An Alternative Global Mean Energy Budget Model Which is Incompatible with Existing Ones

Joseph E Postma[1]

Abstract

A global mean energy budget model is presented which is mutually-exclusive to and hence incompatible with existing common global mean energy budgets. A question then arises out of this incompatibility as to whether or not global energy budget models should be consistent with the Laws of Thermodynamics and Physics and empirical reality, or if there is no requirement of such criteria within science in general.

Capsule: A new global mean energy budget is presented which questions whether or not energy flows in meteorology should be consistent with physics and empirical observation.

[1] University of Calgary, Physics & Astronomy, SB603 2500 University Dr NW, Calgary, AB, Canada, T2N1N4 joepostma@live.ca, jpostma@ucalgary.ca

1 INTRODUCTION

A well-known global energy budget is found in "Earth's Annual Global Mean Energy Budget" (Kiehl & Trenberth 1997), whose Figure 7 is reproduced in this text in Figure 1 (with original caption).

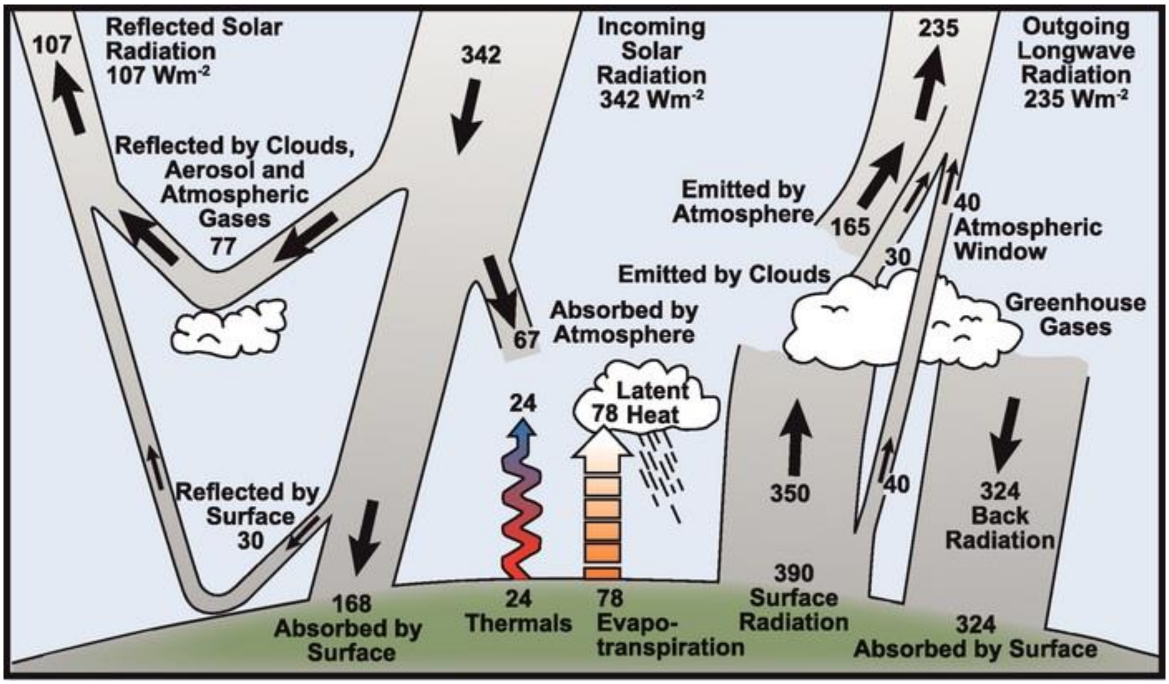

Figure 1: FIG. 7. The earth's annual global mean energy budget based on the present study. Units are Wm^{-2}.

This model is consistent with other treatments found at the textbook and classroom level regarding the climate greenhouse effect, for example from Harvard University in Figure 2, and also from Pennsylvania State University in Figure 3.

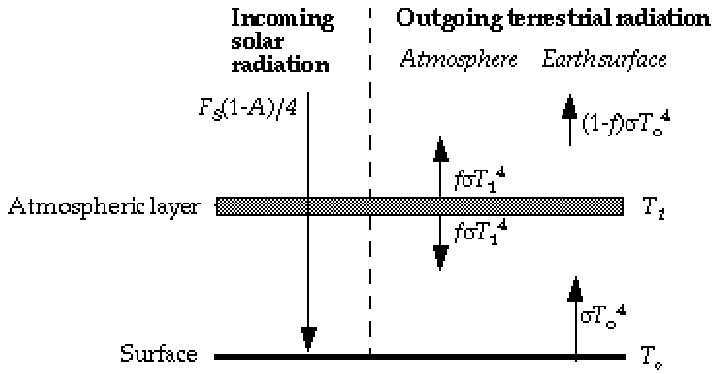

Figure 2: Found at http://acmg.seas.harvard.edu/people/faculty/djj/book/bookchap7.html

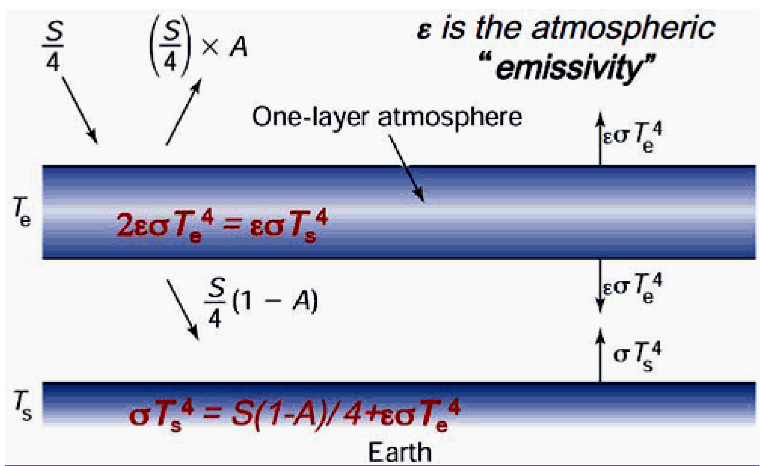

Figure 3: Found at https://www.e-education.psu.edu/meteo469/node/198

Other references to equivalent diagrams and explanations are ubiquitous.

One main point of consistency between these three figures is that solar power is averaged over the surface of the Earth, that is, the cross-section of intercept of solar power by Earth's disk is averaged over the sphere of the Earth, giving the division by four as the ratio of a disk area to that of a sphere's area with the same radius, such as to average the disk-intercept over the entire sphere. This is noted as the one-fourth divisor in Figures 2 & 3 of the solar input, which numerically is the 341 Wm^{-2} as in Figure 1.

Another point of consistency is the cycling of energy flux within the atmosphere, labeled as "Back Radiation" in Figure 1 and as depicted with surface-directed arrows in Figures 2 & 3. This is known generally as "the greenhouse effect", although real greenhouses actually function by limiting convective cooling.

The general concept of a global energy budget is to conserve energy given total inputs and outputs of the system, where the input and output energies manifest from disparate phenomena although having a net causal-link between them. That is, the energy output by the Earth originates in the energy input by sunlight to the Earth, assuming negligible geothermal contribution, however there is largely a circuitous and complex link between solar input energy and terrestrial output energy, the circuitous link being the climate itself. We are interested in tabulating the energy flows through those circuits, for example.

2 DISCUSSION

An alternative global annual energy budget model is here presented in Figure 4 which differs in that it does not average sunshine over the whole surface of the Earth as an input. This model is meant to be very simple for the current discussion and so does not depict internal energy flows within the atmosphere, and we shall discuss only some pertinent gross differences instead.

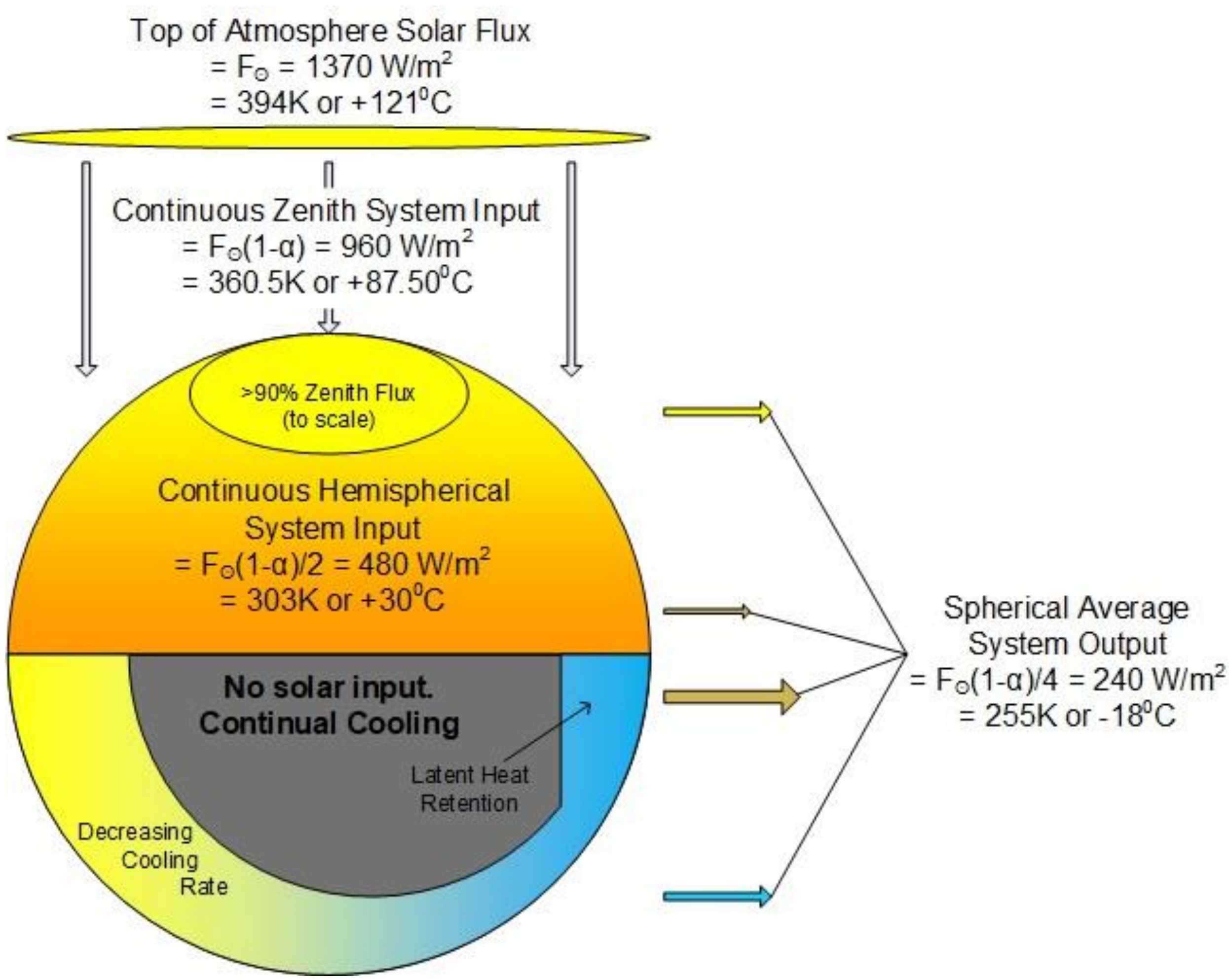

Figure 4: An alternative global mean energy budget.

For example, instead of averaging the incoming solar input over the entire sphere of Earth, the average solar input is instead represented as falling over only a hemisphere and with an intensity distribution which can be ideally determined as the cosine of the solar zenith angle. That is, at any one time, and hence at all times and hence also as an average, solar input falls on a hemisphere only. Certainly the surface of the Earth is rotating beneath this hemispherical input, but at any time the input is only over a hemisphere and has the expected geometrical intensity distribution.

This difference has important consequences. In the standard global energy budget, with solar power being diluted over a total surface area it never actually spreads upon (the entire spherical surface at once), solar power is thus reduced to 168 Wm^{-2} (per Figure 1) which is an equivalent temperature forcing via the Stefan-Boltzmann Law on a blackbody of 233K (-40C, -40F). In other words, whole-surface-averaged solar power is extremely feeble, and we wouldn't expect a climate let alone possibly even a gaseous atmosphere at such a low heating potential supplied by the Sun. On the other hand, this alternative global energy budget supplies solar power over only a hemisphere which sunlight ever falls upon, giving an average forcing of 480 Wm^{-2} or temperature forcing of +303K (+30C, 86F), but which maximizes around the zenith at 960 Wm^{-2} or 360K (87C, 188F). And so, solar power is capable of performing and producing very different physical responses between these two energy budgets, particularly in the examples of, say, being able to melt ice, or the ability to generate cumulonimbus clouds, etc.

Following on this point it is relevant to reference the properties of heat flow, for example:

“If a physical process increases the total entropy of the universe, that process cannot happen in reverse since this would violate the second law of thermodynamics. Processes that create new entropy are therefore said to be irreversible. […]

“Perhaps the most important type of thermodynamic process is the flow of heat from a hot object to a cold one. We saw […] that this process occurs because the total multiplicity of the combined system thereby increases; hence the total entropy increases also, and heat flow is always irreversible. […]

“Most of the process we observe in life involve large entropy increases are therefore highly irreversible: sunlight warming the Earth […].” – Thermal Physics (pg. 82) (Schroeder 2000)

Other references to heat and the nature of heat flow are ubiquitous. The point being here that the standard global energy budget model depicts 324 Wm^{-2} of “Back Radiation” flowing to the Earth surface from the atmosphere, a quantity nearly two-times larger than the solar input of 168 Wm^{-2}. This implies that the atmosphere heats the surface with a far greater power than the Sun does. However, since the origin of energy and specifically heat is the sunlight and its initial absorption into terrestrial matter, then it is implied that energy originally from the Sun has a second and a third go-around at heating the surface. And this multiple go-around process of “Back Radiation” has the peculiarity that it is from the cooler atmosphere acting upon the warmer surface, given that general relationship. On the other hand, the alternative global energy budget in this paper would require only a unidirectional flow of heat down the temperature gradient, which seems more consistent with physics. That is, incoming sunshine of high intensity flux is capable of directly producing climatological effects as a response to heat flow from the Sun, and this flow should step down in intensity as heat flows down temperature gradients through the system as manifest climate, without requiring reversibility of heat flow.

At this point we have sufficient preliminary analysis to tabulate a list of basic differences between the standard global energy budget and the alternative one presented in this paper. See Table 1.

Table 1: Comparison of the standard global energy budget to that of the alternative energy budget presented in this paper

Global Energy Budget	Standard Model	Alternative Model
Solar Input Geometry:	Evenly over entire spherical surface represented as a flat plane	Over single hemisphere as a function of solar zenith angle
Heat Flow:	Reversible/recyclable	Unidirectional
Climate:	As a secondary consequence of heat recycling	As a direct consequence of solar heat flow
Solar power:	Insufficient to create a climate without heat recycling	Sufficient to create a climate directly
Empirically:	Fictional	Observable
Thermodynamically:	Inconsistent with Theory	Consistent with Theory

As one can see from Table 1, the standard model and the alternative model in this paper, although they both conserve total energy to the outside of the system, are entirely mutually exclusive within the bounds of the system itself. The input and output of equal total energies occur over different surface areas, and this difference has an effect on the heating potential of sunlight depicted in such models. That is: is the climate a result of recycling heat energy within itself, or, is the climate the result of solar heat flow?

In the alternative model presented in Figure 4 with sunlight falling upon the Earth in a realistic fashion, one would immediately identify that the climate is the result of solar heat flow through the atmosphere. That is, without going into the details of the internal minutia, one can at least identify the high-temperature heating potential of sunlight and conclude that the climate is the result of solar heat transfer through the atmosphere, with heat flowing down the temperature gradient. On the other hand, with the traditional energy budget, one cannot cursorily examine it and be lead to the idea that solar input power is responsible for creating the climate; rather, it becomes apparent that the climate is largely the result of the climate creating itself via a fashion of heat recycling of a feeble solar input amplified into a more intense flux of "Back Radiation".

Thus, we have mutually exclusive statements about the nature of reality, from two models which seemingly should both satisfactorily represent reality. The standard model is presumably a good representation of reality given that it is peer-reviewed and it is widely cited in climate research, while the alternative model presumably makes for a good representation of reality because it represents the Earth and energy flow into it as it actually empirically exists and is consistent with basic thermodynamic theory, etc. However, both models cannot both be correct, given that they indicate mutually-exclusive processes.

3 CONCLUSION

An alternative mean global energy budget was presented which depicts the energy flow into the Earth system from the Sun in an empirically-realistic way. This lead to differences from the standard mean global energy budget which are mutually exclusive in nature, and which differences by their nature indicate that either one model, or the other, must be inconsistent with physics. The reader is left to consider whether or not it is relevant, or useful, or at all scientific, to value such differences.

REFERENCES

Kiehl, J.T. and K.E. Trenberth, 1997: Earth's Annual Global Mean Energy Budget. *Bull. Amer. Meteor. Soc.*, 78, 197–208, https://doi.org/10.1175/1520-0477(1997)078<0197:EAGMEB>2.0.CO;2

Schroeder, D. V. 2000: *Thermal Physics.* Addison Wesley Longman, 422 pp.