**CO2 vs. Albedo**

**CO2**

In IPCC jargon, *radiative forcing* refers to changes in the radiative flux of the earth, compared to the “pre-industrial” period of 1850-1900. In the more rational jargon of van Wijngaarden and Happer, the term refers to the totality of the radiative flux. The nearby graph of the forcing due to CO2 [1 below this section] shows that at very low concentrations, the forcing due to CO2 rises very rapidly, but after about 100 ppmv, the effect begins to level off. The first 100 parts per million (ppmv) increase the forcing from 0 to about 24 watts per square meter (W/m2), but the next 700 ppmv increases the forcing by only 9 W/m2. A further increase from 800 ppmv to 1,600 ppmv would add less than 3 W/m2.

At present (using IPCC figures), the amount of IR emitted by the surface is 398 W/m2, and the amount emitted to space is 239 W/m2. The difference—159 W/m2— is called the greenhouse effect, G. CO2 is responsible for 30 W/m2, a bit less than 20% of the greenhouse effect.



**Albedo**

The solar flux at our orbit is close to 1360 watts per square meter (W/m2). At present, 30%—the albedo—of that is reflected, and 70% is absorbed. Averaged over the spherical shape of the planet, the absorbed sunlight is 239 W/m2. What would happen if the albedo were somehow different?

Let us begin with a hypothetical ball that is small enough so that it is all at one temperature, and that travels in the same orbit as we do. The nearby graph shows what the temperature would be for albedo values between its possible values of zero and one. For example, if the albedo were 0.3 (=30%), the temperature would be 255 K, which the IPCC has long regarded as the would-be temperature of the earth if we had no greenhouse gases, and the “blackbody equivalent” temperature of the earth as seen from outer space.

If the little ball reflected no light whatsoever, the temperature would be only 23ºC higher, at 278 K, fully 11ºC lower than the surface temperature (289 K) of the earth.

However, an increase in albedo could drop the temperature drastically, even toward absolute zero at an albedo of 1.0. In other words, a decrease in albedo can warm the planet a little, but an increase in albedo can cool the planet a lot.



A recent one-page summary in *Science* [2] of papers in other journals refers to the Sturtian glaciation that occurred from 717 million years ago (717 Ma) until 660 Ma. Here is the explanation of how things happened [2]:

Now, more precise dates, reported last month in *Earth and Planetary Science Letters* (EPSL) and in November 2022 in *Science Advances*, show the eruptions preceded the Snowball Earth event by 1 million to 2 million years. The lag points to a particular way the fire could have triggered the ice: through a chemical alteration of the fresh volcanic rocks known as weathering, which sucks carbon dioxide (CO2) from the atmosphere, turning down the planetary thermostat.

We immediately see a problem with this analysis. Most of the original atmospheric CO2 became locked up in calcium carbonates (and related solids) long ago as stromatolites and other single-celled life forms drew in very abundant CO2 and expelled O2. At the time of the Sturtian glaciation, CO2 levels were certainly higher than they are now, and probably much higher. A reduction to anything below 150 ppmv would end all life on earth. Only reductions to well below about 50 ppmv would have much effect on the radiative forcing. Depending on what the authors think was the reduction of CO2 concentration, the reduction in radiative forcing would be in the range of 5-to-10 W/m2.

By way of contrast, doubling albedo from 30% to 60%, given present solar intensity, would drop by 35 W/m2. What could cause the albedo to change?

[1] W. A. van Wijngaarden1 and W. Happer, “Dependence of Earth's Thermal Radiation on Five Most Abundant Greenhouse Gases,” arXiv:2006.03098v1 4 June 2020

[2] Maya Wei-Haas, “Lava outburst may have led to Snowball Earth,” *Science*, 14 July 2023.