This is the print version of the Skeptical Science article 'Positive feedback means runaway warming', which can be found at http://sks.to/runaway.

Does positive feedback necessarily mean runaway warming?

What The Science Says:
Positive feedback won't lead to runaway warming; diminishing returns on feedback cycles limit the amplification.

Climate Myth: Positive feedback means runaway warming
"One of the oft-cited predictions of potential warming is that a doubling of atmospheric carbon dioxide levels from pre-industrial levels — from 280 to 560 parts per million — would alone cause average global temperature to increase by about 1.2 °C. Recognizing the ho-hum nature of such a temperature change, the alarmist camp moved on to hypothesize that even this slight warming will cause irreversible changes in the atmosphere that, in turn, will cause more warming. These alleged "positive feedback" cycles supposedly will build upon each other to cause runaway global warming, according to the alarmists." (Junk Science)

At a glance

Yet another climate change myth that has not aged well. As of early May 2024, all of the past 12 months had come in at more than 1.5°C above pre-industrial temperatures, so all of the first sentence is now tripe.

However, with regard to the rest of the myth, the evidence suggests it is extremely unlikely that Earth can enter a runaway greenhouse state.

Why is that? We have two good lines of evidence to support the contention. Firstly, we know an awful lot these days about the geography and climate of Earth in the past. Ancient geography can be determined by examining rock sequences on the continents and noting similarities in their fossil faunas, sedimentary environments and ancient magnetism.

So we know, for example, that around 55.8 million years ago, Ellesmere Island, off the NW coast of Greenland, was a lot warmer than it is today. The main geographical difference between then and now was that the Atlantic Ocean was narrower. The faunal difference was a lot more impressive. Where there are now glaciers and polar bears, back then tortoises, snakes and alligators thrived. Their fossils, along with those of redwood, ginkgo, elm and walnut, are to be found in Ellesmere Island's sedimentary rocks.

The time in question is known as the Palaeocene-Eocene Thermal Maximum. As the name suggests, it was probably the hottest climate experienced on Earth in the past 600 million years. To get temperate to subtropical temperatures in the Arctic is indeed impressive. But there was no runaway beyond that. Why?

Trapping of heat by CO_2 and other greenhouse gases causes an energy imbalance on Earth. This imbalance gets amplified by positive feedbacks. A positive feedback happens when the planetary response to a change serves to amplify that change. For example, due to burning of fossil fuels, atmospheric CO_2 has gone up by 50%. The resulting enhanced greenhouse effect is heating up the planet. The heating, among other things, melts arctic permafrost, releasing the CO_2 and methane trapped within it. These gases amplify that initial change. The effect reinforces the cause, which will in turn further increase the effect, which in turn will reinforce the cause… and on and on.

So won't this spin out of control? The answer is almost certainly not. Feedbacks are not just positive. One very important one is that a warmer planet radiates more energy out to space than a cooler one. This feedback is not only negative but it is also strong.

Furthermore, positive feedback cycles will go on and on, but there will be a diminishing of returns, so that after a number of cycles the effects become insignificant. Thus, if we double the atmospheric concentration of CO_2, the amount by which the response to that change - heating - can be amplified is approximately three times.

The creator and spreader of this particular myth is essentially putting words in people's mouths. No surprise there. But we do not need a runaway greenhouse effect to make life on Earth difficult. Just a few degrees of additional heating will do exactly that.

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Further details

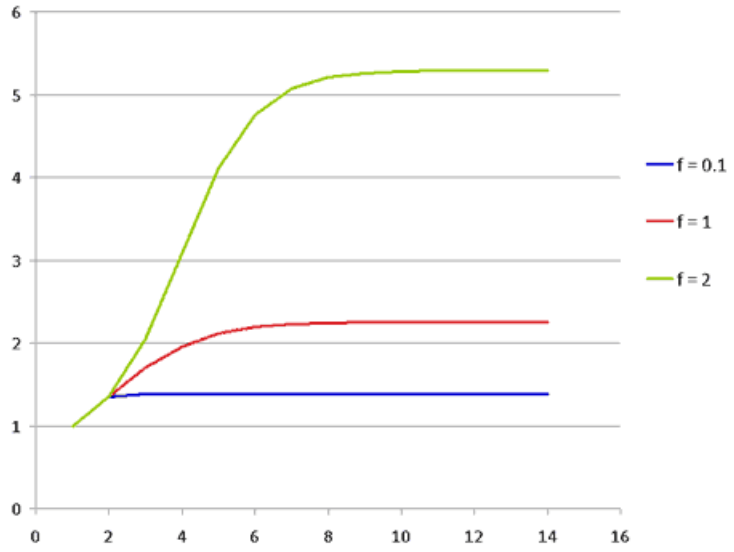
Some deniers ask, "If global warming has a positive feedback effect, then why don't we have runaway warming? The Earth has had high CO_2 levels before: Why didn't it turn into an uninhabitable oven at that time?"

Positive feedback happens when the response to some change amplifies that change. For example: The Earth heats up, and some of the sea ice near the poles melts. Now bare water is exposed to the sun's rays, and absorbs more light than did the previous ice cover; so the planet heats up a little more.

Another mechanism for positive feedback: Atmospheric CO_2 increases (due to burning of fossil fuels), so the enhanced greenhouse effect heats up the planet. The heating "bakes out" CO_2 from the oceans and arctic tundras, so more CO_2 is released.

In both of these cases, the effect reinforces the cause, which will increase the effect, which will reinforce the cause. So won't this spin out of control? The answer is, no, it will not, because each subsequent stage of reinforcement & increase will be weaker and weaker. The feedback cycles will go on and on, but there will be a diminishing of returns, so that after just a few cycles, it won't matter anymore. In addition, negative feedbacks also occur due to warming, of which the powerful Planck response is particularly important. Put simply, the Planck response is a feedback that makes a warmer planet radiate more energy from the top of its atmosphere to space than a cooler planet, thereby reducing the energy imbalance.

The plot below shows how the temperature increases, when started off by an initial dollop of CO_2, followed by many cycles of feedback. We've plotted this with three values of the strength of the feedback, and you can see that in each case, the temperature levels off after several rounds.



So the climatologists are not crazy to say that the positive feedback in the global-warming dynamic can lead to a factor of 3 in the final increase of temperature: That can be true, even though this feedback wasn't able

to cook the Earth during previous periods of high CO_2.

One topic along this theme, that you may have heard of in the media, concerns Arctic Permafrost. This is important because large amounts of organic carbon are stored in the permafrost - ground that remains frozen throughout the year. If large areas of permafrost thaw out as the climate warms, some of that carbon will be released into the atmosphere in the form of carbon dioxide or methane. That will certainly result in additional warming. A serious enough threat, for sure, but projections based on models of permafrost ecosystems suggest that future permafrost thaw will not lead to a 'runaway warming' situation. That's the conclusion from the FAQ regarding permafrost in the IPCC's latest Sixth Assessment Report (AR6)(PDF).

A final point regarding runaway global warming involves deep time. On several occasions in the geological past, Earth has recovered from the 'icehouse' climate state, going back into a Hothouse regime. The implication is that if such profound changes happened before without Earth entering a runaway warming state, it's highly unlikely to occur this time. That is no reason for complacency, though. A few degrees will be bad enough.

Those of a mathematical disposition will find additional interest in the Intermediate version of this rebuttal.

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