Response to “Unified Theory of Climate”

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Introduction

During the last two years that I have been teaching Environmental Science and attempting to explain global warming to my students, I have been frustrated at the lack of solid theoretical understanding of the primary processes coupled with actual data. Speaking as a research physicist, I have been saying to others, “Wait until the physicists get into action. They have an entirely different approach to solving physical problems”.

Sure enough, two such physicists have published their analysis of their fundamental understanding of the climate. In October 2011 Nikolov and Zeller presented their analysis in a poster entitled “Unified Theory of Climate” at the World Climate Research Program in Denver. Their analysis was indeed from fundamental physical and mathematical principles. A month or so later their poster was converted into a document and appeared on Tallbloke (Zeller). From there it spread to WUWT and many other blogs, and it has generated a tremendous amount of discussion.

I would like to add my two-cents to that discussion.

Calculating the Average Temperature of the Earth

It can be something of a difficult problem to define what is meant by the average temperature of the earth. Some have argued that there is no such thing as the “average” temperature; that temperature is a localized measure. However, temperature is a measure of the energy in a system, and energy can be averaged.

Virtually all the energy received on the surface of the earth comes from solar radiation. The sun acts like a black-body with a temperature of 5780 K. According the Stefan-Boltzmann law, the energy it emits is

$$j_0 = \sigma * T^4 \qquad (1)$$

Here $\boldsymbol{j_0}$ is the irradiance measured in watts/m^2, $\boldsymbol{T}$ is the temperature in Kelvins, and $\boldsymbol{\sigma}$ is the Stefan-Boltzmann constant. Of the 63 million watts/m^2 given off by the sun, approximately 1366 watts/m^2 is received at the edge of our atmosphere.

However, not all of the solar radiation from the sun has a direct effect on the surface temperature of the earth. Energy that is reflected does not prove any warming effect. That fraction of the energy reflected is called the albedo, which for the earth is about 30%. The amount of the energy absorbed is emissivity, denoted by the symbol $\boldsymbol{\varepsilon}$**.** Thus,

$$\varepsilon = (1\text{-albedo}) \qquad (2)$$

Equation 1 is thus modified as:

$$j_0 * \varepsilon = \sigma * T^4 \qquad (3)$$

Knowing the radiance, then, the temperature at any given point is:

$$T = \sqrt[4]{\frac{\varepsilon * j_0}{\sigma}} \qquad (4)$$

Thus one only needs to know the average irradiance to calculate the average temperature.

The IPCC Approach

The earth, however, is a rotating sphere, and the problem of calculating the average irradiance is not apparent at first sight. The IPCC made two assumptions to simplify the calculation:

1. At any point the half of the earth is illuminated and half is in darkness. Therefore, the IPCC assumed a hemisphere illuminated by half of the irradiance and:

$$j_1 = \frac{j_0}{2} \qquad (5)$$

2. Since the surface area of a hemisphere is exactly twice the surface are of a disc with the same radius, the effective irradiance is halved again:

$$j_2 = \frac{j_1}{2} = \frac{j_0}{4} \qquad (6)$$

This process is illustrated in Figure 1.

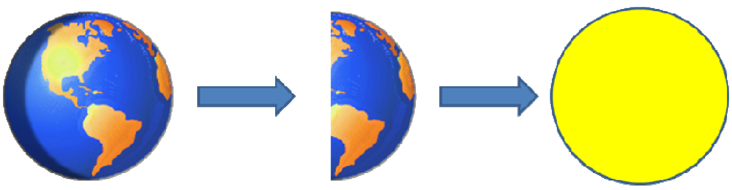

Figure 1: Sphere to Hemisphere to Disc

Using this approximation for the irradiance, j, and applying an albedo of 0.30 the IPCC concluded the average temperature of the earth was about 255K. Since the average temperature of the earth is considered to be 288K then the difference between the calculated and actual average temperatures, which is -33°C, represents the effect of the atmosphere. That is, the presence of earth's atmosphere raises the average temperature by 33°C. Moreover, the only way to account for this is via the "greenhouse effect".

The Approach of Nikolov and Zeller (slightly altered):

Nikolov and Zeller took another approach towards calculating the average irradiance, and thus the average temperature. They said the approximations applied by the IPCC were incorrect, and that the only valid method of finding the average irradiance is to perform a "proper spherical integration of the planetary temperature field." They further specified that they wanted to calculate the average surface temperature of the earth without the presence of an atmosphere at all. They called this "planet" a "gray-body".

It is at this point that I think many people get confused, since they are not accustomed to differential calculus. So I am going to present a slight altered approach.

At any given point on the sunlit portion of the moon the irradiance is given by

$$j_{\theta,\varphi} = j_0 \ \sin\theta \ \cos\vartheta \tag{7}$$

and

$$T^4(\theta,\vartheta) = \frac{\epsilon * j_0 \sin\theta \cos\vartheta}{\sigma} \tag{8}$$

Or

$$T(\theta,\vartheta) = \sqrt[4]{\frac{\epsilon * j_0 \sin\theta \cos\vartheta}{\sigma}} \tag{9}$$

Here the longitude is given by the angle θ relative to the horizon and ranges from 0 to π. The latitude is given by the angle φ relative to the equator and ranges from (–π/2) at the south pole to zero at the equator to (π/2) at the north pole.

Consider the first assumption, that is, the one that accounts for the earth's rotation, made by the IPCC. If the irradiance as a function of longitude on the surface was a linear function of the sun's angle then an arithmetic average would be sufficient.

However, the angle of the sun is non-linear, so rather than performing an arithmetic average, we need to perform the proper way to average a function over a surface. This is done by integrating the function over the range of the given variable from the minimum value of the variable, $\boldsymbol{a}$, to the maximum value, $\boldsymbol{b}$. The average of a function therefore has the general form,

$$f_{avg}(x) = \frac{1}{b-a}\int_a^b f(x)dx \tag{10}$$

The two angles, θ and φ, are orthogonal, and are thus independent of one another. That means we can perform the integration of the two sequentially. That is, we can integrate with respect to one angle while holding the other a constant, then, using the results of that integral as a constant, integrate with respect to the other angle.

Consider the following scenario:

1. At the equator, the angle φ =0 and cos φ=1, which is a constant. There is no solar energy until the sun crests the horizon in the east. At this point the angle of the sun is very low, and θ is zero. During the course of the day the sun rises to its apex at noon and then declines until it sets, and θ = π. The surface temperature at any time during the day is therefore a function of the angle θ and is given as:

$$T(\theta) = \sqrt[4]{\frac{\epsilon * j_\theta}{\sigma}} = \sqrt[4]{\frac{\epsilon * j_0 \sin\theta}{\sigma}} \tag{11}$$

   Since the albedo for a gray-body, such as the moon, is approximately 0.11, from equation 2 above the emissivity is thus 0.89.

2. In order to find the average **daytime** temperature one must now integrate this function with respect to θ over the range of angles for 0 to π, as per equation 10.

$$T_{day}(\theta) = \frac{1}{\pi}\int_0^\pi T(\theta)d\theta = \frac{1}{\pi}\int_0^\pi \sqrt[4]{\frac{\epsilon * j_0 \sin\theta}{\sigma}}\ d\theta \tag{12}$$

   Everything within the radical is a constant except for sin (θ) and can be factored outside the integral. Thus the integral becomes:

$$T_{day}(\theta) = \frac{1}{\pi}\sqrt[4]{\frac{\epsilon * j_0}{\sigma}}\int_0^\pi \sqrt[4]{\sin\theta}\ d\theta \tag{13}$$

   As far as I can tell, the above integral does not have a closed form and must be evaluated numerically (Vanovschi). When this is done the value of the integral is :

$$\int_0^\pi (\sin\theta)^{1/4}\ d\theta = 2.7 \tag{14}$$

   This yields the average daytime temperature:

$$T_{day} = \frac{2.7}{\pi}\sqrt[4]{\frac{\epsilon * j_0}{\sigma}} \tag{15}$$

   Taking j_0 to be 1366 w/m^2, the average daytime temperature would thus be:

$$T_{day} = \frac{2.7}{\pi}\sqrt[4]{\frac{\epsilon * j_0}{\sigma}} = \frac{2.7}{\pi} * 383K \cong 329K \tag{16}$$

3. Assuming that the nighttime temperature is approximately a constant and lasts the same length of time as the daytime, the average temperature at the equator during one day is

$$T_{eq} = \frac{1}{2}\left(T_{day} + T_{night}\right) = \frac{1}{2}(329K + T_{night}) \tag{17}$$

Determining T_{night} is not as simple as setting the irradiance to zero. There are three factors that affect the nighttime temperature:

a. The background deep-space radiation of 2.72K, which is the smallest affect.
b. The irradiance from the earth. Assuming the irradiance of the earth is equal to 1366 w/m^2, the maximum irradiance on the lunar surface is about 0.37 w/m^2. This much irradiance would produce a maximum nighttime temperature of approximately 50K.
c. The effect of the heat capacity of the moon's surface. The stored energy from the sun during the day would result in a lag in reaching the minimum temperature at night. According to the published results of the *Diviner* project, the minimum nighttime temperature at the equator would be about 90-95K.

Using the third value of 93K yields an average equatorial temperature of about **211K**. This compares quite favorably with Diviner measurements.

The second assumption by the IPCC, that the effective surface area is half of the area of a hemisphere, suffers from the same fault. Again, one must integrate the function over the latitude of the sphere.

Having determined the average daytime temperature at the lunar equator from equation 16, we can now average this over the latitudes from pole to pole. At any given latitude

$$T_{avg}(\vartheta) = T_{day} * \frac{1}{\pi}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \sqrt[4]{\cos\vartheta}\ d\vartheta \tag{18}$$

The value of the integral of $(\cos\varphi)^{1/4}$ in equation 18 is the same as that in equation 14 above. Thus,

$$T_{avg} = \frac{2.7}{\pi} T_{day} = 283K = 10^{o}C \tag{19}$$

We can now average with the nighttime temperature, which is about the same at all latitudes, to get an overall gray-body temperature:

$$T_{gb} = \frac{1}{2}\left(T_{avg} + T_{night}\right) = \frac{1}{2}(283K + 93K) \cong 188K \tag{20}$$

Notice that the results are significantly different than that of Nikolov and Zeller, which was about 155K.[1] While 33K higher, it is still significantly lower than the results of the Stefan-Boltzmann approach of the IPCC.

Following the approach of the IPCC, the average calculated temperature of the moon would be:

[1] According to the posting on Tallbloke today, which gives a *Diviner*-calculated mean lunar temperature of from 192-197K, this is very good agreement.

$$T'_{gb} = \sqrt[4]{\frac{\epsilon * j_2}{\sigma}} = \sqrt[4]{\frac{\epsilon * 342}{\sigma}} \cong 270K \quad (21)$$

Given the results so far from the *Diviner* project the IPCC approach is clearly wrong.

Almost all the predictions from the IPCC and others are predicated on the results of models, as if those model results were equivalent to actual, real-live data. These models, however, were all predicated on assumptions concerning the nature of the effect of the atmosphere on temperature.

Nikolov and Zeller have done us a great service by pointing out the errors of the most fundamental of assumptions: the role of the greenhouse effect. Whether you agree with their method or not, their method begins with firm foundational principles, and their results are outstanding. We must come to the place where we follow where the data leads, not our pre-conceived ideas.

Works Cited

Vanovschi, Vitalii. The Number Empire--Definite Integral Calculator. <http://www.numberempire.com/definiteintegralcalculator.php>.

Nikolov & Zeller. Unified Theory of Climate. <http://tallbloke.files.wordpress.com/2011/12/unified_theory_of_climate_poster_nikolov_zeller.pdf>.

Dr. Sweger did his undergraduate work at Duke University, graduating in 1965, and earned his Ph.D. in Solid State Physics at American University in 1973. He is currently adjunct faculty at National College, where he teaches Environmental Science, among other subjects. He previously has posted a paper entitled **Earth's Climate Engine** which can be found at http://junksciencearchive.com/Greenhouse/Earth-s_Climate_Engine.pdf. From the Executive Summary:

While models can be useful, the results must be compared to actual measurements, i.e. data. Data is the language of science, but little has been done in that regard with the climate change models.

It is the premise of the author that water vapor is the dominant influence in determining and understanding global climate. Water vapor is much more abundant in the atmosphere than carbon dioxide, and its physical properties make it more important as well. During daylight hours it moderates the sun's energy, at night it acts like a blanket to slow the loss of heat, and it carries energy from the warm parts of the earth to the cold. Compared to that, if carbon dioxide has any effect it must be negligible. Thus, the purpose of this paper is to explore the effect of water vapor on climate.

Detailed calculations and analysis of data from several locations clearly demonstrate that the effect of water vapor on temperature dominates any proposed effect of carbon dioxide. Furthermore, it is clear from the data presented that water vapor acts with a negative feedback on temperature, not a positive one. That is, the data demonstrate that increasing the level of water vapor in the atmosphere results in a decrease of temperature, not an increase as predicted by the climate models. In essence, atmospheric water vapor acts as a thermostat.