Science Topic 09-23-23

CliSciPol

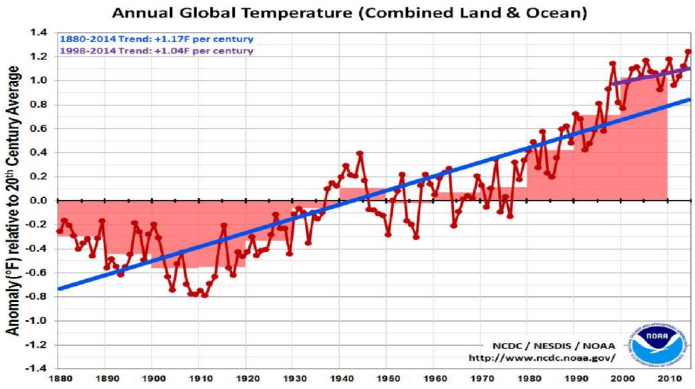
Climate Science and Policy for Nonscientists

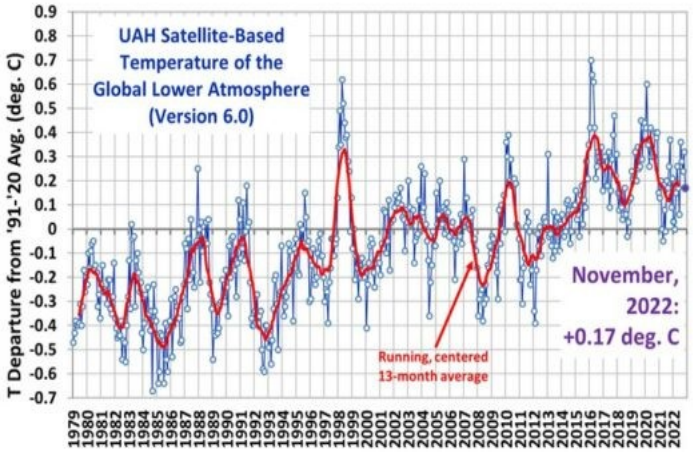
One picture is worth a thousand words.

How Much Will the World Warm by 2100?

How Strong a Warming Force is Rising CO2 Levels?

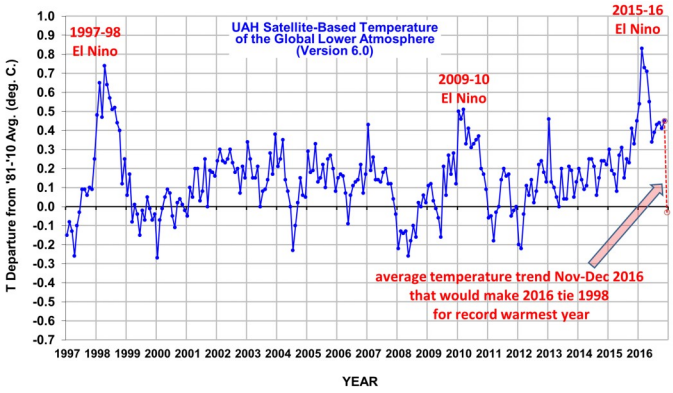
The world, has been warming at a fairly steady rate for the last 140 years. According to the IPCC AR6 (2021), the world has warmed by 1.09 C since the pre-industrial period (1850-1900) (AR6 WGI p.5), so the rate of warming is less than 1 C per century. Various data sets show that the temperature rise is relatively linear, and some, such as the one here, show that the rate of warming is declining slightly (disputed).



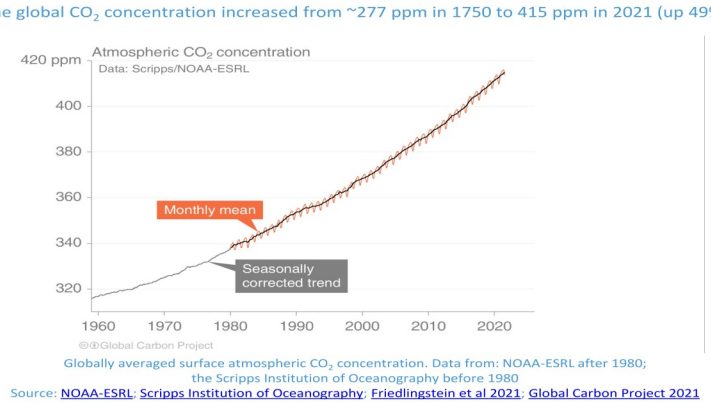


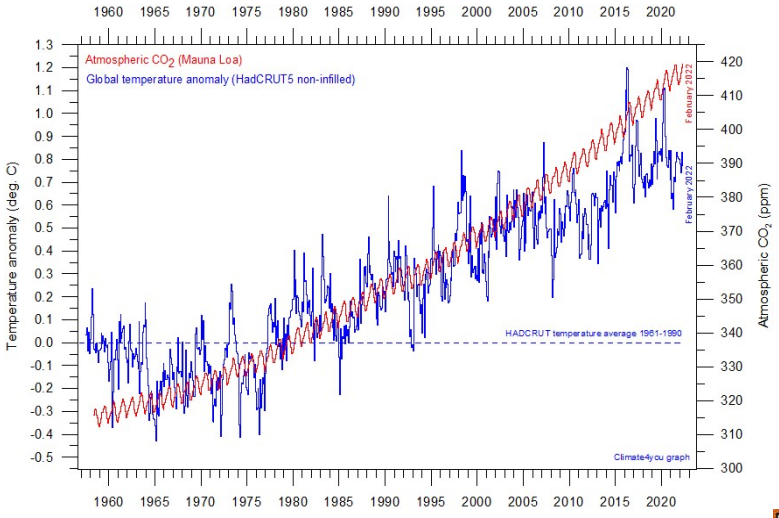
The University of Alabama Huntsville satellite data set through 11/30/22 shows that world temperatures paused from about 2002-2014 and again from about 2016 through 2022. Virtually all of the data sets show the rate of temperature rise to be steady or decreasing. AR6 states that present world temperature is "unprecedented," but there is no claim (as often appears in the media) that the rate of rise has accelerated. (AR6 WGI p.6)

The 1998, 2009, and 2015 temperature spikes were caused by strong El Ninos, which demonstrates the power of oscillating ocean currents to affect world temperatures. It is disputed how much of these El Nino spikes is actually global warming as opposed to just the transfer of heat energy back and forth between the oceans and the atmosphere.



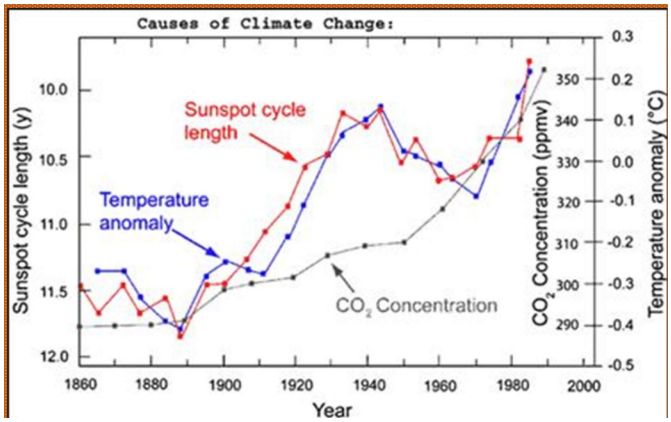
The rate of rise of atmospheric CO2 levels has been significant since the 1950s and has been fairly linear since 1960 with a slight increase in the rate of rise since about the year 2000. The present rate of rise is about 2.5 ppm per year or about 6% per decade.





According to AR6, temperature rise is driven virtually 100% by human-caused factors. (AR6 WGI p.5). But, while over the last 20 or so years there has been a slight increase in the rate of CO2 rise, the rate of temperature rise has stayed the same or even declined. This calls into question the theory of a simple causal connection between CO2 rise and temperature rise.

Some scientists contend that natural forces caused the warming from 1910-1945 and also caused the cooling from 1945-1975. CO2 levels were not rising fast enough to have caused the 1910-1945 warming, and, obviously, rising CO2 did not cause the subsequent period of cooling. Suggested causes include solar variability and oscillating ocean currents, such as the Atlantic Multidecadal Oscillation and the Pacific Decadal Oscillation. But AR6 insists that natural forces have not been significant since the preindustrial period.



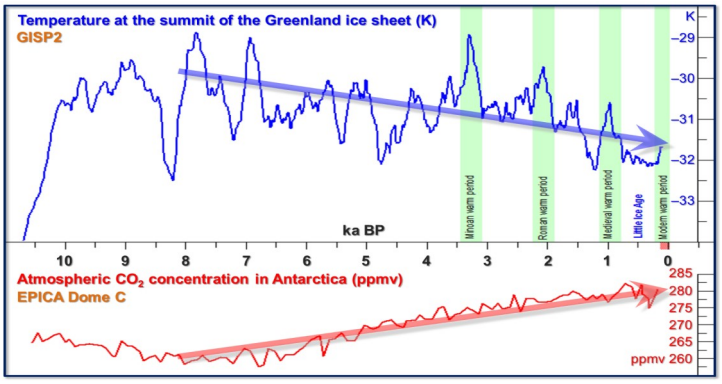


Figure 7. Reconstructed Greenland mean temperature anomalies (top) and Antarctic CO_2 concentration (bottom). Halving the temperature anomalies to allow for polar amplification gives a reasonable approximation of global temperature change in the Holocene. Since the Holocene Optimum began about 9,000 years before present (ka BP), global temperature has fallen by ~1°C, though CO_2 concentration rose throughout.[34]

For the last 8,000 years world temperatures have trended downward with significant short-term cyclical movements while CO2 levels have trended upwards. So it is obvious (a) that there have been natural cooling forces operating during this period that were more powerful than the CO2 warming force, and (b) that there have been natural forces operating that caused cyclical temperature movements. But AR6 takes the position that virtually all of the temperature rise since the preindustrial period is attributable to human activity. (AR6 WGI p.6)

Over the last 600 million years changes in CO2 level have tended to follow changes in temperature, or to move independently of temperature change, not to precede temperature change. This rebuts the idea that changing CO2 levels have any significant causal effect on temperature change.

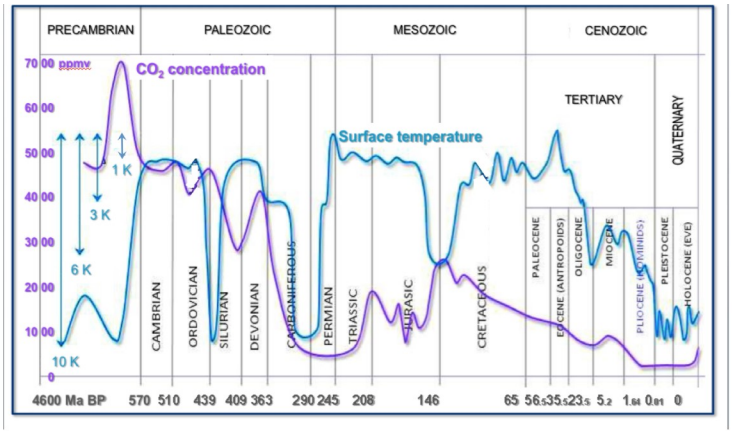
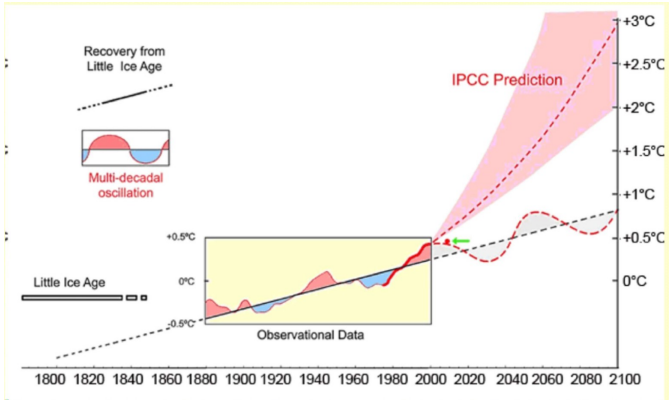


Figure 1. Graph of global temperature and atmospheric CO_2 concentration over the past 600 million years. Note both temperature and CO_2 are lower today than they have been during most of the era of modern life on Earth since the Cambrian Period. Also, note that this does not indicate a lock-step cause-effect relationship between the two parameters.[5]



This image shows two methods of predicting world temperatures through the year 2100. The trend line approach shows temperatures rising roughly another 1 C, which a significant number of scientists consider to be non-problematical, if not actually beneficial.

The computer models from AR4 (2007), shown here, calculate temperature rise by 2100 as from 2.0 C up to 4.5 C beyond the top of the image. But CO2 levels have been rising steadily (with some recent acceleration) since 1960, while the rate of temperature rise has been steady (with arguably some decline) at roughly 1 C per century. The models calculate a dramatic, immediate increase in the rate of warming. But, if CO2 continues to rise at the same rate it has been rising for the last 60+ years, why should this suddenly produce a dramatic increase in the historical rate of temperature rise?

There is reason to believe that rising CO2 levels in the future will have less effect than in the past because of the CO2 Saturation Effect. Infrared blocking is the Greenhouse Effect. This graph is based on measured data showing that the power of CO2 as a greenhouse gas decreases as the CO2 concentration in the atmosphere increases.

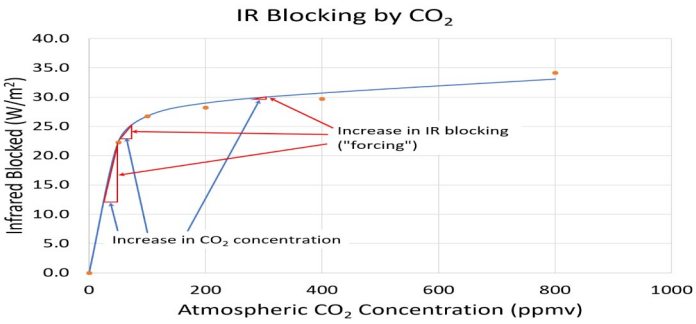


Figure 6: IR blocking for CO_2 concentrations from 0 to 800 ppmv. Given an increase in the CO_2 concentration, the effect decreases as the amount of atmospheric CO_2 increases.

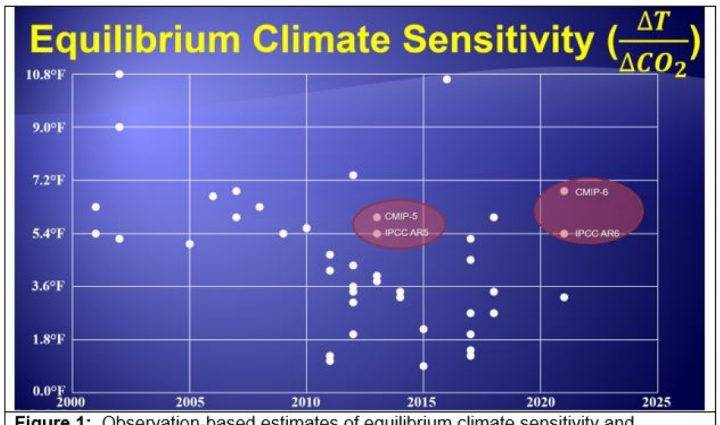


Figure 1: Observation-based estimates of equilibrium climate sensitivity and estimates from CMIP-5 and 6 and IPCC AR5 and AR6.

The Greenhouse Effect is real. CO2 is a greenhouse gas, and adding CO2 to the atmosphere causes some amount of warming. Unfortunately scientists have never been able to measure the actual warming strength of CO2 in the atmosphere, and so they are forced to estimate it. The formal scientific name for the CO2 warming strength is Equilibrium Climate Sensitivity (ECS). AR6 states that ECS is "close to, or at least not inconsistent with" 3.0 C. (AR6 WGI p.1005). This means that, if the CO2 level is doubled to 560 from the … [continued on next page]

pre-industrial level of 280 ppm, then world temperatures will eventually rise by 3.0 C as a result. Unfortunately there is wide divergence among scientists' estimates of ECS. There is a clear downward trend in these estimates (as shown in the graph on the prior page), and most of the estimates since 2010 are below 3.6 F or 2.0 C. Some scientists believe that ECS is significantly less than 2.0 C. One survey of studies on sensitivity has concluded that the best estimate is 1.35 C., but there is a wide range in the estimates of the correct number. AR6 acknowledges that there have been a "multitude of studies" concluding that ECS was lower than the AR6 estimate, but then fails to address these studies. (AR6 WGI p. 1007)

Computer models – important points -

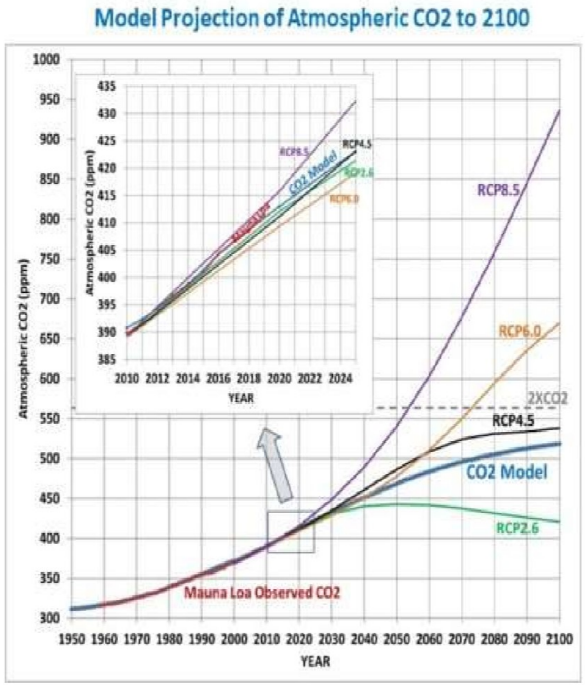
They use scientific theories but are not themselves scientific theories.

They are complex computer programs that perform hypothetical calculations.

Each model must in some way make an assumption as to ECS, CO2 warming strength, and as to the rate of CO2 rise.

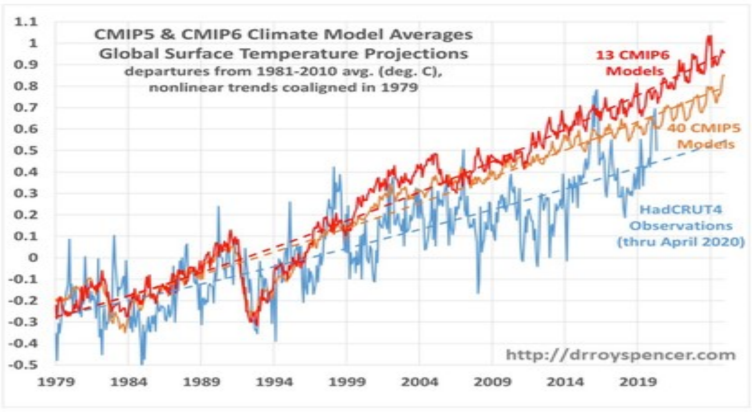
They have never been verified.

To predict future temperatures a computer model must assume in some way a number for ECS and a path for the rise of atmospheric CO2. The output of the model can never be any more accurate than the accuracy of the assumptions used. The accuracy of these models has never been proven. In fact, there is substantial reason to doubt their accuracy, which will be discussed below.

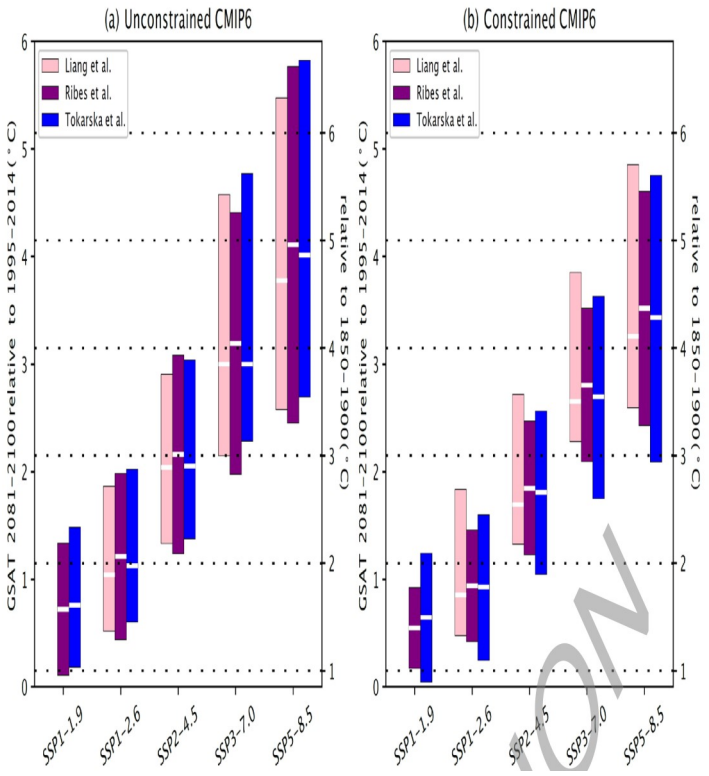


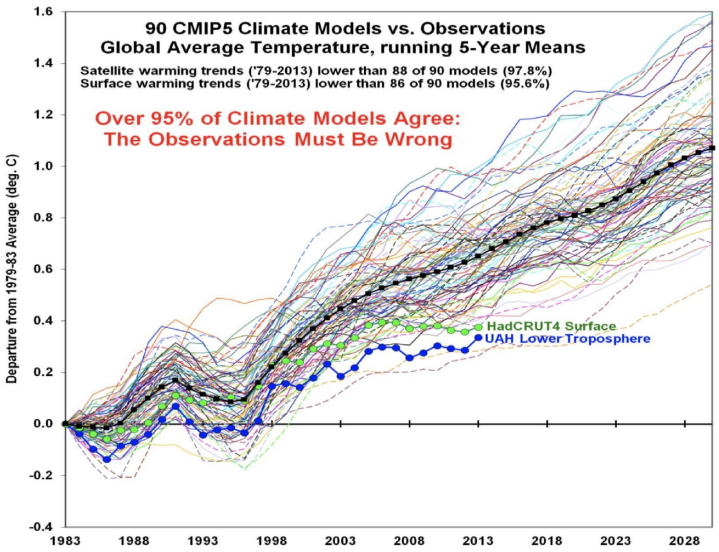
The IPCC prepares sets of assumptions for the computer models to use. In order for the results of the different models to be compared, they have to be making similar assumptions, for example, as to CO2 levels, population increases, amounts of electricity generated, sources of that electricity, land use, etc. These sets of assumptions are called "Pathways" or "Scenarios," and are given identifying numbers. The attached graph shows the assumptions as to CO2 levels contained in Pathways RCP8.5, RCP6.0, RCP4.5, and RCP2.6. The graph also presents an independent projection of the likely atmospheric CO2 level through 2100 (CO2 Model). The model projects that the CO2 level in 2100 will be less than 560 ppm (2XCO2), hence less than the doubling level of 560 ppm since the pre-industrial period. The present CO2 level is 420 ppm. If it continues to increase at the present rate of 2.5 ppm/year, it will be 420 +78 x 2.5 = 615 ppm in the year 2100, far below the number assumed in RCP8.5 and also RCP6.0.

The models have a long history of overpredicting temperature rise, and the CMIP6 models used in AR6 (2021) have turned out to be even worse than the CMIP5 models used in AR5 (2013). The overprediction problem was bad enough in AR6 that the IPCC felt obliged for the first time to "constrain" the models, i.e. disregard the models that produced unrealistically high numbers. (AR6 WGI p.581). (See the next image)



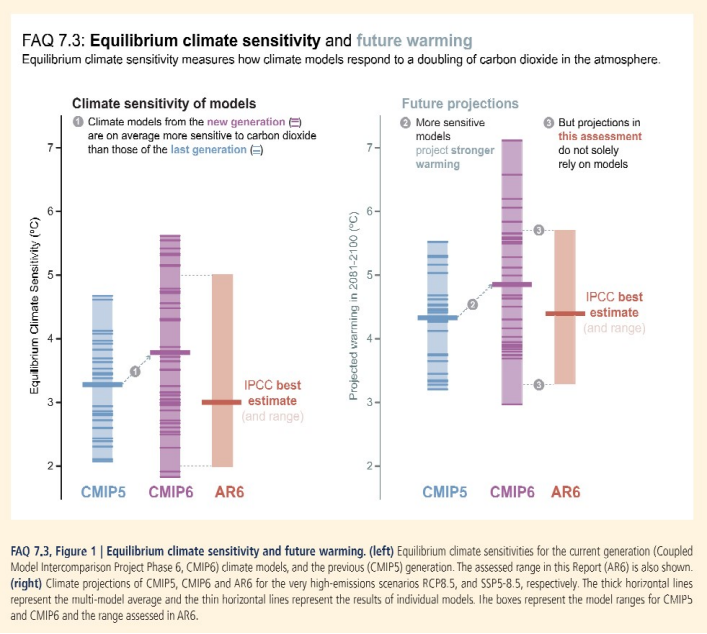
The assumptions of the particular Pathway determine the temperature rise that a model calculates. (AR6 WGI p.581). But in formulating these Pathways the IPCC made no judgment about the likelihood that any of these Pathways would actually occur. The Pathways were intended to cover a range of possible paths of world development. There is growing consensus among scientists that the assumptions in RCP8.5 and RCP6.0 are unrealistic, because CO2 levels can not possible reach the levels assumed. (See the second prior graph). Therefore all the model runs using those assumptions can be disregarded, and those are the model runs that calculate potentially dangerous global warming in the range of 3-6 C above the present temperature. There is a growing consensus that the world's actual Pathway is somewhere between SSP1-2.6 and SSP2-4.5, as shown in the second prior graph. For those Pathways the models calculate additional warming through 2100 of between 0.5 and 2.5 C. (AR6 WGI p.581).





Another major problem with the models (in addition to calculating numbers higher than reality) is how much they disagree among themselves, as shown here. There is no convergence that might be interpreted as suggesting a consensus number.

AR6 admits that the CMIP6 models (in addition to calculating higher numbers than the CMIP5 AR5 models, the prior generation) actually had more disagreement among themselves (more spread) than the CMIP5 models, as shown in this graph from AR6. (AR6 WGI p. 1025). The AR6 "best estimate" of 3.0 C for ECS is lower than what was calculated both by the models in AR5 (2013) and in AR6 (2021). (AR6 WGI p. 1025).



FAQ 7.3, Figure 1 | Equilibrium climate sensitivity and future warming. (left) Equilibrium climate sensitivities for the current generation (Coupled Model Intercomparison Project Phase 6, CMIP6) climate models, and the previous (CMIP5) generation. The assessed range in this Report (AR6) is also shown. **(right)** Climate projections of CMIP5, CMIP6 and AR6 for the very high-emissions scenarios RCP8.5, and SSP5-8.5, respectively. The thick horizontal lines represent the multi-model average and the thin horizontal lines represent the results of individual models. The boxes represent the model ranges for CMIP5 and CMIP6 and the range assessed in AR6.

Conclusion

Since the pre-industrial period the rate of temperature rise has been roughly linear at the rate of 1 C per century. CO2 has been rising at a significant ,and roughly linear rate since the late 1950s, but this has not resulted in any increase in the rate of temperature rise. If anything, the rate of temperature rise has diminished. The models for nearly 30 years have been predicting that there will be a rapid increase in the rate of temperature rise, but this has never happened. There is little basis to expect that the rate of temperature rise is going to increase significantly above its present level of around 1 C per century, which is arguably beneficial, as is discussion in a separate science topic.

If CO2 doubling occurs in 2100 and ECS = 3.0, as estimated by AR6, then temperatures should be rising at the rate of 2.4 C per century, which is obviously not happening. The present rate of rise of 1 C per century corresponds to ECS = 1.9, which is consistent with many of the observation-based estimates discussed above.