the atmosphere via evaporative cooling, not radiation. Hence such a heat transfer can't happen. You can't just assume there are radiated heat transfers in each direction with a net effect. Mathematically the result is the same, but there is only one possible physical explanation, as Claes has described. Yes, the radiative rate of cooling will be affected, because the scattered radiation is really a part of the quota of radiation which the warmer body can radiate, so it doesn't use up its own thermal energy for that part. However, in the case of the surface/atmosphere interface, at least 70% of heat transfer from the surface to the atmosphere is non-radiative transfer. (I say 70% because you need to take into account the fact that much of the radiation observed rising from the surface is really just the scattered backradiation, none of which is actually transferring heat from the surface to the atmosphere; most heat is transferred by simple molecular collision processes – i.e. sensible heat transfer.) There is nothing to stop the rate of non-radiative cooling from increasing to compensate for any slowing of radiative cooling.

When a body receives incident radiation it "detects" those frequencies (and corresponding intensities) which it can itself radiate. This portion of the incident radiation (which will be all the radiation from a cooler body, or just some from a warmer body) resonates. The resonating process is the process whereby it can "detect" the temperature of the source. The resonating process amounts to immediate re-radiation of equivalent frequencies and intensities. There is no conversion of energy to thermal energy. We know this because if there were, some of that new thermal energy would temporarily warm the already warmer target (impossible by 2nd LoT) and that thermal energy could then escape by means other than radiation. Hence we can't explain all the radiation we observe unless we understand that there is a natural restriction (law) that the incident radiated EM energy can only be used to fulfil part of the target's quota of thermal radiation. The heat transfer is not an algebraic net result of physical heat transfers in two directions because we cannot assume all such energy would be re-radiated. Instead, it is the physical result of only that incident radiation which is represented by the area above the cooler body's Planck curve but under the warmer body's curve."

An interesting point about Doug Cotton's explanation of radiant heat exchange, is that a mutual exchange of energy which causes no state change in either object, is logically equivalent to no exchange having occurred at all. We cannot distinguish certain parcels of energy for other equal parcels of energy exchanged in the same location, as it is equivalent to no change having occurred at all. The only thing we can detect is that when radiant energy of sufficient power is absorbed, it will induce an increase in temperature until equilibrium is achieved. We know that the area of the warmer Plank curve above that of the cooler curve must be involved and be responsible for the heat transfer and temperature increase, but the mutually corresponding areas of the Plank curves for the two body's emissions either may, or may not, be exchanged and have the same effect which is no effect. The "cool portion" of the radiation may or may not travel between the bodies and be exchanged, and it really doesn't matter which option occurs because they are indistinguishable from each other. The materialist objection to Johnson's heat transfer was thus entirely inconsequential in the first place, and it has relevance only when it comes associated with the intent to cause warmer objects to become warmer still from the impingement of radiation from colder objects, as required in the scheme of the GHE. Only with this scheme can adherents claim that radiation from the atmosphere has twice the heating power of the Sun, even though the atmosphere is far colder than the spectral temperature of sunlight; there is nothing which is more patently absurd.

Greenhouses do not create heat; they simply trap heated air…air which is heated through contact with objects that are heated by sunlight. The atmosphere does not trap heated air because it isn't a physically rigid barrier – it is a gas and so it naturally flows and cools heated objects. Greenhouses do the opposite of what the open atmosphere does. The atmosphere does not cause heating via its back-radiation because there is no evidence that this occurs, and this is not how a real physical greenhouse functions in any case. If a real physical greenhouse cannot heat by back-radiation, then neither can the atmosphere. Trapped radiation cannot heat itself up and increase its own spectral temperature; radiation with a spectral temperature of -18^0C will always be radiation of a -18^0C spectral temperature, and this radiation cannot induce heating above its own spectral temperature nor can it interact with itself to increase its own "Wein-peak" frequency. This is probably related to a fundamental restriction from the Laws of Thermodynamics. Radiation cannot increase its own temperature, nor the temperature of its own source.

The atmosphere is heated partially by direct sunlight and mostly by contact with the ground surface which itself was heated by sunlight. An atmospheric lapse rate distribution will naturally arise for any planetary body which will cause lower layers of atmosphere to be warmer than the average middle layer and upper layers. The fact that an effective blackbody temperature is a measure of an integrated spectrum which arises from a continuum of depths in an emission column, and that the main source of heating occurs at the bottom of that column, and that there is a natural lapse rate distribution of the gas where the bottom must be warmest *a priori*, mathematically guarantees that lower-layer gas will have a higher kinetic temperature than the average and higher-layer gas independent of any additional mechanism.

The atmosphere, like anything else, simply *holds* heat. Anything with a temperature is obviously *holding* heat, but *trapping* heat is the opposite thing that the atmosphere does (aside from the latent heats of H_2O). A physical greenhouse traps heat by protecting against and preventing the natural cooling effects of the open atmosphere. The atmosphere, and a physical greenhouse, are opposite. They are opposites. That is why a real greenhouse functions. They should never have been equated, even in analogy. Cooling at the surface is enhanced by the atmosphere during both day and night, rather than retarded. The top 10 meters or so of a square meter column of soil holds more heat, and holds it at a higher temperature, than the entire 10,000 kg of atmosphere going from the surface to outer space. The only "trapping" of heat that the atmosphere and the whole system in general can actually do is within the two latent heats from H_2O; the rest of the system can only hold heat and freely shed it as a simple function of their mass and heat capacity.

Even the very primary idea which underlies the whole ensuing framework of the GHE and the resultant alarm based upon it - the idea that a thermally kinetic -18^0C should be found in the air near the ground surface because of the terrestrial albedo - is wrong. The terrestrial albedo of 0.3 is not found at the ground surface and so therefore it is fundamentally incorrect to have ever even made that insinuation in the first place. It should have remained perfectly clear that the terrestrial albedo is caused mainly by clouds and so therefore the ensuing effective radiative blackbody temperature could not possibly be found kinetically at the ground surface. The mathematics could not be any more simple: the sequence of [5 4 3 2 1] has an average of 3; this average of 3 is equivalent in analogy to the effective blackbody temperature of a column sequence of gas in a gravitational field, with warmer numbers being found at the bottom of the column and cooler ones on the top for fundamental thermodynamic reasons, in which they all contribute to the resulting average of an effective radiative blackbody temperature of -18^0C. Mathematics and thermodynamics require the surface air to be warmer than the average layer of air completely independent of any atmospheric backradiation or heat trapping effect of which the atmosphere is not even capable in the first place, and by which a real greenhouse does not even function.

The "atmospheric GHE" is just the phrase we use to denote the difference between the effective blackbody radiation temperature and the kinetic air temperature near the surface; it does not actually denote any physical heating mechanism or temperature amplification or heat-trapping function, and it is actually an entirely benign comparison of physically distinct metrics, i.e., effective radiation temperature vs. spatially-specific kinetic temperature. The concept has no relationship to an actual physical greenhouse, nor is it all that physically meaningful *a priori* due to the indistinct comparison between principally distinct metrics. It is a travesty that the scientific institution would have ever accepted through review and promoted the pretense that the atmosphere provides twice as much heat as the Sun, just because a bunch of ideologues agreed for it to be so. If this brand of ideological speciousness is allowed to continue to be passed off as science, then without a doubt this has marked the end of the evolutionary development of the human mind and what lies ahead for humanity is a slow decline back into a permanent dark age of unconsciousness. Alarmism based on the atmospheric greenhouse effect really is just that depraved, and is one of the absolute worst psychological conditions that the human mind has ever developed. The atmospheric greenhouse effect is one of the worst analogies that has ever been created, and given the degree of alarm and expenditure of monies and an entire field of specious alarmist science that has been justified on its pretext, one of the most damaging to human fecundity.

5.2. A Note on the Human Mind

If you placed yourself out into the woods, naked and with no tools, what would you do? What would an animal do? An animal would just start sniffing around and eating whatever smelled eatable. But a human wouldn't do that. The first thing a human would do (if there were no option for escape!) is start changing the local environment, by building a shelter, by fashioning bodily coverings, by using sharp rocks and learning how to create sharp rocks for cutting, by using vines to tie things together, by figuring out how to store water and food, by making sharply-pointed sticks for hunting, by making a controlled fire for various purposes, etc. There is virtually no overlap between the behaviour of an animal and the behaviour of a human, aside from basic bodily function. All of man's actions for fundamental survival are based on changing the environment. If man is not supposed to change the environment, then it means that man is not supposed to exist, because man only exists with a mind whose greatest benefit is in understanding how to change the environment in order to ensure bodily survival. But man does exist, and so the choice is yours: Do you want to exist? If you do, you have to accept that the very existence your life, *the existence of your mind*, changes the environment and in profound and universally unique ways. What humans do on this planet, what our minds do for survival, is *universally unique*; these processes are not found anywhere else in the entire universe that we know for certain, and are at least extremely infrequently encountered in theory. This is not something to feel bad about, but to feel tremendously happy and ecstatic about, because you are doing things which do not occur in the rest of the universe! Did you not come out of the universe? Did the universe not in some way create you? Then you are supposed to be here and doing what we do by definition. Now some of you may be "office workers" and you cannot understand how it is that your life is engaged in changing the environment; that may be so, but you only exist because others are changing the environment and providing you the energy and sustenance required for your survival. You must realize you play a part in this. If you cannot handle the idea that the environment will change due to your existence, and that is *has* to change due to the existence of your mind, then I do not know what to tell you, but I hope you do not hurt yourself or other people as you sort out your desire for non-existence. But as Sabin Colton has observed:

"*I maintain that a planet that does not develop intelligent life is a waste of a planet; and intelligent life that does not reach the stars is also a failure.*"

If it is the negative aspects of human existence which makes you sick and tired of "what humans are doing on the planet", then all you have to do is stop supporting those aspects. It is that easy. You do not have to force anyone else to do anything they do not want to – you simply do what you yourself can do and lead strongly by example, and defend what you know is right. And the way to stop supporting such aspects can only be achieved by learning and informing yourself as to what exactly in the most final and complete and exhaustive analysis is the source and cause for these aspects, because it is only once you become fully informed and face the truth's which you may have been unable to perceive or accept until now, that you will have the knowledge and confidence required to make a change in yourself, and in the environment around you. And if for you it is as simple as not wanting to pollute the planet, then just remember, that no human actually likes pollution, but plants love carbon dioxide, and they want more of it.

One must also let-go of the wholly corrupt implication that, just because we're discussing that the existence of mind and consciousness is based upon the necessity of changing the environment, that environmental change is something which would not happen if the human mind did not exist. The idea that the environment is static or that it should remain apparently static over some time period is entirely fraudulent. Something like 99.9% of all species which have ever existed are extinct, and they are extinct because they did not have the capacity to adapt to natural environmental changes. The entire fundamental chemical & climatic natures of the oceans, the land surfaces, and the atmosphere, have changed drastically in the past, and the only reason that the environment might appear static to the underdeveloped mental awareness of the sense-perceptionist is because these changes happened in the past, rather than within their own lifetimes. Whereas even the most cursory awareness of the cycles of ice-ages over even just the last few million years is enough to inform oneself that the climatic changes in the current generation are essentially negligible, and are stochastically meaningless. The history of the entire universe itself is a history of environmental change, and of evolutionary development of various contexts and degrees, to more highly ordered and more complex structures and forms of matter. The human mind grasps and comprehends this natural order of things implicitly, and reflects this power and function of the universe willfully. The point is to do it well, rather than do it poorly.

5.3. Summary Statements

1) The surface of albedo is not the ground surface, and so it never was correct to associate the radiative temperature of -18^{0}C with the ground surface in the first place, since the albedo is what determines the equilibrium temperature and the albedo is not found with the physical surface.

2) Even as the climate models show, an increase in cloud height causes an increase in temperature at the surface. This is not due to a backradiation GHE but due to the lapse rate of the atmosphere combined with the average surface of equilibrium being risen further off of the surface.

3) A real greenhouse doesn't become heated by internal backradiation in any case, but from trapped warm air which is heated by contact with the internal surfaces heated by sunlight, and then physically prevented by a rigid barrier from convecting and cooling. The open atmosphere doesn't do what a greenhouse doesn't do in the first place, and the open atmosphere does not function as a rigid barrier either.

4) The heat flow ordinary differential equation of energy conservation is a fundamental equation of physics. It combines the fundamental mechanics of heat flow together with the most venerated law of science, conservation of energy. This equation predicts what should be observable if backradiation or heat-trapping is introduced to the equation, in accordance with the main idea of the atmospheric GHE, that a higher temperature than the insolation will be achieved. A higher-than-insolation temperature is not achieved in experimental data, and we make it clear how one could test the postulate with even more surety by using the "Bristol Board Experiment".

5) An important factor for why the introduction of backradiation into the equation fails to match the real world is because radiation cannot actually increase its own Wien-peak frequency and its own spectral temperature signature; radiation cannot heat up its own source. The Laws of Thermodynamics are real and universal.

6) The rate of cooling at the surface is enhanced, rather than retarded, relative to the entire atmospheric column, by a factor of 10. Therefore, backradiation doesn't seem to slow down the rate of cooling at the surface at all. Backradiation neither causes active heating, nor slowed cooling, at the surface. (Given Claes Johnson's description of radiative heat transfer, radiation from a colder ambient radiative environment should slow down the rate of cooling, and we agree with that. What we didn't agree with was that "slowed cooling" equated to "higher temperature" because that is obviously sophistic logic. And now in any case, it is apparent that sensible heat transfer from atmospheric contact at the surface dominates the radiative component process anyway, leading to ten times the rate of cooling at the surface relative to the rest of the column.)

7) Given the amount of latent heat energy actually stored (i.e. trapped) within the system, and that this energy comes from the Sun, and considering the Zero-Energy-Balance (ZEB) plot, it is quite apparent that this energy gets deposited in the equatorial regions and then shed in the polar regions. This trapped latent heat prevents the system from cooling much below 0^0C, which keeps the global average temperature higher than it would otherwise be and thus leads to an "interpreted appearance" of a GHE caused by "GHG trapping", when the only trapping of energy is actually only in H_2O latent heat.

8) Subsoil readings prove that a large amount of energy is held at a significant temperature (warmer than the surface) overnight, and because this soil is warmer than the surface, and the surface is warmer than the atmosphere, then the direction of heat flow is from the subsoil to the atmosphere. And as discussed, the atmosphere seems to enhance surface cooling rather than impede it.

9) The heat flow equation can be modeled to show that the Sun is capable of maintaining large amounts of water under the solar zenith at about 14 degrees C. This is very close to the surface average of $+15^0$C. The Sun can maintain a liquid ocean at $+14^0$C because it takes a long time for heated water to lose its thermal energy. This is also in combination with the surface of albedo being raised off the surface where the lapse rate will maintain a near-surface average of $+15^0$C in any case.

10) The issue has never been about whether radiation moves freely about in the atmosphere (it does), the question is whether once it has arrived at the surface, does it get more than one go at generating heat (i.e. "back radiation" heating)? We say "no" because a) no such phenomenon as "back radiation heating" is cited in any thermodynamics textbooks and b) nor has any such effect been measured empirically. GHE believers are left not knowing whether to support the "back radiation" heating or the "delayed cooling" (i.e. "blanket effect") argument for the GHE; this is because each is a contradiction in terms and may separately be shown to not have any empirically proven basis. The Laws of Thermodynamics probably play a part in this.

11) As Alan Siddon's has explained [41], it isn't actually clear, and there seems to be a plain logical contradiction, when we consider the role of non-GHG's under the atmospheric GHE paradigm. If non-GHG's such as nitrogen and oxygen don't radiate, then, aren't they the ones *trapping* the thermal energy which they sensibly pick up from the sunlight-heated surface and from GHG's? If on the other hand they do radiate, then aren't they also GHG's? If a GHG radiates, and the others gasses don't, then doesn't that mean that GHG's cause cooling because they provide a means for the atmosphere to shed thermal energy? If the GHE is caused by trapping heat, then aren't all non-GHG's contributing to the effect since they can't radiatively shed the thermal energy they pick up? Isn't how we think of the GHE therefore completely backwards? In any case, everything with a temperature is *holding* heat; the only place *trapping* can be thought to be occurring is in latent heat.

6. Acknowledgements

I would like to thank Carl Brehmer for the use of his data, Tim Ball for advising on reference material and related questions, and John O'Sullivan, Martin Hertzberg, Sabin Colton, Alberto Miatello and Pierre Latour for reviewing this document. This research and paper has received no financial support and is not conducted under any auspices of any institution. I would like to thank the group of independent scientists known on the blogosphere as "The Slayers", and to all fellow members of Principia Scientific International. Special thanks to Alan Siddons and Hans Schreuder for breaking the path. And loving thanks to my wife for having me read "State of Fear" when we first met, which steered my scientific career into the realm of skeptical rationalism.

Appendix A: Numerical Solution of the Basic Heat-Flow Energy Conservation Equation

```
function ThermalODE_AppA

tau = 4e5;       %net thermal constant (mass * Cp)
albedo = 0.3;    %albedo, using 0.3 for common generality
emis = 0.7;      %emissivity, using 0.7 for Kirchhoff
Temp0 = 0;       %initial starting temperature for beginning the integration
days = 13;       %number of days to run the model

%time, in seconds, 5000 points
time = linspace(0,days*86400,5000);
%input flux W/m^2, approximating Solar values
Flux_In = 1370*(1 - albedo)*sin(2*pi/86400*time);
%set negative sin values to zero flux (night time)
Flux_In(Flux_In < 0) = 0;
%after 10 days, remove forcing to see temperature decay just because...
Flux_In(time >= 11*86400) = 0;

%set the tolerance tighter for better accuracy
opts = odeset('RelTol',1e-6);
%call Matlab ode45 function, using TPrime function below
[SLN_TIME SLN_TEMP] = ode45(@(dummy_time,Temp) ...
    TPrime(dummy_time,Temp,Flux_In,tau,time,emis),time,Temp0,opts);

%plot the results
%plotting parameters here can be variously modified
%subplot(2,1,1) %use this for making subplots when required
plot(time/86400,Flux_In,SLN_TIME/86400,SLN_TEMP);axis tight



function dTdt = TPrime(dummy_time,Temp,Flux_In,tau,time,emis)
% function to numerically integrate
% dT / dt = ( Flux_In - emis*sigma*T^4 ) / tau

%interpolate the input flux to the integration point
f_int_t = interp1(time,Flux_In,dummy_time,'spline');

%return value of differential at current Flux & Temperature
dTdt = (f_int_t - 5.67e-8*emis*Temp.^4)/tau;
```

Appendix B: Matlab Code for Calculating Solar Altitude, Airmass, and Distance

```
function [alt varargout] = Solar_Altitude(JD,latitude,longitude)
%[Altitude(deg), Airmass(opt.1), Distance(opt.2, meters)] =
%Solar_Altitude(Julian Day, Latitude, Longitude);
%Returns solar altitude and optionally the airmass & distance, accurate to
%~0.01 degrees between 1950 and 2050.
%Julian Day can be a vector, but the other parameters should be scalars.
%If solar altitude is below horizon, airmass will report airmass for 90
%degrees, equal to 31.7349.


%Number of days since JD 2451545.0 = 2000 UT 12:00:00
n = JD - 2451545.0;%days

%Mean longitude (corrected for aberration);
L = rem(280.460 + 0.9856474*n,360);%deg

%Mean anomaly;
g = rem(357.528 + 0.9856003*n,360);%deg

%Ecliptic Longitude
lambda = L + 1.915*sind(g) + 0.020*sind(2*g);%deg

%Obliquity of Ecliptic
eps = 23.439 - 0.0000004*n;%deg

%Solar Right Ascension
f = 180/pi;
t = tand(eps/2).^2;
alpha = rem(lambda - f*t.*sind(2*lambda) + ...
(f/2)*(t.^2).*sind(4*lambda),360);%deg

%Solar Declination
delta = asind(sind(eps).*sind(lambda));%deg

%West longitude of observatory in hours
WLO = longitude/15;%hrs

% Greenwhich Mean Sidereal Time at JD
GMST = rem(18.697374558 + 24.06570982441908*(JD - 2451545.0),24);%hrs

% Local Sidereal Time at JD and longitude
LST = GMST - WLO;%hrs

%Solar local hour angle
ha = LST - alpha*12/180;%hrs
ha = ha * 180/12;%degrees

%Altitude, degrees
alt = asind(sind(latitude).*sind(delta) + ...
      cosd(latitude).*cosd(delta).*cosd(ha));
alt = alt(:);
```

```
if nargout >= 2
    %Zenith angle
    zt = (90 - alt); zt(zt > 90) = 90;
    %Airmass of target: Young, A. T. 1994. Air mass and refraction. Applied
    %Optics. 33:1108-1110.
     X = ( 1.002432*cosd(zt).^2 + 0.148386*cosd(zt) + 0.0096467 ) ./ ...
(cosd(zt).^3 + 0.149864*cosd(zt).^2 + 0.0102963*cosd(zt) + 0.000303978);
     varargout(:,1) = X{:};
end

if nargout >= 3
    d = (1.00014 - 0.01671*cosd(g) - 0.00014*cosd(2*g))*149597870691;
%149597870691 = 1au (meters)
    varargout(:,2) = d{:};
end
```

Appendix C: Script for TOA Flux Calculation

```
%script for plotting annual TOA and seasonal surface Flux
sbc = 5.67e-8;
albedo = 0.3;
SeffT = 5770;       %K, value from Gray ***
RSun = 6.96e8;      %meters

JD0 = 2456099.5;    %June 21, 2012, UT:00hrs
JD = linspace(JD0-180,JD0 + 180,100000);
time = (JD-JD0)*86400;%seconds

%Solar altitude, airmass, and distance
[Sol_Alt Sol_X Sol_Dist] = Solar_Altitude(JD,34.8,112.5);

%disappear Sun below horizon
Sol_Alt(Sol_Alt < 0) = 0;

%at TOA
Sol_Const = sbc*(SeffT^4)*(RSun./Sol_Dist).^2;

%absorbed at surface weighted for local projection
Flux_In = (1 - albedo)*Sol_Const.*sind(Sol_Alt);

subplot(2,1,1)
plot(time/86400,Sol_Const);axis tight;
subplot(2,1,2)
plot(time/86400,Flux_In);axis tight;
```

Appendix D: Script for Seasonal Lag Example

```
function ThermalODE_AppD
%script for seasonal lag

SeffT = 5770;    %K, value from D.F. Gray (1992)
RSun = 6.96e8;   %meters
tau = 125e5;     %net thermal constant (mass * Cp)
albedo = 0.3;    %albedo, using 0.3 for common generality
emis = 0.7;      %emissivity, using 0.7 for Kirchhoff
Temp0 = 260;     %initial starting temperature for beginning the integration
                 %(so that it doesn't need to "come up" to temp)

JD0 = 2456099.5; %June 21, 2012, UT:00hrs
%one year centered on 2012 solstice
JD = linspace(JD0-182.625,JD0 + 182.625,10000);
time = (JD-JD0)*86400;%start at zero, in seconds
%get real solar altitude & distance
[Sol_Alt Sol_X Sol_Dist] = Solar_Altitude(JD,34.8,112.5);
Sol_Alt(Sol_Alt < 0) = 0;%get rid of Sun below horizon

Sol_Const = 5.67e-8*(SeffT^4)*(RSun./Sol_Dist).^2;%TOA Flux

Flux_In = (1 - albedo)*Sol_Const.*sind(Sol_Alt);%input surface flux W/m^2

%set the tolerance tighter for better accuracy
opts = odeset('RelTol',1e-6);
%call ode45 function, using TPrime_0 function below
[SLN_TIME SLN_TEMP] = ode45(@(dummy_time,Temp) ...
    TPrime_0(dummy_time,Temp,Flux_In,tau,time,emis),time,Temp0,opts);

%plot results; Input flux & response temperature
plot(time/86400,sqrt(sqrt(Flux_In/5.67e-8)),SLN_TIME/86400,SLN_TEMP);axis
tight
axis([time(1)/86400 time(end)/86400 200 360]);


function dTdt = TPrime_0(dummy_time,Temp,Flux_In,tau,time,emis)
% function to numerically integrate
% dT / dt = ( Flux_In - emis*sigma*T^4 ) / tau

%interpolate the input flux to the integration point
f_int_t = interp1(time,Flux_In,dummy_time,'spline');

%return value of differential at current Flux & Temperature
dTdt = (f_int_t - 5.67e-8*emis*Temp.^4)/tau;
```

Appendix E: Script for Heat-Flow Equation with the GHE

```
function ThermalODE_GHE_AppF

%tau*T(t)' = Flux_In + G0 - (1-gamma)*emis*5.67e-8*T(t)^4
%G0 = constant-value GHE
%gamma = GHE as porportional to T(t)^4

tau = 4e5;        %net thermal constant (mass * Cp)
albedo = 0.3;     %albedo, using 0.3 for common generality
emis = 1.0;       %emissivity, using 1.0 for surface (generally can be lower)
Temp0 = 0;        %initial starting temperature for beginning the integration
days = 13;        %number of days to run the model

gamma = 0;      %GHE return factor - use 0.77 as per Jacob 1999
G0 = 0;         %GHE constant forcing factor - use 324 W/m^2 as per K&T Budget

%time, in seconds, 5000 points
time = linspace(0,days*86400,5000);
%input flux W/m^2, approximating Solar values
Flux_In = 1370*(1 - albedo)*sin(2*pi/86400*time);
%set negative sin values to zero flux (night time)
Flux_In(Flux_In < 0) = 0;
%after 10 days, remove forcing to see temperature decay just because...
Flux_In(time >= 11*86400) = 0;

%set the tolerance tighter for better accuracy
opts = odeset('RelTol',1e-6);
%call Matlab ode45 function, using TPrime function below
[SLN_TIME SLN_TEMP] = ode45(@(dummy_time,Temp) ...
    TPrime(dummy_time,Temp,Flux_In,tau,time,emis,gamma,G0),time,Temp0,opts);

%plot the results
%plotting parameters here can be variously modified for plotting desired
metrics
subplot(2,1,2) %use this for making subplots when required
plot(time/86400,sqrt(sqrt(Flux_In/5.67e-8)),SLN_TIME/86400,SLN_TEMP);


function dTdt = TPrime(dummy_time,Temp,Flux_In,tau,time,emis,gamma,G0)
% function to numerically integrate
% dT / dt = ( Flux_In + G0 - (1-gamma)*emis*sigma*T^4 ) / tau

%interpolate the input flux to the integration point
f_int_t = interp1(time,Flux_In,dummy_time,'spline');

%return value of differential at current Flux & Temperature
dTdt = (f_int_t + G0 - (1-gamma)*emis*5.67e-8*Temp.^4)/tau;
```

Appendix F: Table of Climate Data

Table 1: Data set for June 21 & 22, 2012, beginning 00hrs local on the 21st.

Time (hrs)	Air Temp (Kelvin)	Humidity (%rh)	Dew Point (°C)	Ground Temp (Kelvin)	Insolation (W/m^2)
0.0	293.5	16	-6.1	296.5	0
0.5	291.5	18	-6.2	296	0
1.0	291	19	-5.9	295	0
1.5	290.5	18	-7	294.5	0
2.0	290.5	17	-7.8	293.5	0
2.5	289	19.5	-7.2	293.5	0
3.0	288	20.5	-7.4	292.5	0
3.5	287	23	-6.8	292	0
4.0	287	24	-6.2	291.5	0
4.5	286	27	-5.5	291	0
5.0	285.5	29	-5	290.5	0
5.5	285	29	-5.5	290	36
6.0	287	26	-5.2	290	138
6.5	290.5	21.5	-4.7	291	237
7.0	295	18	-3.4	292.5	343
7.5	298	13.5	-4.8	295.5	449
8.0	300.5	13.5	-2.8	304.5	554
8.5	303.5	10	-4.5	314.5	653
9.0	305	9	-4.8	323	743
9.5	306.5	7.5	-6.1	330	825
10.0	308	6.5	-6.9	334.5	894
10.5	309	6.5	-6.1	339	954
11.0	310	4	-11.6	341	998
11.5	310.5	4	-11.3	344	1031
12.0	310.5	2.5	-17	345.5	1053
12.5	310.5	2.5	-17	345.5	1060
13.0	311	2.5	-16.7	345.5	1044
13.5	311.5	4	-10.6	345	1013
14.0	311.5	4	-10.6	344.5	965
14.5	311	4	-10.9	343.5	897
15.0	310.5	4	-11.3	341.5	829
15.5	310.5	4	-11.3	338.5	717
16.0	310	2.5	-17.3	336.5	664

16.5	309.5	2.5	-17.6	332.5	567
17.0	309	2.5	-18	328	466
17.5	307	4	-13.7	324	360
18.0	305.5	4	-14.7	319.5	254
18.5	305	4	-15	313.5	147
19.0	304	5	-13	309	64
19.5	302.5	6.5	-10.8	306.5	12
20.0	300.5	7.5	-10.5	304	0
20.5	298	10	-8.7	302	0
21.0	297.5	11	-7.9	300.5	0
21.5	296.5	13.5	-6	299.5	0
22.0	295	14.5	-6.2	298.5	0
22.5	294	16	-5.7	298	0
23.0	294	16.5	-5.3	297	0
23.5	293.5	17.5	-5	296.5	0
24.0	292.5	19.5	-4.4	296	0
24.5	293	20.5	-3.3	295.5	0
25.0	292.5	23	-2.2	295.5	0
25.5	291.5	25	-1.9	295	0
26.0	291.5	26	-1.3	294	0
26.5	291	29.5	0	294	0
27.0	290.5	30.5	0	293.5	0
27.5	290	32	0.2	293.5	0
28.0	289.5	35	1	293	0
28.5	289	35.5	0.8	292.5	0
29.0	287.5	38.5	0.6	292	0
29.5	286.5	42	0.9	291	27
30.0	288.5	38	1.3	291	121
30.5	292	32.5	2.2	291.5	215
31.0	296.5	26.5	3.2	292.5	317
31.5	301	21.5	4	295.5	424
32.0	302	20	3.8	306	530
32.5	304	14.5	0.9	313.5	630
33.0	305	14	1.2	321.5	724
33.5	305.5	12.5	0	327.5	809
34.0	306	9	-4	330.5	881
34.5	307	9	-3.3	333.5	942
35.0	307.5	7.5	-5.3	335.5	988
35.5	308	9	-2.6	337	1020

36.0	308.5	8.5	-3	339.5	1044
36.5	308.5	8.5	-3	340	1052
37.0	309	8	-3.4	341	1036
37.5	310	7	-4.4	341.5	1009
38.0	309.5	8	-3	341	972
38.5	309.5	8	-3	339	915
39.0	309	8	-3.4	337	846
39.5	309.5	6.5	-5.8	335.5	768
40.0	309	8	-3.4	334	677
40.5	309.5	7	-4.8	331.5	586
41.0	308.5	8	-3.8	328	483
41.5	306.5	9	-3.7	324	381
42.0	305.5	10	-3	319	278
42.5	304.5	10	-3.8	313.5	176
43.0	303.5	10	-4.5	309	85
43.5	302.5	11.5	-3.4	307	18
44.0	300.5	11	-5.6	304.5	0
44.5	299	12.5	-5	302.5	0
45.0	297.5	13.5	-5.2	301	0
45.5	296	14.5	-5.4	299.5	0
46.0	294	17.5	-4.6	298.5	0
46.5	293.5	17	-5.4	297	0
47.0	292	19	-5.1	296.5	0
47.5	292	18	-5.8	295.5	0

Appendix G: Table of Albedo Measurements

Table 2: Data set for Albedo Derivation

Time (hrs)	Insolation	Reflected	Albedo
13/06/2012	W/m^2	W/m^2	%
5.5	18	5	0.277778
6	125	38	0.304
6.5	270	54	0.2
7	370	105	0.283784
7.5	430	110	0.255814
8	535	150	0.280374
8.5	615	160	0.260163
9	715	166	0.232168
9.5	855	205	0.239766
10	970	216	0.22268
10.5	1025	222	0.216585
11	1084	228	0.210332
11.5	1095	235	0.214612
12	1100	243	0.220909
12.5	1093	240	0.219579
13	1072	245	0.228545
13.5	1050	245	0.233333
14	995	242	0.243216
14.5	930	230	0.247312
15	850	215	0.252941
15.5	777	200	0.2574
16	666	177	0.265766
16.5	566	160	0.282686
17	445	130	0.292135
17.5	355	100	0.28169
18	300	75	0.25
18.5	212	66	0.311321
19	119	42	0.352941
19.5	10	3	0.3

Appendix H: Sample List of References Adhering to the Back-Radiation Model of the GHE

All the references and quotations below conform to the to the "back-radiation model" of the GHE, which is based on a comparison with actual greenhouses made of glass. The problem is that this well-known comparison is incorrect. Like anything else, the interior surfaces of a greenhouse warm up by absorbing sunlight. But what the glass enclosure then does is trap the surface-heated air, acting as a physically rigid barrier to convective heat dissipation. This is why a greenhouse gets warmer than the outside air. This fact can be verified by alternately opening two small panels of the greenhouse: first, open a wall panel at ground level. No significant temperature decrease will be observed. Next, open a roof panel; the temperature will drop noticeably and quickly.

Now, if trapped radiation were involved, radiation would escape equally well from either the base or the top when an escape hatch appears. The fact that the greenhouse only cools when a roof panel is opened indicates that the increased warmth comes about only because heated air has been trapped. Thus, the premise that radiation-trapping in the atmosphere is analogous to radiation-trapping in a real greenhouse, is unsound. Yet this analogy is consistently used to justify an atmospheric form of the GHE. Although the glass in a real greenhouse does not cause additional warming by trapping radiation, we are told that trace gases do perform this task - by virtue of a comparison to something that does not actually occur! Greenhouses were invented by human beings to protect a pocket of air against the cooling forces in the atmosphere; i.e., they do the opposite thing that the atmosphere actually does, so to compare the atmosphere to a physical greenhouse is just silly. We are not without remit to state that this line of justification or reasoning is obfuscatory at best or outright fraudulent at worst.

If back-radiation augments the warming that sunlight provides, as alleged in the references and quotations in this appendix and by the heat-flow equation developed earlier in this report, then the atmospheric GHE should be able to generate more warmth than real-time insolation can provide, even at its maximum. To this author's knowledge, however, this has never been demonstrated.

NASA

"*Why is this process called "The Greenhouse Effect?" The Sun heats the ground and greenery inside the greenhouse, but the glass absorbs the re-radiated infra-red and returns some of it to the inside.*"

http://www-istp.gsfc.nasa.gov/stargaze/Lsun1lit.htm

Hunan University, China

"*Light from the sun includes the entire visible region and smaller portions of the adjacent UV and infrared regions. Sunlight penetrates the atmosphere and warms the earth's surface. Longer wavelength infrared radiation is radiated from the earth's surface. A considerable amount of the outgoing IR radiation is absorbed by gases in the atmosphere and reradiated back to earth. The gases in the atmosphere that act like glass in a greenhouse are called greenhouse gases.*"

http://jpkc.lzjtu.edu.cn/hjhx/jpkc/7.ppt

Appalachian State University, North Carolina

"*Our atmosphere is a selective filter since it is transparent to some wavelengths and absorbs others. The greenhouse effect occurs when the energy absorbed is not all radiated because of the filtering of the atmosphere. Some of the earth's radiated energy is reflected back to the surface. Consequently the earth's atmosphere has an increased temperature. This process is much like the action of glass in a greenhouse.*"

http://www.physics.appstate.edu/courses/FirstExamReview.rtf

The University of the Western Cape, South Africa

"*A greenhouse is made entirely of glass. When sunlight (shortwave radiation) strikes the glass, most of it passes through and warms up the plants, soil and air inside the greenhouse. As these objects warm up they give off heat, but these heat waves have a much longer wavelength than the incoming rays from the sun. This longwave radiation cannot easily pass through glass, it is re-radiated into the greenhouse, causing everything in it to heat up. Carbon dioxide is the pollutant most responsible for increased global warming.*"

http://www.botany.uwc.ac.za/envfacts/facts/gwarming.htm

The Institute for Educational Technology, Italy

"*Just as it happens in a greenhouse where the function carbon dioxide performs in the atmosphere is played by glass-rafters, the sun's energy arrives down at the earth, where it is partially absorbed and partially reflected. Such reflected heat, however, is reflected again, by glass as for the greenhouse, by carbon dioxide as for the atmosphere, down on earth: it is as if a part of the heat were entrapped, thus determining a growth of temperature on the ground.*"

http://www.itd.cnr.it/ge8/rivista/inglese/num_2/galil3.htm

The Austrian JI/CDM- Programme

"*The Earth's atmosphere is comparable to a glass roof of a greenhouse: the short-wave solar radiation passes through nearly unhindered and warms the Earth's surface. From the Earth's surface, the short-wave radiation is partly absorbed and partly reflected back as long-wave thermal radiation. However, this long-wave thermal radiation cannot pass the atmosphere unhindered due to the greenhouse gases but is partly reflected back again to the Earth's surface.*"

http://www.ji-cdm-austria.at/en/portal/kyotoandclimatechange/ourclimate/greenhouseeffect/

U.S. Department of the Interior, U.S. Geological Survey

"*The gases that encircle the Earth allow some of this heat to escape into space, but absorb some and reflect another portion back to the Earth. The process is similar in Mountain View, only, the greenhouse there is made of glass instead of gas.*"

http://hvo.wr.usgs.gov/volcanowatch/1998/98_10_22.html

Science Encyclopedia

"*The greenhouse effect is the retention by the Earth's atmosphere in the form of heat some of the energy that arrives from the Sun as light. Certain gases, including carbon dioxide (CO2) and methane (CH4), are transparent to most of the wavelengths of light arriving from the Sun but are relatively opaque to infrared or heat radiation; thus, energy passes through the Earth's atmosphere on arrival, is converted to heat by absorption at the surface and in the atmosphere, and is not easily re-radiated into space. The same process is used to heat a solar greenhouse, only with glass, rather than gas, as the heat-trapping material.*"

http://science.jrank.org/pages/3148/Greenhouse-Effect.html

RealClimate

"*The factor of two for the radiation emitted from the atmosphere comes in because the atmosphere radiates both up and down.*"

http://www.realclimate.org/index.php/archives/2007/04/learning-from-a-simple-model/

ThinkQuest Education Foundation

"*In a greenhouse, heat from the sun enters the glass. The heat in the form of infra-red light bounces and heads back up towards the glass. The glass then allows only some of this heat to escape, but reflects back another portion. This heat remains bouncing within the greenhouse. In the case of planet Earth, there is no glass, but there is an atmosphere which retains heat or releases heat.*"

http://library.thinkquest.org/11353/greenhouse.htm

Weather-Climate.org

"*This warming effect is called the "greenhouse effect" because it is the same process as that which occurs in a greenhouse on a sunny day. The glass is transparent to short-wave radiation but absorbs the outgoing long-wave radiation, causing a rise in temperature inside the greenhouse.*"

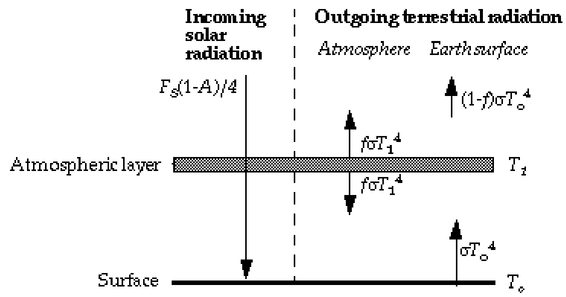
http://www.weather-climate.org.uk/04.php

University of Alaska-Fairbanks, Physics Department

"*Greenhouse gases act as a blanket. Some of you may wonder how a greenhouse takes solar energy and turns it into thermal energy. A good example of this is something you can observe every day in the summer in your own car. It happens when you leave your car in a sunny parking lot with the windows up. The solar energy is passing through the glass and is heating the car's interior. What's really happening is the short wave infrared waves are going in and are turning into long wave infrared waves, which cannot escape.*"

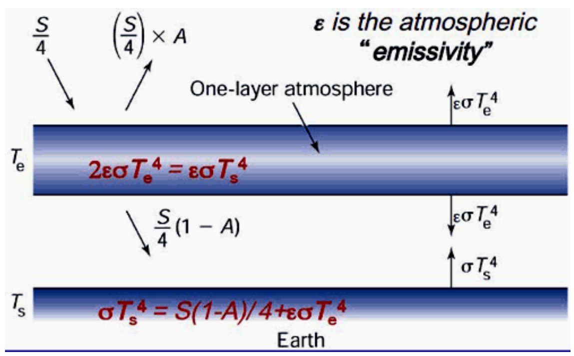
http://ffden-2.phys.uaf.edu/102spring2002_Web_projects/C.Levit/web%20page.html

Harvard University



http://acmg.seas.harvard.edu/people/faculty/djj/book/bookchap7.html

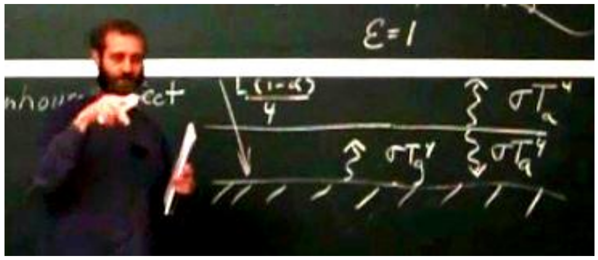
Pennsylvania State University



https://www.e-education.psu.edu/meteo469/node/198

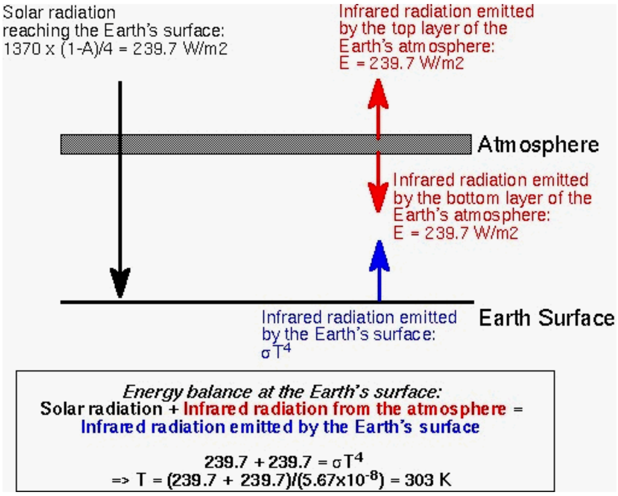
University of Chicago

Found in Chapter 3, lecture 5 video lecture: *The Greenhouse Effect.*



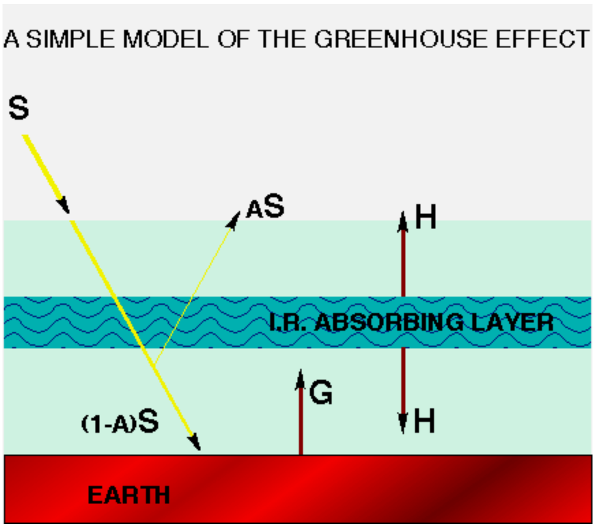
http://mindonline.uchicago.edu/media/psd/geophys/PHSC_13400_fall2009/lecture5.mp4

University of Washington's Department of Atmospheric Sciences.



http://www.atmos.washington.edu/2002Q4/211/notes_greenhouse.html

Columbia University



http://eesc.columbia.edu/courses/ees/climate/lectures/gh_kushnir.html

Enviropedia.org.uk

"*Greenhouse gases like water vapour, carbon dioxide, methane and nitrous oxide trap the infrared radiation released by the Earth's surface. The atmosphere acts like the glass in a greenhouse, allowing much of the shortwave solar radiation to travel through unimpeded, but trapping a lot of the longwave heat energy trying to escape back to space. This process makes the temperature rise in the atmosphere just as it does in the greenhouse.*"

http://www.enviropedia.org.uk/Climate_Change/Greenhouse_Effect.php

The U.S. government's Environmental Protection Agency

"*The energy that is absorbed is converted in part to heat energy that is re-radiated back into the atmosphere. Heat energy waves are not visible, and are generally in the infrared (long-wavelength) portion of the spectrum compared to visible light. Physical laws show that atmospheric constituents—notably water vapor and carbon dioxide gas—that are transparent to visible light are not transparent to heat waves. Hence, re-radiated energy in the infrared portion of the spectrum is trapped within the atmosphere, keeping the surface temperature warm. This phenomenon is called the "greenhouse effect" because it is exactly the same principle that heats a greenhouse.*"

http://www.epa.gov/ne/students/pdfs/activ13.pdf

UK government website:

"*After gas molecules absorb radiation, they re-emit it in all directions. Some of the infrared radiation absorbed by gases in the atmosphere is therefore re-radiated out towards space and eventually leaves the atmosphere, but some is re-radiated back towards the Earth, warming the surface and lower atmosphere (illustrated by the 'back radiation' term in Figure 2). This warming is known as the greenhouse effect and the gases that are responsible for it are known as greenhouse gases.*"

http://www.bis.gov.uk/go-science/climatescience/greenhouse-effect

PBS

"*Inside an artificial greenhouse filled with plants, the surrounding glass traps the sun's energy, making it warm inside, even while outside the temperature may be much colder. This same effect happens every day on the Earth. Gases within the atmosphere act like glass, trapping the sun's heat.*"

http://www.pbs.org/wgbh/nova/ice/greenhouse.html

BBC

"*A greenhouse works because of the glass panels that line the roof and walls. The glass is transparent to the visible light from the sun, so sunlight can shine in and warm things inside the greenhouse. Now a body at about 35°C emits mostly infrared radiation. (On the other hand our sun, with a surface temperature of about 5500°C, emits mostly visible light.) The glass panels are opaque to infrared light. The result is that the glass lets the energy of the sun in, but won't let it back out. This keeps the inside of a greenhouse warm. Replace the greenhouse with Earth and glass panels with atmosphere in the above example, and that is how the Earth's greenhouse effect works.*"

http://www.bbc.co.uk/dna/h2g2/A283277

University Corporation for Atmospheric Research (UCAR)

"*Have you ever been inside a greenhouse on a cold winter day? It might be cold outside, but inside the greenhouse lush green plants flourish in the warmth and sunshine. Greenhouses are made of glass and are designed to hold heat inside. The atmospheres of some planets are able to trap energy just like a greenhouse. Energy from the Sun can enter the atmosphere, but not all of it can easily find its way out again. What blocks the Sun's energy from escaping a planet's atmosphere? Unlike a greenhouse, planets do not have a layer of glass over them! Instead, molecules in the atmosphere called greenhouse gases absorb the heat.*"

http://www.windows.ucar.edu/tour/link=/earth/interior/greenhouse_effect.html

Boston University

"*A simple greenhouse effect model*

A. *Glass represents the 'normal' greenhouse effect on earth and is at top of atmosphere*
B. *Solar shortwave radiation S largely makes it to surface*
C. *For energy balance, top of glass must send S back out*
D. *Greenhouse gases don't have a preferred direction; they send S units in both directions – up and down*
E. *Thus, the surface of the earth receives 2S due to the greenhouse effect – instead of 1S if there were no atmosphere!*
F. *Thermal radiation emitted from earth = 2S*"

http://people.bu.edu/nathan/ge510_06_6.pdf

From *Fundamentals of Thermal Radiation*

"*[Greenhouse gases] act as a shield between the radiation emission from the Earth's surface and the heat sink of outer space, adding additional resistance to heat rejection by the Earth, without significantly affecting the shorter wavelength solar radiation absorbed by the Earth. … The same effect occurs in greenhouses and solar collectors, where the glass cover transmits solar energy in the visible spectrum; however, glass is nearly opaque at IR wavelengths, so emission from the plant beds or collector plate cannot escape, and the greenhouse or solar collector temperature remains well above the outdoor ambient temperature. This is actually the origin of the descriptive term 'greenhouse' in 'greenhouse gases'.*"

Appendix I: Sample List of References for the Insulative Description of the GHE

This sample of quotation references describe the GHE as an insulative mechanism similar to a physical greenhouse. Comparison can variously be made to blankets, parked cars, clothing, etc. However, all of these types of comparisons are physically inappropriate. These physical objects with solidity were invented by humans to trap warmed air near a source of heat. The air stays warm because it is prevented from blowing away, circulating, convecting, or what have you, because those things would otherwise be the natural response of heated air in the gaseous atmosphere. "Greenhouse gasses", by definition, do not have the physical ability of a solid to trap warm air…they have no ability to prevent the circulation or convection of warm air away from its source of heat, which is the physical ground surface. Real greenhouses, or blankets, etc., do the opposite thing that the atmospheric gases naturally do, and an increase of a trace GHG in the gaseous atmosphere has no effect on the ability of the gas to circulate. Thus, the premise that the flawed concept of "gaseous-insulation" in the open atmosphere is analogous to heated-gas-trapping in a physically solid greenhouse (or other) is unsound. Yet this analogy is consistently used to justify an atmospheric form of the GHE. Any gas in the open atmosphere is not capable of trapping itself or other gases, yet we are told that trace gases do perform this task by virtue of a comparison to something that does not actually occur.

Ontario Ministry of Natural Resources

"Our atmosphere is full of invisible gases, some of which are greenhouse gases. Greenhouse gases insulate the Earth. They trap the sun's heat and keep our planet warm enough to sustain life"

http://www.mnr.gov.on.ca/en/Business/ClimateChange/2ColumnSubPage/STDPROD_090050.html

Georgetown University

"Furthermore, CO2 is not the only greenhouse gas to be increasing in concentration in the atmosphere. … CFC's, though relatively low in concentration, actually absorb infrared radiation that otherwise passes through the atmosphere, so they act as particularly effective insulators."

http://bouman.chem.georgetown.edu/S02/lect23/IntrotoGreenhouseEffect.pdf

Newfoundland & Labrador Department of Education

"Recently, however, human activities have increased the amount of greenhouse gases in the atmosphere. This increase has thickened the insulation around the planet, which has caused Earth's overall average surface air temperature to increase and is believed to be the cause of more severe weather events."

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool/ES3205_student_text_chapter_18.pdf

UCAR

"This absorption-emission-absorption cycle serves to keep the heat near the surface, effectively insulating the surface from the cold of space."

http://www.ucar.edu/learn/1_3_1.htm

LandLearn NSW

"Greenhouse gases act as an insulation layer to trap some of the sun's energy in the earth's atmosphere, between the earth's surface and this insulation layer. This is similar to the situation in a greenhouse - the glass walls allow heat and sunlight in during the day and trap it there so it can warm the plants that are growing inside."

http://www.landlearnnsw.org.au/sustainability/climate-change/what-is-it/greenhouse-gases

eHow

"The gases, including water vapor, methane, carbon dioxide and nitrous oxide, insulate our earth much like a blanket."

http://www.ehow.com/how-does_4926343_how-greenhouse-gases-work.html#ixzz27gfbkXNH

National Geographic

"Earth stays warm by trapping heat from the sun in the atmosphere. The planet has a layer of protective gases --- called greenhouse gases --- that act as an insulating blanket around the planet to hold in heat. After sunlight hits Earth and ricochets back up, much of that solar radiation bumps into the greenhouse gas layer and bounces back to us."

http://greenliving.nationalgeographic.com/greenhouse-effect/

Appendix J: Matlab Code for H_2O simulation with Phase Change and Latent Heat

```
function ThermalODE_VarCp_AppJ

%load the interpolated fit objects for Cp ice & liquid (they are fcns of T)
Cp_ice = load('Cp_ice.mat'); Cp_ice = Cp_ice.Cp_ice;
Cp_liq = load('Cp_liq.mat'); Cp_liq = Cp_liq.Cp_liq;
albedo = 0.05;  %albedo; ocean water can be darker
emis = 0.95;    %emissivity
opts = odeset('RelTol',1e-6);   %set the tolerance tighter
T_liqice = 273.15 * 1;  %K; Temperature of 0C ice/liq; Set '* 1' to '* 3'
% so that latent heat range isn't computed; ODE fcn will still change Cp
%between different phases (Temp < 273.15 vs. Temp > 273.15)
mass = 1000;  %kg
days = 150;  %number of days to model
NPts = 50000;   %number of time points

%The number of time points in the model is a sensitive parameter beyond the
%usual model tolerance issue.  We can't predict when the phase change/latent
%heat will occur, so we can only run the model up until the point where
%that occurs, and then adjust the relevant parameters at that point. But
%error creeps in because we won't peg exactly the time where the changes
%occur.  So, you have to have enough points in the model that you will peg
%"close enough" to the phase changes, such that the subsequent error
%differential of total energy is small relative to the total energy.

%J, total energy to bring 0C solid ice to 0C liquid water
enth_fus = 334000*mass;
E_lat = zeros(1,NPts);%variable to track through latent range
tot_E = zeros(1,NPts) + mass*Cp_ice(173.15);%J, total accumulated energy,
%starting at said value as an approximation to energy content @173.15
SLN_TEMP = ones(1,NPts)*173.15;%array for solution temperatures, starting at
%-100C because this is the only range I could find Cp data for ice
ODE_SLN = [];%dummy array for Matlab ODE solution object
time = linspace(0,days*86400,NPts);%time, in seconds

gamma = 0;    %GHE return factor
G0 = 0;       %GHE constant forcing factor

%input flux W/m^2, approximating Solar values with 0.18 extinction plus blue
%sky scattering
Flux_In = (1370*0.82 + 75) * sin(2*pi/86400*time) * (1 - albedo);
%another option for input flux (i.e. constant)
%Flux_In = 168 * ones(1,length(time));
%set negative sin values to zero flux (night time)
Flux_In(Flux_In < 0) = 0;

%switchfield parameters for tracking phase changes
switch_to_ice = true;
switch_to_liq = false;
switch_to_fus = false;
%for indicating that solution requires re-computation after phase change
recompute = true;
```

```
for i = 2:NPts
    %check if you're back to ice
    if E_lat(i-1) <= 0 && switch_to_ice
        recompute = true;
        switch_to_ice = false;
        switch_to_liq = true;
        switch_to_fus = false;
    %check if you're into liquid
    elseif E_lat(i-1) >= enth_fus && switch_to_liq
        recompute = true;
        switch_to_ice = true;
        switch_to_liq = false;
        switch_to_fus = false;
    end

    %if the solution requires recomputation due to phase change
    if recompute
       i%just to give an indication in the cmd window things are running
       ODE_SLN = ode45(@(dummy_time,Temp)TPrime(dummy_time,Temp,Flux_In ...
           (i-1:end),mass,Cp_ice,Cp_liq,time(i-1:end),emis,gamma,G0), ...
           time(i-1:end),SLN_TEMP(i-1),opts);
        recompute = false;%don't come back here unless you need to
    end

    if SLN_TEMP(i-1) <= T_liqice && E_lat(i-1) <= 0%then we're in ice
        SLN_TEMP(i) = deval(ODE_SLN,time(i));
        E_lat(i) = E_lat(i-1);%track latent energy
    elseif SLN_TEMP(i-1) >= T_liqice && E_lat(i-1) < enth_fus % in lat
        SLN_TEMP(i) = SLN_TEMP(i-1);
        E_lat(i) = E_lat(i-1) + sum(interp1(time(i-1:i),Flux_In(i-1:i) + ...
            G0 - (1 - gamma)*emis*5.67e-8*SLN_TEMP(i-1:i).^4, ...
            time(i-1):time(i)));%track latent energy
    elseif SLN_TEMP(i-1) >= T_liqice && E_lat(i-1) >= enth_fus %in liquid
        SLN_TEMP(i) = deval(ODE_SLN,time(i));
        E_lat(i) = E_lat(i-1);%track latent energy
    elseif SLN_TEMP(i-1) <= T_liqice && E_lat(i-1) <= enth_fus %in lat...
        %this will kick back to the other 'in lat' elseif after single entry
        SLN_TEMP(i) = SLN_TEMP(i-1);
        E_lat(i) = E_lat(i-1) + sum(interp1(time(i-1:i),Flux_In(i-1:i) + ...
            G0 - (1 - gamma)*emis*5.67e-8*SLN_TEMP(i-1:i).^4, ...
            time(i-1):time(i)));%track latent energy
    end

    %add up total accumulated energy: total input minus total output,
    %interpolated at one second to match unit scale.
    tot_E(i) = tot_E(i-1) + sum(interp1(time(i-1:i),Flux_In(i-1:i) + ...
      G0 - (1 - gamma)*emis*5.67e-8*SLN_TEMP(i-1:i).^4,time(i-1):time(i)));

    %perform the switchfield check to inform the next iteration
    if E_lat(i) <= 0 && switch_to_fus
        p = 1 %display value just to indicate phase change in cmd window
        E_lat(i) = 0;%reset this to "peg" the value (rqrd abve for elseif's)
        switch_to_ice = true;
        switch_to_fus = false;
        switch_to_liq = false;
    elseif E_lat(i) > 0 && E_lat(i) < enth_fus && ~switch_to_fus
```

```
        p = 2 %display value just to indicate phase change in cmd window
        SLN_TEMP(i) = T_liqice;%reset this to "peg" the value
        switch_to_ice = false;
        switch_to_fus = true;
        switch_to_liq = false;
    elseif E_lat(i) >= enth_fus && switch_to_fus
        p = 3 %display value just to indicate phase change in cmd window
        E_lat(i) = enth_fus;%reset this to "peg" the value
        switch_to_ice = false;
        switch_to_fus = false;
        switch_to_liq = true;
    end
end

%plot the solution
plot(time/86400,SLN_TEMP);title('Temperature');
axis([0 days 0 400])
%display mean temp of last day and copy to clipboard
mean_temp = mean(SLN_TEMP(round(NPts*(days-1)/days):end)) - 273
clipboard('copy',mean_temp)
%display mean total energy on last day
mean_E = mean(tot_E(round(NPts*(days-1)/days):end))

function dTdt = TPrime(dummy_time,Temp,Flux_In,mass,Cp_ice,Cp_liq,time, ...
    emis,gamma,G0)
% function to numerically integrate
% dT / dt = ( Flux_In + G0 - (1-gamma)*emis*sigma*T^4 ) / tau

%interpolate the input flux to the integration point
f_int_t = interp1(time,Flux_In,dummy_time,'linear');

tau = 0;
if Temp <= 273.15
    tau = mass * Cp_ice(Temp);
elseif Temp > 273.15
    tau = mass * Cp_liq(Temp);
end

%return value of differential at current Flux & Temperature
dTdt = (f_int_t + G0 - (1-gamma)*emis*5.67e-8*Temp.^4)/tau;
```

Appendix K: Results for the H_2O Model Simulation

Table 3: Results from H_2O Simulation

Mass	Temperature With Latent	Temperature Without Lat.	Anomaly	Days
2.0	-62.5	-66.2	3.7	5
5.0	-39.2	-47.9	8.7	5
10.0	-16.0	-29.8	13.8	5
17.0	1.8	-14.4	16.2	10
25.0	10.0	-4.1	14.0	10
50.0	12.1	8.1	4.0	10
100.0	12.7	12.2	0.4	25
250.0	13.2	13.2	0.0	50
1000.0	13.4	13.4	0.0	150

References:

1. Gerlich, G. and R.D. Tscheuschner, *Falsification of the Atmospheric CO2 Greenhouse Effects Within the Frame of Physics.* International Journal of Modern Physics B, 2007. **23**(03): p. 275-364.
2. Smith, A.P., *Proof of the Atmospheric Greenhouse Effect.* ArXiv e-prints, 2008.
3. Donohoe, A. and D.S. Battisti, *Atmospheric and Surface Contributions to Planetary Albedo.* Journal of Climate, 2011. **24**.
4. Hayden, B.P.; Available from: http://atlantic.evsc.virginia.edu/~bph/AW_Book_Spring_96/AW_Book_21.html.
5. Hertzberg, M., *Earth's Radiative Equilibrium in the Solar Irradiance.* Energy & Environment, 2009. **20**(1).
6. Schneider, E.K., B.P. Kirtman, and R.S. Lindzen, *Tropospheric Water Vapor and Climate Sensitivity.* Journal of the Atmospheric Sciences, 1998. **56**.
7. Gray, D.F., *The Observation and Analysis of Stellar Photospheres*. 2nd ed. Cambrdge Astrophysics Series1992, New York: Cambridge University Press.
8. Briegleb, B.P., *Delta-Eddington Approximation for Solar Radiation in the NCAR Community Climate Model.* Journal of Geophysical Research, 1992. **97**(D7): p. 7603-7612.
9. Chou, M.-D. and M.J. Suarez, *A Solar Radiation Parameterization for Atmospheric Studies*, in *Technical Report Series on Global Modeling and Data Assimilation*, M.J. Suarez, Editor 1999, NASA.
10. Hansen, J., et al., *Climate Impact of Increasing Atmospheric Carbon Dioxide.* Science, 1981. **213**(4511).
11. Wikipedia. *Atmosphere of Earth*. Available from: http://en.wikipedia.org/wiki/Atmosphere_of_Earth.
12. Wikipedia. *Atmosphere Model Plot*. Available from: http://en.wikipedia.org/wiki/File:Atmosphere_model.png.
13. 2005; US Climate Change Science Program Report]. Available from: http://sciencespeak.com/MissingSignature.pdf.
14. Miskolczi, F.M., *Greenhouse Effect in Semi-Transparent Planetary Atmospheres.* Quarterly Journal of the Hungarian Meteorological Service, 2007. **111**(1): p. 1-40.
15. Science, F.o.; Available from: http://www.friendsofscience.org/assets/documents/The_Saturated_Greenhouse_Effect.htm.
16. Moroney, C., R. Davies, and J.P. Muller, *Operational Retrieval of Cloud-Top Heights Using MISR Data.* IEEE Transactions on Geoscience and Remote Sensing, 2002. **40**(7).
17. Davies, R. and M. Molloy, *Global Cloud Height Fluctuations Measured by MISR on Terra from 2000 to 2010.* Geophysical Research Letters, 2012. **39**.
18. Ignatiev, N.I., et al., *Altimetry of the Venus cloud tops from the Venus Express observations.* Journal of Geophysical Research, 2009. **114**(E00B43).
19. Wikipedia. *Venus*. Available from: http://en.wikipedia.org/wiki/Venus.
20. Haberman, R., *Elementary Applied Partial Differential Equations*. 3rd ed1998, Upper Saddle River, NJ: Prentice Hall, Inc.
21. WolframAlpha. Available from: http://www.wolframalpha.com/.
22. Mathworks. Available from: http://www.mathworks.com/.

23. Arya, S.P., *Introduction to Micrometeorology*. 2nd ed. International Geophysical Series. Vol. 79. 2001: Academic Press.
24. Bader, D.C., et al., *Climate Models: An Assessment of Strengths and Limitations*, in *Synthesis and Assessment Product 3.1*, J.W.A. Adamson, Editor 2008, U.S. Climate Change Science Program.
25. Kiehl, J.T. and K.E. Trenberth, *Earth's Annual Global Mean Energy Budget.* Bulletin of the American Meteorological Society, 1997. **78**(2): p. 197-208.
26. Jacob, D.J., *Introduction to Atmospheric Chemistry*1999: Princeton University Press.
27. Wikipedia. Available from: http://en.wikipedia.org/wiki/Stevenson_screen.
28. USNO, N.A.O., *The Astronomical Almanac*, 2000, U.S. Government Printing Office: Washington, D.C.
29. Schlosser, W., T. Schmidt-Kaler, and E.F. Milone, *Challenges of Astronomy* 1994, New York: Springer-Verlag.
30. Pionas, P., *Satellite Thermal Control Engineering*, 2004.
31. Ice. *The Engineering ToolBox*. Available from: http://www.engineeringtoolbox.com/ice-thermal-properties-d_576.html.
32. Liquid. *The Engineering ToolBox*. Available from: http://www.engineeringtoolbox.com/water-thermal-properties-d_162.html.
33. Postma, J.E. *Understanding the Thermodynamic Atmosphere Effect*. 2011; Available from: http://www.ilovemycarbondioxide.com/pdf/Understanding_the_Atmosphere_Effect.pdf.
34. Postma, J.E. *The Model Atmospheric Greenhouse Effect*. 2011; Available from: http://principia-scientific.org/publications/The_Model_Atmosphere.pdf.
35. Postma, J.E. *Copernicus Meets the Greenhouse Effect*. 2011; Available from: http://principia-scientific.org/publications/Copernicus_Meets_the_Greenhouse_Effect.pdf.
36. Wikipedia. *Ocean Current from NOAA*. Available from: http://en.wikipedia.org/wiki/Ocean_current http://en.wikipedia.org/wiki/File:Ocean_surface_currents.jpg.
37. Briggs, Smithson, and Ball, *Fundamentals of Physical Geography*1989, Toronto: Copp Clarke and Pitman.
38. Hofstadter, D.R., *I Am a Strange Loop*2007.
39. Johnson, C. *Mathematical Physics of BlackBody Radiation*. 2012; Available from: http://www.csc.kth.se/~cgjoh/ambsblack.pdf.
40. Cotton, D. *Radiated Energy and the Second Law of Thermodynamics*. 2012; Available from: http://principia-scientific.org/publications/psi_radiated_energy.pdf.
41. Siddons, A. *The Hidden Flaw in Greenhouse Theory*. 2010; Available from: http://www.americanthinker.com/2010/02/the_hidden_flaw_in_greenhouse.html.