Basic Climate Physics #3

One fact at a time

This short essay is the third in a short series about basic (meaning all-inclusive) physics that pertains to the subject of climate.

Bear in mind that my purpose is not to engage in details about wind, rain, snow, storms, historical climatology, Milankovitch cycles, or any of the common topics discussed about climate. What I will discuss is some simple physics.

IPCC's Inept Physics

As you read the statement to the right from the IPCC, you get the feeling that they're shaking a pillow feather in your face. They introduce a symbol α_P without defining it, but tell us that the variable helps stabilize the climate. But their ignorance of physics shows up in the last clause: "a warmer planet radiates more energy to space."

The clue to the fundamental physics error in the statement to the right is to be found in IPCC's *First Assessment Report* (*FAR* 1990), which said

> "Firstly, the mean temperature of the Earth's surface is already warmer by about 33°C (assuming the same reflectivity of the Earth than it would be if the natural greenhouse gases were not present."

> The Planck response represents the additional thermal or longwave (LW) emission to space arising from vertically uniform warming of the surface and the atmosphere. The Planck response α_P, often called the Planck feedback, plays a fundamental stabilizing role in Earth's climate and has a value that is strongly negative: a warmer planet radiates more energy to space.
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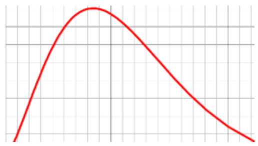
> IPCC, 6^{th} *Assessment Report* (*AR6*, 2021)

Translation: Given the assumption that the reflectivity (albedo) of the earth is constant, the hypothetical non-GHG planet absorbs precisely the same amount of heat from the sun as the earth does now and radiates that same amount into space. The surface is 33ºC warmer than that hypothetical non-GHG earth, *but our hotter planet radiates precisely the same amount of energy to space.*

For a second example, consider Venus. The surface is hot enough to melt lead, but because of its very high albedo of 75%, the planet absorbs 156 W/m^2 from the sun and emits 156 W/m^2 to space, versus our 239 W/m^2. *In this case, the hotter planet radiates less energy to space.*

QED!

Stefan-Boltzmann radiation law



The spectrum of blackbody radiation was well known in the middle-to-late 1800s. The Stefan-Boltzmann radiation law tells us the total amount of radiation emitted, and Planck's equation (1900) tells us the spectral distribution (how much IR at what photon energy). The atmosphere is not a blackbody, but solid materials and liquids are. That is, the earth's surface is a blackbody radiator.

Specifically,

$$I_{\text{surf}} = \varepsilon \sigma T^4$$

In this equation, the coefficient $\sigma = 5.67 \times 10^{-8}$ W/m^2 per K (or per ºC). The intensity is in watts per square meter, and the temperature is in Kelvins. The *emissivity* ε of the earth averages about 0.94, but climate scientists usually take it to be 1.0. To find how much the emission varies with temperature, we find the differential, including the emissivity for completeness:

$$dI = 4\varepsilon \sigma T^3 dT$$

At a temperature of 289 K, the coefficient of dT is 5.47 W/m^2 per ºC with $\varepsilon = 1$, and 5.14 W/m^2 per ºC with $\varepsilon = 0.94$. Citing various investigators, IPCC's *AR6* says, Overall, there is *high confidence* in the estimate of the Planck response, which is assessed to be $\alpha_P = -3.22$ W m^{-2} °C^{-1} with a *very likely* range of –3.4 to –3.0 W m^{-2} °C^{-1} and a *likely range* of –3.3 to –3.1 W m^{-2} °C^{-1}.

These IPCC estimates *assume* that approximately 40% of the additional heat radiated from a warmer surface stays within the earth and 60% of the additional heat goes into space. (IPCC's minus signs indicate outgoing heat.)

Summary

It is clear that the IPCC has some serious misunderstandings about basic physics. The lesson in this short essay is that the radiation from the surface of the planet (for that matter *any planet*) is determined by the Stefan-Boltzmann radiation law. We will discuss the radiation to space in the next essay.

More importantly, the next essay will summarize the physics of the first two lessons and insert the Stefan-Boltzmann law to produce one all-inclusive equation that will not predict future climate, but will tell us what *cannot* happen.

Modelers, BEWARE!