Basic Climate Physics #9

One fact at a time

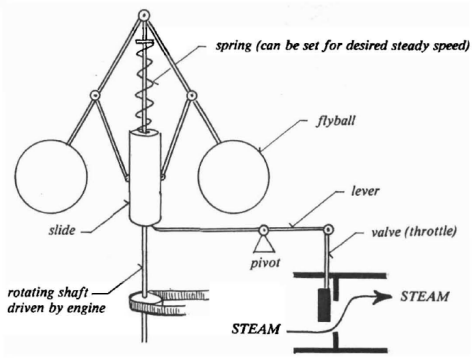
This short essay is the ninth in a short series about basic (meaning all-inclusive) physics that pertains to the subject of climate.

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.

Feedback

The term *feedback* was probably introduced by electrical engineers, but the term has been used in other fields ranging from control theory to psychology. For example, "That dress looks good on you" is regarded as positive feedback, and "You smell bad" is regarded as negative feedback.

The original scientific meaning, to which we will adhere, is that positive feedback is regenerative feedback: more begets more, rather like compound interest. By contrast, negative feedback is corrective feedback: if you see that your car is too far to the left of your lane, you nudge the steering wheel to the right.

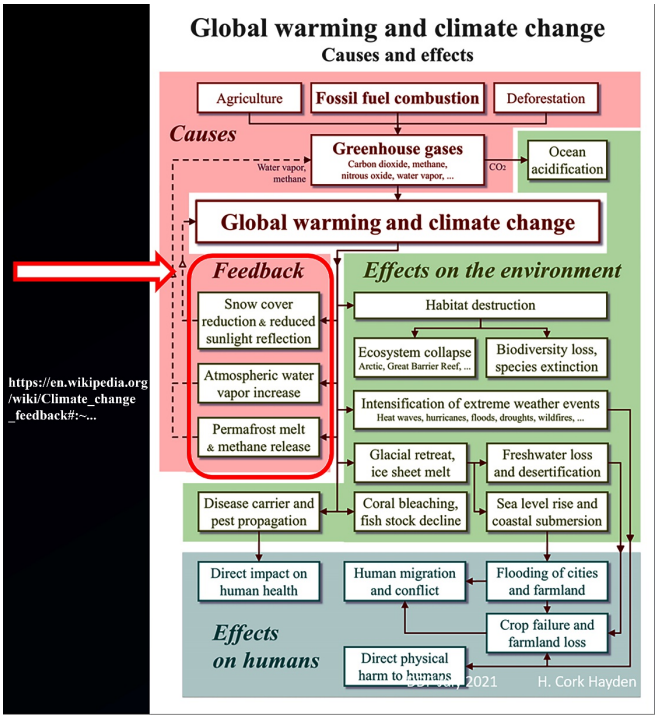


Feedback systems abound in engineering. For example, James Watt applied the principle to the steam engine to keep it running at a (nearly) constant RPM regardless of load. If the engine sped up, flyballs would swing out further from the axis, and a lever mechanism would reduce the amount of steam into the engine. A very similar mechanism is found on small gasoline engines (on lawnmowers and the like), most of them relying on the breeze from the cooling fan as a measure of RPM.

The power steering mechanism on cars works in a similar way. You turn the steering wheel, establishing a "set point." A hydraulic system turns the wheel to an amount determined by the set point, and a negative feedback system keeps it from turning the wheels either too little or too much. (A positive feedback system would immediately turn the wheels as far as they could go, given the slightest nudge of the steering wheel.)

Cruise control works in a similar way. You accelerate up to your desired speed, and then press a button to establish the set point. A signal from the speedometer is compared to the set point. If your car speed varies up (as when you are going uphill or downhill) the system adjusts the fuel and air to the engine.

Over geologic history the surface temperature has varied only plus of minus about 3% (~10K out of 300 K), so it is obvious that the climate is controlled by *negative* feedback.



Feedback in climate models

Climate scientists all (we hope!) recognize that—by itself—CO_2 cannot possibly change the surface temperature very much, even if we double the concentration. If the amount of CO_2 doubles, the "radiative forcing ΔF" (that is, a small change in the greenhouse effect G) would be 3.7 W/m^2. *By itself*, that "radiative forcing" would raise the surface temperature by a trivial 0.68ºC.

IPCC introduces three positive feedback mechanisms into their models. That increase in CO_2 (1) melts snow and ice, thereby reflecting less sunlight to space; (2) increases the H_2O content of the air, thereby increasing the "radiative forcing" and (3) melts permafrost, thereby increasing the amount of methane (CH_4), a GHG.

CO_2, however, does none of those things. Heat does. You can see from the diagram that that the red line from "Global warming and climate change" points into those three feedback mechanisms. The upshot of the argument is that heat begets more heat.

Now, we will look at IPCC's numbers for a doubling of atmospheric CO_2 concentration:

1. The "radiative forcing ΔF (i.e., an incremental change to the greenhouse effect of 159 W/m^2) will be 3.71 W/m^2.
2. The most probable temperature rise caused by that ΔF will be 3ºC.
   If the surface temperature rises by 3ºC, the surface—by the Stefan-Boltzmann law—radiate 16.4 *more* W/m^2 than at present.

So, the IPCC is saying that 3.71 W/m^2 of heating begets 16.4 W/m^2 of heating. Heat produces 4.4 times as much heat. That's positive feedback for you, and there is no end in sight. One unit of heat begets 4.4 units of heat, and each of the 4.4 units of heat begets 4.4 more units of heat, … without end. To repeat the obvious, CO_2 does not cause the alleged positive feedback mechanisms; heat does. *Any* heat from *any cause* does. So why isn't the planet boiling?

Climate models have neither found a way to account for all the IR (especially the increase due to temperature rise) nor identified the negative feedback mechanisms that ultimately control the climate.

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