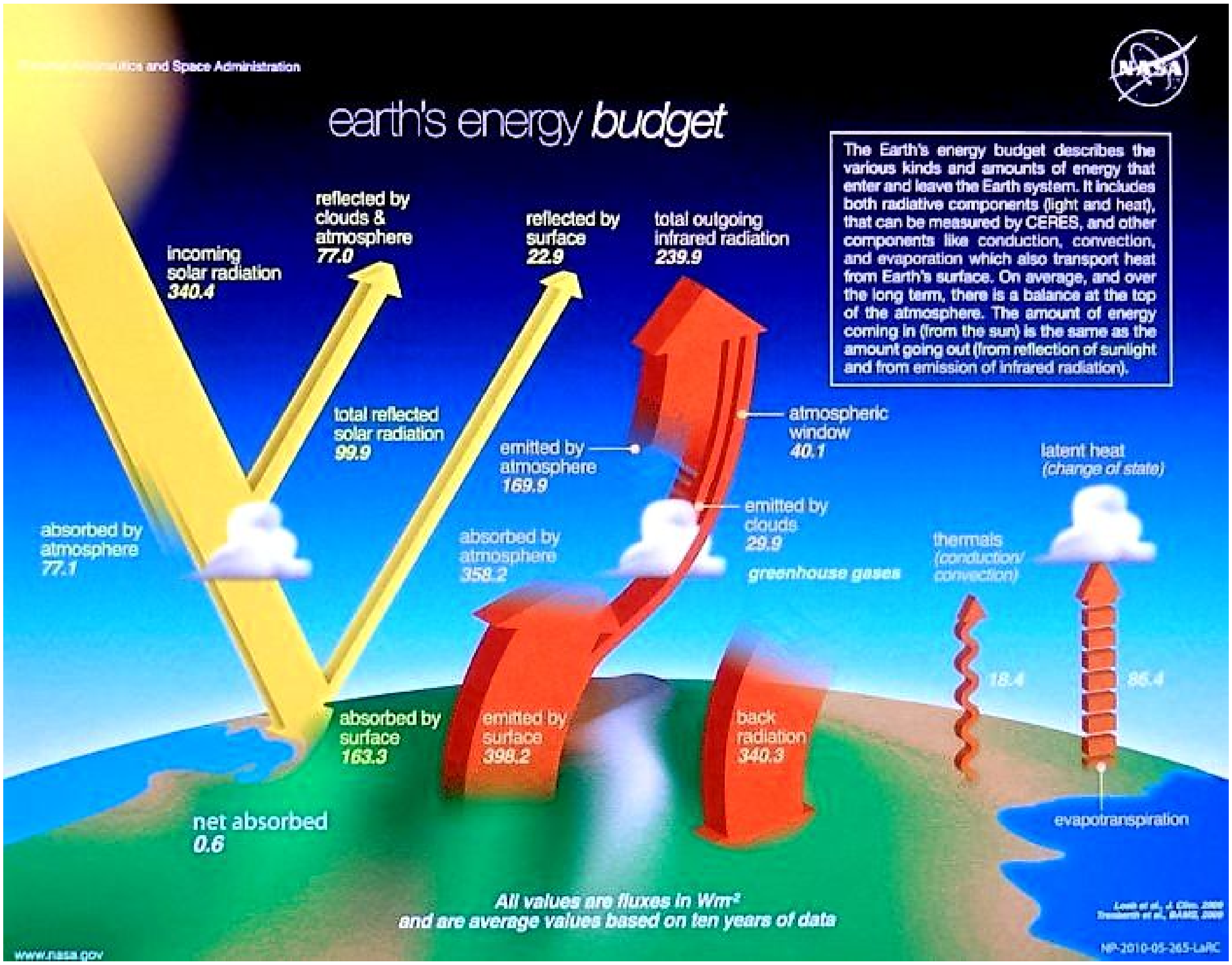
A Critical Lesson from the NASA Earth Energy Budget

The essence of the argument that an increase in the concentration of carbon dioxide, an infrared-active or greenhouse gas, causes the Earth's surface to become warmer lies in a radiation-dominant viewpoint in the transport of energy between the surface and the atmosphere. This viewpoint is depicted in the NASA energy budget shown below:



If the Earth's surface is simply viewed as a black body radiator at temperature T as though it were isolated in space with no other energy loss mechanisms, then the rate of energy loss by means of radiation would be

$$P = 398.2 \text{ W/m}^2 = \sigma T^4 = (5.6697 \times 10^{-8} \text{ W/m}^2\text{K}^4)\, T^4 \text{, and } T = 289.5 \text{ K}$$

Since the Earth's average surface temperature is usually said to be about 288 K, this means that the Earth's surface is assigned an emissivity of 1.02, making it a super black body radiator. Real objects generally have an emissivity less than 1 and never more than 1.

Let us note a result discussed in my post *mgh, Not Just Greenhouse Gases, Provides a Warm Earth* because I do not want this critical observation to be lost among other observations. I want to discuss its implications more here.

Of the 398.2 W/m² of infrared radiation emitted from the surface in this NASA Earth energy budget, 358.2 W/m² is absorbed by the atmosphere. The atmosphere only absorbs infrared radiation at the wavelengths that water vapor and carbon dioxide absorb, aside from very minor absorption by other infrared-active gases. It does not act like a black body absorber and it does not act like a black body emitter. But we can establish upper and lower bounds on what the atmosphere is capable of doing if we treat it as though it were a black body radiator. When dealing with complex physics problems, it is always good to know when the answers you provide are within the physically possible bounds.

Doing so, and taking Ta to be the temperature of the black body absorber and Ts the temperature of the surface, we have

$$\sigma (Ts)^4 - \sigma (Ta)^4 = 358.2 \text{ W/m}^2,$$

which is the maximum electromagnetic radiation the absorber can absorb from the higher temperature emitter black body. We know that for the NASA Earth energy budget that the first term on the left is 398.2 W/m², albeit with an emissivity of 1.02, so we calculate that

$$Ta = 163.0 \text{ K}.$$

Now this is a very interestingly low temperature. There is no temperature this low in the U.S. Standard Atmosphere Table of 1976. The temperature with altitude drops approximately linearly in the troposphere, stabilizes at the minimum temperature of 216.65 K in the tropopause, and then increases with altitude through the stratosphere until there is essentially no atmosphere left to do any absorbing of infrared photons. At 86 to 90 km altitude, in the mesopause, there is another temperature minimum of about 186.9 K in that table, though other sources say the temperature can get as low as 173 K. These very low mesopause temperatures are caused by strong cooling due to carbon dioxide radiation of heat to space. At 1000 km altitude, the U.S. Standard Atmosphere of 1976 temperature is 1000 K and the density of the atmosphere is only 2.9×10^{-15} times that at sea level. Of course any surface thermal radiated heat absorbed in the upper atmosphere is generally going to be radiated out into space and not radiated back to the surface in any case.

So, there is no black body shell around the Earth at a temperature of 163.0 K. But we can make an approximate calculation of where in the solar system we could place a black body absorber at a temperature of 163.0 K that could absorb such a large fraction of the power irradiated from the NASA Earth surface.

A black body radiator/absorber at temperature 163.0 K radiates 40.0 W/m^2 , which matches the power of the infrared radiation that NASA says escapes the Earth's atmosphere without absorption.

So we ask where does a sphere around the Sun in radiative equilibrium with the Sun have an energy output rate of 40.0 W/m^2 corresponding to a temperature of 163.0 K? This will be where the product of the power output per unit area of the photosphere of the Sun times the surface area of the sphere at the radius of the photosphere equals 40.0 W/m^2 times the surface area of the sphere centered on the sun with a radius r large enough that the temperature of that sphere will be 163.0 K. That is a temperature far above that of the distant universe, so it should be found somewhere within our solar system. We have:

Temperature of the sun on the photosphere = 5772 K
Radius, R, of the sun at the photosphere = 6.957×10^5 km

We calculate the power output per unit area on the Sun's photosphere using the Stefan-Boltzmann Law to be:

Power output at the solar photosphere radius = 6.293×10^7 W/m^2

For the solar photosphere radius R, the distance r at which the solar power will be reduced to 40 W/m^2 , will be

$$r^2 = [(6.293 \times 10^7 \text{ W/m}^2) / (40 \text{ W/m}^2)] R^2 = [(6.293 \times 10^7 \text{ W/m}^2) / (40 \text{ W/m}^2)] [6.957 \times 10^5 \text{ km}]^2$$

and so $r = 8.726 \times 10^8$ km.

The mean radius of the Earth's orbit is 1.496×10^8 km, so according to the NASA Earth energy budget, 358.2 W/m^2 of power radiated as infrared radiation from the Earth's surface is dumped into the Earth's atmosphere at a distance from the Sun which is minimally 5.83 times further from the Sun than is the Earth. Measured from the Earth, rather than the sun, the distance that portions of the surface emitted radiation is absorbed in space varies from 4.83 to 6.83 times the mean radius of the Earth's orbit.

NASA has a most interesting definition of the Earth's atmosphere. What is more, how does that energy absorbed in the distant portions of our solar system manage to return to the Earth's atmosphere in any way that might increase the temperature of the Earth's surface? Of course it does not. This NASA Earth Energy Budget is a complete farce, as are the many similar Earth energy budgets used by the UN IPCC reports to justify their claims that adding carbon dioxide to the atmosphere will cause catastrophic warming problems for mankind.

One must also take note that without the absorption of this 358.2 W/m^2 of power from the surface, the idea that the atmosphere can back radiate 340.3 W/m^2 to the surface becomes impossible. It is the absorption of the surface radiated power coupled with the back radiation of a nearly as great power that is the very basis of the claim that adding more greenhouse gases to the atmosphere will cause the Earth surface temperature to rise. And no, there is no way that water vapor, carbon dioxide, and methane gas can absorb and emit more infrared radiation than can a black body absorber. They fall well short of being as effective as absorbers and emitters as is a black body absorber/radiator.

According to the U.S. Standard Atmosphere of 1976 table, the coldest temperature within the Earth's atmosphere is the 216.65 K of the tropopause, the layer of the atmosphere between the troposphere and the stratosphere. A black body layer placed there could at most absorb a power of infrared emitted from the surface of

$$P = \sigma (Ts)^4 - \sigma (216.65 \text{ K})^4,$$

where $\sigma T^4 = (5.6697 \times 10^{-8} \text{ W/m}^2 \text{K}^4) (216.65\text{K})^4 = 124.9 \text{ W/m}^2$ and $\sigma (Ts)^4 = 398.2 \text{ W/m}^2$

$$\text{so } P = 273.3 \text{ W/m}^2$$

This upper limit absorption of 273.3 W/m^2 is well less than the claimed absorption of 358.2 W/m^2. What is more, this black body in the tropopause would radiate 124.9 W/m^2 to space, making this energy flux immediately unavailable in the Earth's atmosphere.

Even if the theoretical limit of absorption did occur in the tropopause, one would still have the insurmountable problem of finding a way to return any significant portion of this absorbed energy to the surface from the tropopause to provide any significant warming of the surface. Equally important, such a violation of such an easily calculated upper limit on the fraction of the surface infrared emission which can be absorbed wipes out any confidence one can reasonably have in any of the NASA science used to create this Earth energy budget. Indeed, there are many other errors in this fanciful creation.

This upper limit as defined by the Stefan-Boltzmann Law of Electromagnetic Radiation and is itself much too high an upper limit for the following reasons:

1) The surface of the Earth does not emit the 398.2 W/m^2 as claimed by NASA because this surface is not emitting radiation at a vacuum interface and has competing energy loss mechanisms cooling at least local submicroscopic areas of the surface briefly. This is a matter dictated by the Law of Conservation of Energy. Since less energy is emitted from the surface as infrared radiation, the atmosphere cannot absorb as much either.

2) As noted earlier, water vapor, carbon dioxide, methane, and other infrared-active molecules can each absorb only a fraction of the wavelengths of infrared radiation that a black body absorber/radiator can. These gas molecules also have many cases of overlap of those wavelengths they do absorb. Therefore, once again, the fraction of the wide spectrum of infrared radiation that the surface emits that can be absorbed by the atmosphere is much reduced.

3) The mean free path for the absorption of such infrared as the infrared-active molecules absorb is much too short for surface emitted infrared radiation that can be absorbed to reach the tropopause before it is absorbed. Indeed, in most areas of the Earth, the absorption mean free path for water vapor is many, many times too short for this to happen. Even that for carbon dioxide at present concentrations is much too short for this to happen. This means the temperature differentials are much reduced and consequently much less energy is absorbed.

4) The density of infrared-active absorbers in the troposphere, even if each were a black body absorber/radiator, would not be great enough to absorb all of the radiation coming from the surface even if that radiation could make it to the tropopause.

There is still another important consequence. The black body absorber/emitter we have placed in the tropopause to maximize the absorption of radiation from the surface is, as noted above, radiating 124.9 W/m^2 directly into space. Since the surface is radiating 40.1 W/m^2 directly into space, all but 74.9 W/m^2 of the total radiation from the entire Earth system being radiated into space is accounted for. Let us add up the remaining energy flux into the atmosphere:

77.1 W/m^2 directly absorbed from solar insolation
273.3 W/m^2 deposited into the black body absorber in the troposphere
18.4 W/m^2 deposited in the atmosphere by thermals (conduction/convection)
86.4 W/m^2 deposited in the atmosphere by the condensation of water vapor

Total = 455.2 W/m^2

How could an atmosphere with an additional power input of 455.2 W/m^2 direct 340.3 W/m^2 of this power toward the surface and only 74.9 W/m^2 toward space? The asymmetry of radiation to the surface and into space in the NASA Earth energy budget was already a red flag. This asymmetry is now worse. Note also that the sum of these two radiative fluxes is now 40.0 W/m^2 short of the 455.2 W/m^2 of remaining energy flux into the atmosphere.

In short, the NASA Earth Energy Budget is based on nonsense physics. This, we are told, is the settled science of the climate. Is it any surprise that computer models based on nonsense physics have been making wrong predictions of climate warming for 19 years now?

Garbage physics in means no reality out.

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