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Trenberth's (2022) Greenhouse Geometry

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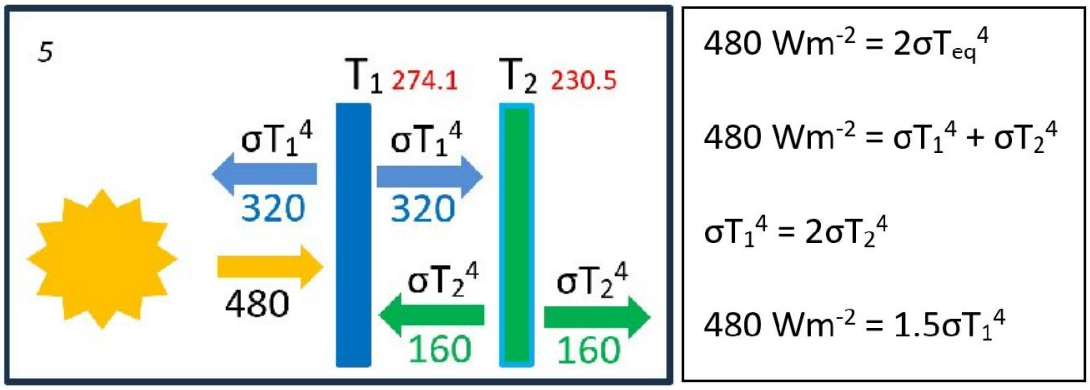
"How Does a Greenhouse Effect Work?" asks Kevin Trenberth in his new book (The Changing Flow of Energy Through the Climate System, Cambridge University Press, 2022, Chapter 3, Sidebar 3.2). The answer is two plates in space, with sunlight shining on the first at a rate of 480 Wm^{-2}; and four equations are presented to describe the resulting energy flow system (480, 320, and 160 Wm^{-2}); see Fig. 3.3, panel 5 on page 30:



Since this structure is open at both sides, if we want to apply it for Earth-like conditions, a planetary surface should be introduced, and the equations have to be slightly modified to describe the surface-atmosphere geometry. After doing so, we have an energy flow system with incoming solar radiation (Wm^{-2}) = 480, outgoing longwave radiation OLR = 480, and surface upward LW emission ULW = 720 = 1.5OLR. The greenhouse effect is G = ULW – OLR = 240 = OLR/2, and the normalized geometric greenhouse factor is g = G/ULW = 1/3. Here we show that these relationships are accurately satisfied by the real Earth's clear-sky energy flow system. With the up-to-date CERES EBAF Edition 4.2 Version 2 data (release date 2-January-2024, global means 10/2000–09/2023): OLR = 265.95 Wm^{-2}, ULW = 398.75 Wm^{-2}, hence 1.5OLR = 398.92 Wm^{-2} (0.17 Wm^{-2} difference) and the greenhouse effect is G = 398.75 – 265.95 = 132.80 Wm^{-2} with OLR/2 = 132.97 Wm^{-2} (0.17 Wm^{-2} difference). The normalized greenhouse factor is g = 132.80/398.75 = 0.333. This parameter is one of the most stable from all climate data: its value was estimated as 0.33 in 1989 and determined as 1/3 in 2008; CERES EBAF Edition 2.8 (2017) found it as g = (398.40 – 265.59)/398.40 = 0.33336. — This close equivalence of the real Earth's greenhouse factor and the

GHG-independent geometric model implies that long-lived greenhouse gases do not play the role of the LW control knob that governs the greenhouse effect but produce a background on which water vapor and the lapse rate adjust and maintain the demanded greenhouse magnitude. In our talk, we present all the data needed to prove that Earth's atmosphere follows this simple "plate-state" geometry. It can be shown [1] that not only the clear-sky greenhouse fluxes, but the whole annual global mean energy flow system, both clear-sky and all-sky, shortwave and longwave, at the TOA, within the atmosphere and at the surface, even the non-radiative flux components, may be derived from first principles without any reference to the atmospheric gaseous composition. Graeme Stephens' idea could not be more timely: "Instead of the traditional paradigm of properties define processes, study how processes define property." We would add: Study how *principles* define processes, then property. In this talk, we show how geometric principles define radiative processes to generate and maintain the required atmospheric state[2].

References:

[1] Zagoni, M. (2023) Arithmetic relationships in Earth's global mean energy flow system. https://egusphere.copernicus.org/preprints/2023/egusphere-2023-698/

[2] https://earthenergyflows.com/Trenberths_greenhouse_geometry.html