Copernicus Meets the Greenhouse Effect

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The Earth-Centered Solar System

Ptolemy's epicyclic, nested-spheres, model of the solar system worked wonderfully for predicting the movements and positions of the planets. It was a model which, for the time-period, could correctly predict the broad observables, but it accomplished this with, as we now know, completely unrealistic internal physics and boundary conditions.

By "broad observables", we refer to the actually observable and measureable characteristics of the system. In the case of Ptolemy's model of the solar system, these 'observables' were the positions and movements of the planets. The meaning of this term is therefore generally self-explanatory.

How one interprets the meaning of the term "boundary condition" is a somewhat more philosophically and scientifically interesting concept. The idea of a "boundary condition" can be understood to apply to the physical conditions of a system, but also, to the cognitive domain which is created, and then bounded, by the assumptions which go in to establish what are *believed to be* the aforementioned physical conditions of that system. However, the *assumed physical conditions* of the system, which establish what type of mathematics and physics are created by the human mind in the attempt to characterize the system and understand its observables, can be incorrect, *even though* we might still succeed in creating a physics which satisfies the relevant observables. In this case, the internal physics would not necessarily correspond to reality, even if they might make successful predictions of the external observables.

The Ptolemaic solar system is the pertinent example: for 1400 years we assumed that the Earth is at the center of the solar system, because this seemed to be a perfectly reasonable assumption given that we observe the Sun, stars, and wandering planets circling about us, every day. But there are slight variations in the observed "tracks" of the Sun and planets relative to the fixed firmament, and so a physics of 'epicycles' was created to explain and describe those variations. Given the time-period and its associated technology, this model of the heavens was believed, by the vast majority of Natural Philosophers, to explain the universe quite well-enough indeed.

So in this model we had a cognitive-physical boundary condition: the implicit assumption that the Earth was at the center of all the heavens and that all the heavens circle about it. Looking back with the advantage of our knowledge today, we understand that the Ptolemaic model was actually only a cognitive boundary condition, and not an actually physical one corresponding with reality. With the assumption of an Earth-centered universe comes a defined cognitive domain, or phase-space, or boundary condition, into which research and thought on the nature of the universe is conducted. This is also called a paradigm. And once a paradigm becomes firmly entrenched, it can take thousands of years before someone thinks of questioning the primary assumptions of said paradigm in the face of unexplainable observables, as had been the case for the Ptolemaic Model. The difficulty becomes nearly insurmountable in consideration of the fates of some of the first individuals to do so, to the wrong people. The existing Ptolemaic physics could always incorporate new and more precise observations, simply by extending the existing physics to include more and more epicycles upon the celestial spheres.

Copernicus & the Greenhouse Effect

Fast forward to 1543 and the publication of "On the Revolutions of the Celestial Spheres" by Nicolaus Copernicus. The Copernican "revolution" wasn't merely just a change in the assumed physical conditions of the system; it presented an entirely new phase-space, an entirely unique boundary condition, in which the human mind could explore permutations of a new axiomatic field. It was a qualitative and quantitative shift in cognition, where essentially *none* of the previous physics any longer had any relevance or meaning. The observed facts, or broad observables, remained entirely the same of course, but the new underlying assumptions directed an entirely new and unique physics. The Copernican paradigm created an entirely new cognitive phase-space which minds could explore, leading directly to the created thoughts and physics of such as Kepler, Newton, Einstein, etc. It is very easy to conclude that the success of the Copernican Model in the history of science is due to the logically valid fusion of both cognitive *and* physical boundary conditions; that is, the way we started thinking about the system is the way the system *actually does* behave – the Sun *really is* at the center of the solar system and the planets *really do* circle about it.

In my July 2011 paper, 'The Model Atmosphere[1]', I reviewed the standard model and associated boundary conditions of the radiative atmospheric greenhouse effect (GHE), which is postulated to explain the surface-air temperature on the Earth. The paper cited sixty-three major references to the model of the GHE, which included academic sources such as Harvard's Atmospheric Chemistry modeling group, Pennsylvania State University, the University of Washington's Department of Atmospheric Sciences, etc., and a multitude of websites from NASA, governmental and international institutions, and various general scientific public outreach organizations. I clearly recall my own undergraduate astrophysics training at the University of Western Ontario, where in the first year, the physics classroom was taught this very same model as well. The model discussed in the July paper *is the standard model* of the postulated greenhouse effect in Earth's atmosphere; it is reproduced below in Figure 1.

[1] http://www.tech-know.eu/uploads/The_Model_Atmosphere.pdf

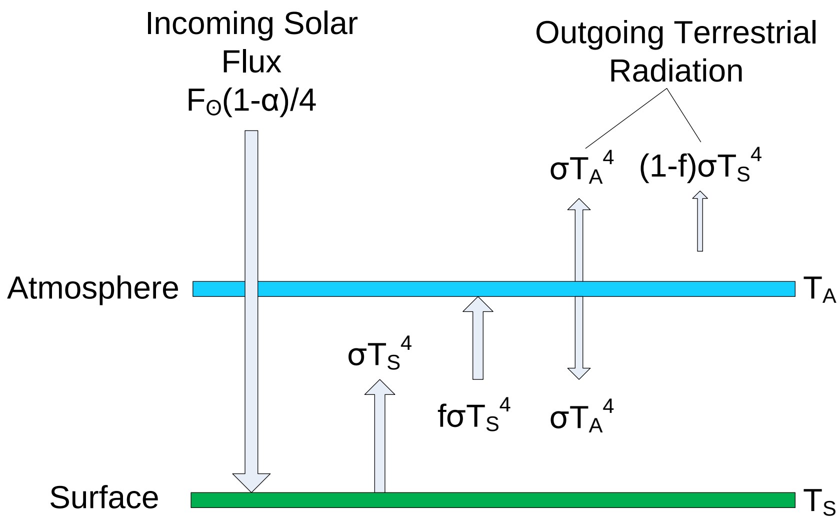

Figure 1: The standard model of the greenhouse effect. This model contains all of the boundary conditions and basic physics which characterize the system under the GHE.

Readers can examine the full mathematical breakdown of this model in the July paper. Here, let us simply examine it in terms of the concepts we have already introduced here: observables, boundary condition, paradigm, and internal physics. The observable is slightly more technical than its analogue in the solar system models. The observable here is related to the Law of Conservation of Energy, i.e., that the energy coming in from the Sun must equal the energy being output from the Earth. This observable is captured under the label in the figure of "Incoming Solar Flux" and its related mathematical expression; it has a value of about 240 Watts per square meter (240 W/m^2). This term is balanced by the "Outgoing Terrestrial Radiation", which has the same numerical value. These two observables also represent the boundary conditions of the model, both physically and cognitively. The "internal physics" is then everything else that happens within the guise of this boundary condition, and is represented by all the other terms and arrows in the diagram.

Let us more closely examine the boundary condition and associated paradigm of this model. It uses two horizontal lines, one to represent the ground, and one to represent the atmosphere. This is called a plane-parallel model because the ground and atmosphere are treated as "planes" and they are "parallel" to each other. The incoming solar flux is divided by a factor of "4" (this is the numeral "4" you see in the diagram) so as to average the Solar energy over the entire globe, because the globe is actually a sphere but here we draw it as a horizontal line, for convenience. But at the expense of a larger diagram we can just as easily use the same averaged values and draw the model as a circle, more intuitively representing the Earth, as shown here in Figure 2.

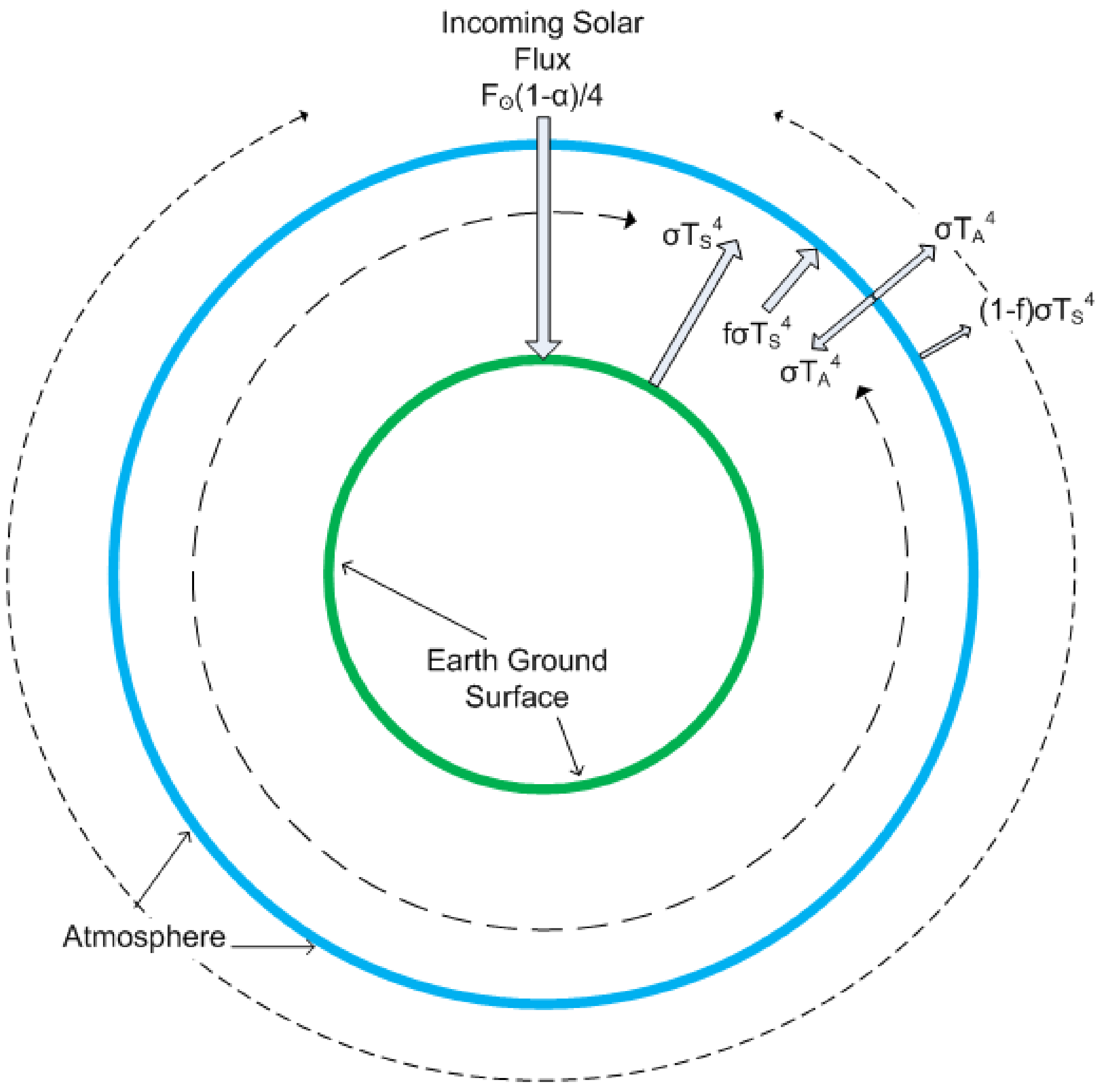

Figure 2: The standard model greenhouse effect re-drawn as a circle, to represent the shape of the Earth. The *averaged* incoming solar flux comes in from every direction and the internal physics also occurs everywhere, with the arrowed-lines pointing into them and circling about the model reminding us of that.

A Neo-Copernican Paradigm Shift

In the above figure it is much simpler to observe that this standard model GHE treats the solar insolation as coming in to all sides of the Earth, and it justifies this boundary condition by using what is said to be the "average value" of the solar power. All well and good... However, does the light from the Sun *actually* come in to all sides of the Earth at once? Obviously, sunlight actually comes in to only one side, or hemisphere, of the Earth, ever. This is assumed to not be a problem in the standard GHE model because we're using the average value of the intensity of sunlight anyway, and so it all works out to be equal in the end.

But, are we sure about that? In this standard model, what are the physical units used in quantifying the solar power? This was already cited and was listed as 240 W/m^2. A Watt is a Joule per second, so the explicit units of this power is Joules, per second, per square meter ($J/s/m^2$). It is an amount of energy (J), spread over one-second of time (s), spread over one square meter of space (m^2). Such a quantification of energy is known as *energy flux density*, or more loosely called *power*. What this value of solar power represents is therefore a one-second average 'snapshot' of radiation coming into, and going out from, the Earth over its entire surface area, according to the standard model.

Are we sure this adequately describes the real physical system? The standard model effectively treats the Earth as having sunlight coming in over all parts of the Earth at once, with no day-time and no night-time, and with one-quarter the value of the incoming energy flux density of the actual solar power to account for this, which makes it equal to the average terrestrial output power. This boundary condition is justified because it is claimed to satisfy the broad requirement of conservation of total energy, i.e., that the solar input must equal the energy of the terrestrial output.

However, there is a physical error in this. The model equates the *energy flux density* of the incoming power, to that of the outgoing power. This is *not* a requirement of the Law of Conservation of Energy (LCE). The LCE pertains to total energy, i.e., the total number of Joules only, but *not* to the flux density of those Joules of energy. This is a fundamental error in the primary boundary condition of the model, and it sets up a cognitive phase-space which therefore may not necessarily correspond with reality. So the error is two-fold: one, in treating the Earth as if it has no day-time and night-time; two, in equating energy flux densities for the LCE as opposed to the specific total energy.

The reason this is an error is the Stefan-Boltzmann Law of radiation, which can be used to convert radiative energy flux density into an equivalent temperature. The model "average" solar input power of 240 $J/s/m^2$ has an equivalent temperature of about -18^{0}C (255K or -0.4^{0}F). With the cognitive boundary condition that the Sunlight only provides -18^{0}C worth of temperature in any given second over the entire surface area of the globe at once, you must postulate a scheme of physics to raise the temperature on the Earth to something much warmer than this. This scheme of "physics" is called the greenhouse effect. The average daily temperature found near the ground-surface is +15^{0}C so it seems apparent that the Solar sunlight cannot directly account for it.

In a *physically-real* one-second snapshot of the input and output energies, however, Solar power actually only comes in to *one side* of the Earth. This means that there is no possible way that the energy flux density of input vs. output could ever be the same in numerical value – the input comes in over the surface area of one hemisphere, but the output comes out of the surface area of the entire sphere. And since a hemisphere has half of the surface area of an entire sphere, the average input energy flux density must have a value twice as large as that of the output. The total energy balance between input and output is still *exactly* the same, satisfying and in-line with the meaning of the Law of Conservation of Energy, but the energy flux density, or power temperature of the radiation, is not and never needed to be, the same in numerical value.

What Would Copernicus Think?

The standard model greenhouse effect makes a simple but critical mistake in not differentiating between the concepts of energy flux density and total energy, in the context of the Law of Conservation of Energy. Along with this comes the un-realistic model of a dim, cool Sun, simultaneously shining on *both sides* of the Earth at once. This establishes a cognitive boundary condition, or paradigm, which does not conform to reality. In reality, an actual per-second, per-square meter snapshot has the sunlight shining upon *one* side of the Earth in *any* moment, and the Earth *returning* energy to space over *both* the light and dark sides. This was all formally explained and proven mathematically in the July paper. A model which incorporates the actually physical boundary conditions as they really exist was presented in that paper, and is reproduced below in Figure 3.

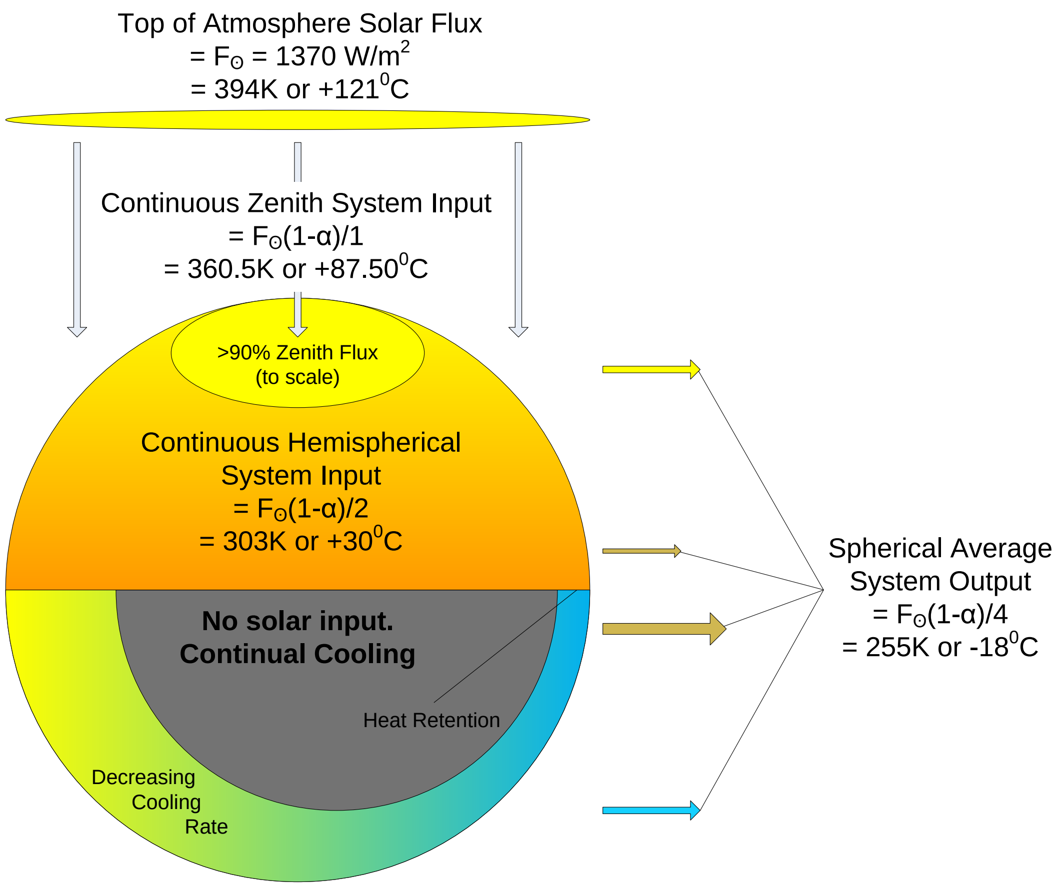

Figure 3: Earth is in fact, on average, *cooler* than the solar radiative input temperature. With this single physical reality, the need to postulate a radiative greenhouse effect evaporates.

And so in fact, the temperature forcing into the climate system from the Solar energy has a linearly-distributed average value of 480 W/m^2, or +30^{0}C. At maximum intensity directly under the Solar-noon, this input forcing is potentially as high as +121^{0}C! But the day-time hemisphere of the Earth doesn't actually achieve +30^{0}C, even though we know it absorbs all the energy required to potentially reach this temperature. But then where does the energy go if it doesn't show up as temperature? That's very simple: it goes into other degrees of freedom within the system, such as latent heat, evaporation, convection, etc., and it also goes into warming up the ground surface from the cooled-temperature it went down to over the previous night. This new model directly achieves the Law of Conservation of Energy, but it does it with correct internal physics.

Copernicus' Bachelorhood and Frozen Dinners

Does it really make that much of a difference to use the *actual* value of the energy density input vs. simply equating that parameter to the output density of energy? Well, yes it does. Imagine you start the Earth-system off from absolute zero temperature, completely frozen, and then begin inputting energy as per the standard model greenhouse: -18^{0}C worth of temperature forcing coming in to *all sides* of the planet from an omnipresent, dim and cool Sun. Would you expect -18^{0}C worth of temperature forcing from sunlight to be able to melt the copious quantities of ice in the now-frozen oceans? I certainly wouldn't. On the other hand, what if you had +30^{0}C worth of temperature forcing, on average over *half* of the Earth, with a continuous maximum of up to +121^{0}C under the solar-noon? Indeed, we should certainly expect this *actual* power level of solar energy to easily melt the ice into water *and* to cause its evaporation and generate a climate cycle.

Most human beings on this planet are familiar with cooking their own food, and so there is a very simple and direct analogy to understand how this thermal physics works. Take the example of a frozen "TV-dinner". Typically these might list a cooking recipe of, say, 425^{0}F (218^{0}C or 495K), for 60 minutes. Could you substitute for one-quarter of the power, but cook it for four-times longer, and expect to achieve the same result? Could you substitute for four-times the power, and cook it for one-quarter the time period? Could you imagine attempting either of those scenarios with a twenty-five pound turkey at your next Thanksgiving dinner? The total energy spent would be exactly the same in all scenarios, but the physical response in each is entirely unique.

There are valuable, actual, and real-world differences between the standard model greenhouse paradigm and the physically correct paradigm explained above. I submit that, just as there are such between the solar-system models of Ptolemy and Copernicus, there are also such between the standard GHE model and the "Reality Model" reviewed here and presented in the July 2011 paper. This new model has boundary conditions which are both cognitive *and* physical, in a logically valid fusion, just like the Copernican model, as opposed to the Ptolemaic. We have adherence to the exact same external observables, but completely different internal physics, and a completely different paradigm and thought-process which describes it. The atmospheric greenhouse effect is really just an artefact of a fictional boundary condition, and its associated aberrant cognitive domain.