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Commentary

Rapid rising in radiative forcing

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The energy balance between the earth (and its atmosphere) absorbing solar radiation and its radiation into space determines the equilibrium temperature of the earth's surface. The process of the earth and its atmosphere as a whole radiating long-wave electromagnetic waves into space includes the transmission of surface radiation by the atmosphere, absorption, reflection, reverse radiation, atmospheric radiation to space, etc. When the concentration of greenhouse gases, such as CO_2, in the atmosphere changes, the absorption of surface radiation by the atmosphere also changes immediately, thereby changing the equilibrium temperature of the atmosphere and the surface. The relationship between equilibrium temperature and atmospheric CO_2 content, so-called the earth's climate sensitivity, is a focus of climate dynamics research.

Recently, a research article in *Science* [1] shows that the University of Miami and other research institutions collaborated to confirm that radiative forcing, $RF_{2\times CO2}$, in the widely used earth climate sensitivity measurement model of $\Delta T_{2\times CO2} = -RF_{2\times CO2}/\lambda$ CO_2 is not at all a constant. Because the immediate radiative forcing component, $IRF_{2\times CO2}$, in $RF_{2\times CO2}$ is far from a constant, where the subscript "$2 \times CO_2$" refers to the doubling of atmospheric CO_2 concentration. Previously, people generally regarded it as a constant in the research and discussion of the earth's climate change, although the scientific community has also proposed its typical concentration path correlation value [2].

This conclusion is consistent with the multi-period historical data of the Coupled Model Inline Project (CMIP). As shown in **Figure 1**, $IRF_{4\times CO2}$, which corresponds to a double-call of the doubling of CO_2 concentration and has a rough mathematical relationship of $IRF_{4\times CO2} \approx 2 \times IRF_{2\times CO2}$, over the past 160 years has shown an obvious trend of increasing. This means that the surface temperature rise caused by the doubling of CO_2 concentration has been increasing year by year [1].

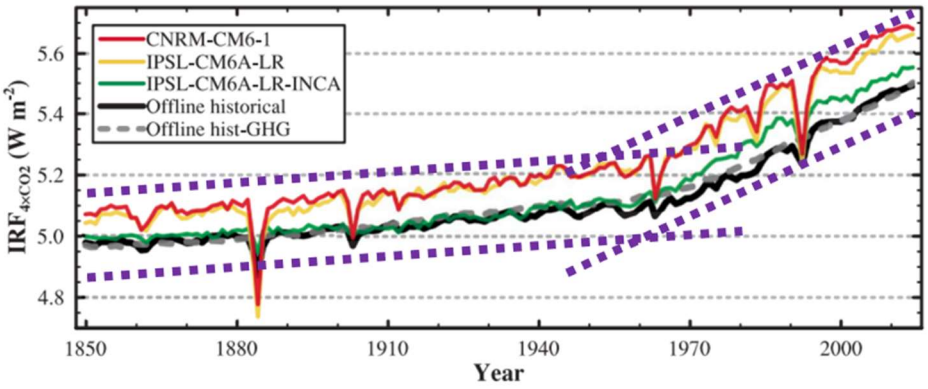

Figure 1. Changes in $IRF_{4\times CO2}$ in the past 160 years [1].

It is worth noting that when the piecewise linear trend lines (purple dotted line, the same below) are depicted to the curves in the figure, it was found that in the time history of radiative forcing over the years, there is a clear concave inflection point with a positive second-order derivative. This inflection point position is basically consistent with the inflection point positions of the global average temperature change rate [2] (shown in **Figure 2** [3]) and the atmospheric CO_2 concentration and emissions [4,5] (shown in **Figure 3**). After the inflection point, the curve is steeper, the time derivative is larger, and the radiative forcing and the earth's average temperature rise are increasing at a faster rate.

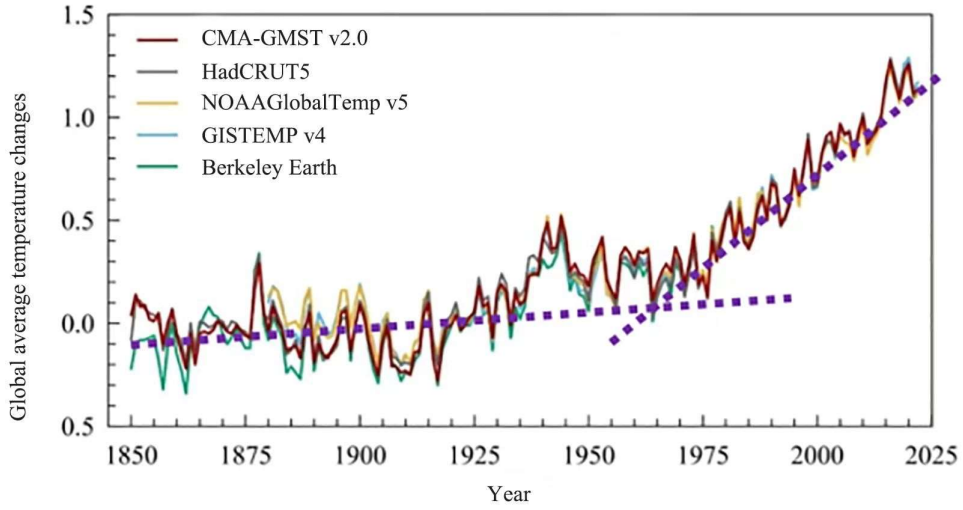

Figure 2. Global average temperature changes in the past 170 years [3].

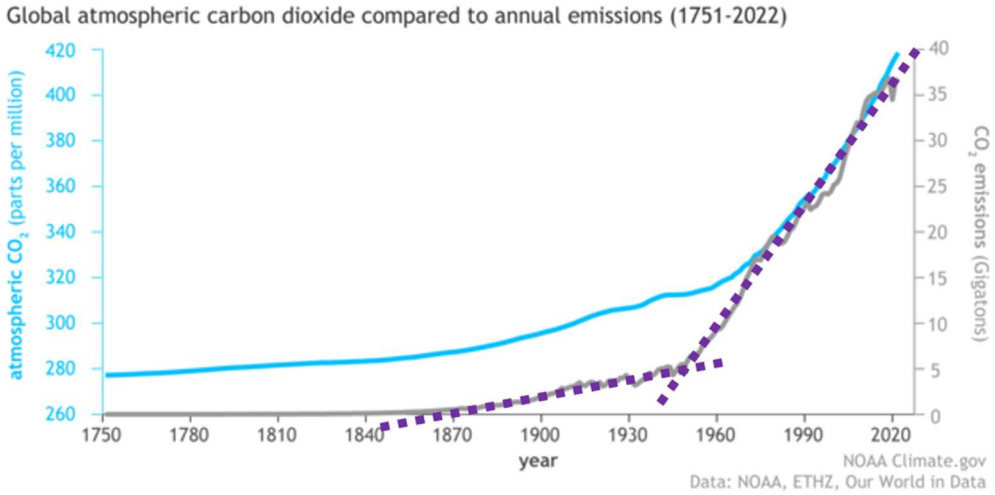

Figure 3. Changes in atmospheric CO_2 concentration and emissions over the past 170 years [5].

In short, the increase in radiative forcing is already in a stage of rapid growth. Greenhouse gases, such as CO_2, emitted by humans in modern production and living on the earth are still accelerating the warming of the earth. The need for research, development, and use of clean energy is becoming increasingly urgent. Of course, although there is bound to be full of resistance when the scientific community urges

the North American elites to voluntarily give up the lifestyle of big cars, big houses, and high emissions, it is definitely a move of great merit, because we know that energy saving means emission reduction.

For subsequent researchers, if the internal scientific mechanism of the inflection point of the curve of radiative forcing versus time can be clarified, it will undoubtedly help to better and more effectively avoid the next concave inflection point, or even create a convex inflection point, through brainstorming scientific and technological research. This will make the earth's climate more stable and livable.

Conflict of interest: The author declares no conflict of interest.

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