AN ASSESSMENT OF THE CONVENTIONAL GLOBAL WARMING NARRATIVE

Richard Lindzen

With a comment by Nic Lewis

The Global Warming Policy Foundation
Technical paper 5

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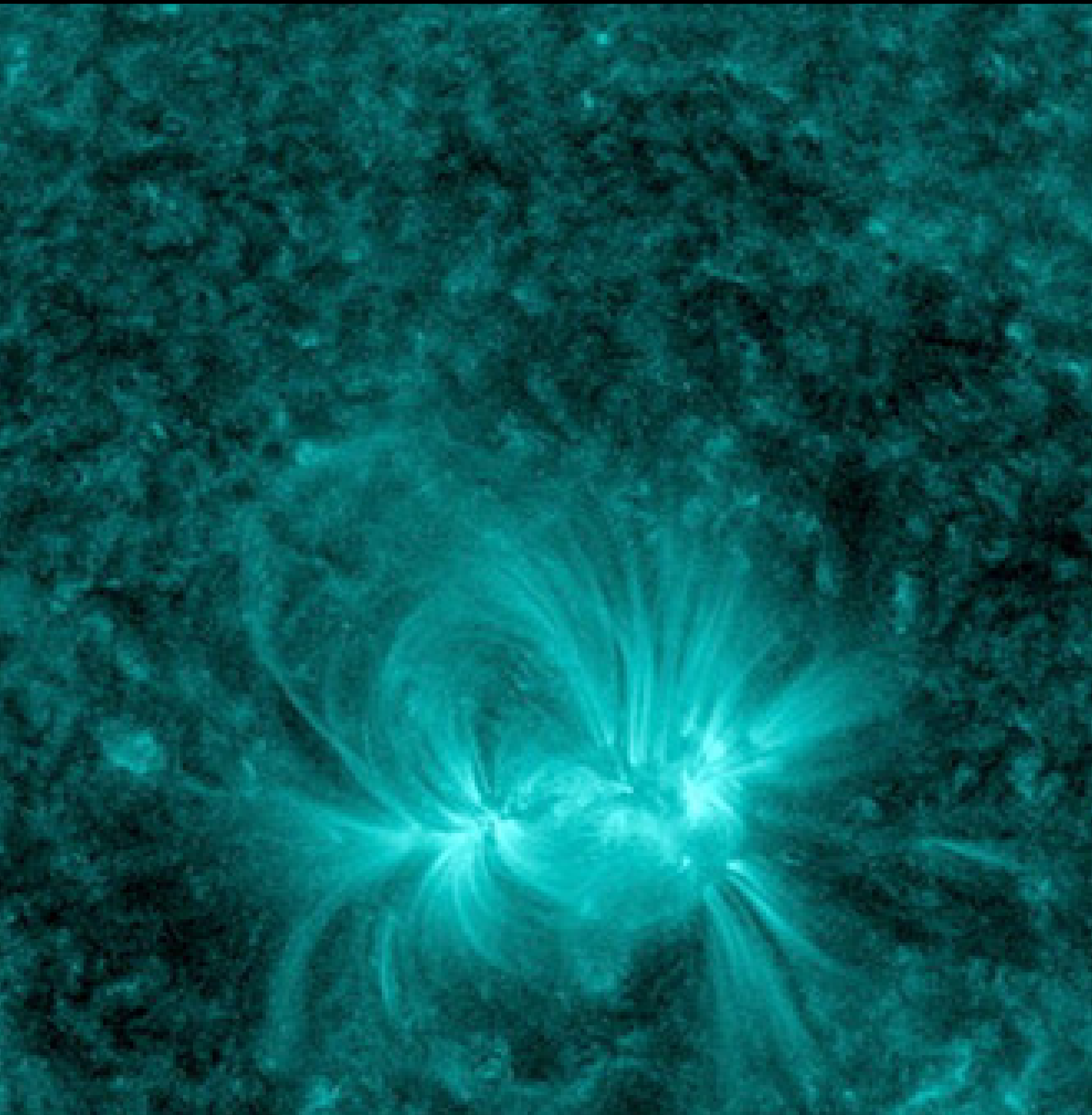

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About the author

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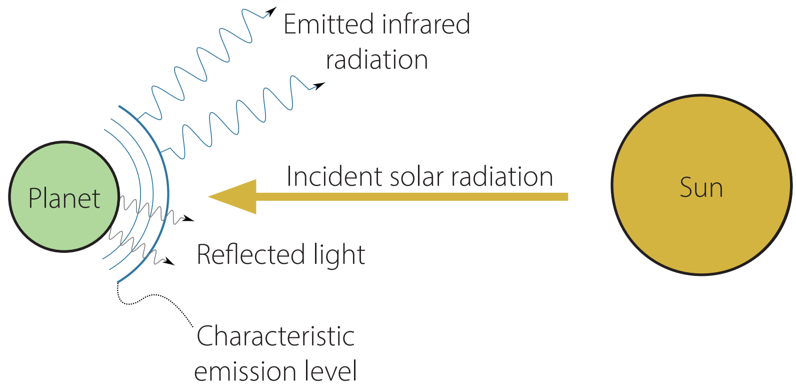
Abstract

The one-dimensional picture of the greenhouse effect and the role of carbon dioxide in this mechanism dominates current depictions of climate and global warming. We briefly review this picture. We then discuss the shortcomings of this approach in dealing with the three-dimensional climate system. One problem is determining what temperature on the real Earth corresponds to the temperature in the one-dimensional treatment. This, in turn, leads to the traditional recognition that the Earth has, in fact, many climate regimes at present. Moreover, there have been profound changes in the temperature difference between the tropics and polar regions over millennia, but at the same time the temperature of the tropical regions has remained little changed. The popular narrative assumes that small changes in the tropics are amplified at high latitudes. There is no basis for this assumption. Rather, the difference is determined by dynamic heat fluxes in the atmosphere and oceans, with the controlling flux due to baroclinic instability in the atmosphere. Changes in mean temperature are primarily due to changes in the tropic-to-pole difference, and not to changes in the greenhouse effect. The stability of tropical temperatures in the face of strongly varying heat fluxes out from those latitudes points to the existence of strong negative feedbacks in the radiative-convective response of the tropics. Finally, we will comment on the so-called impacts of climate change.

1. The popular narrative

We will begin with a brief description of the greenhouse effect as commonly presented in popular books on climate change (Emanuel 2018, Krauss 2021, for example). Figure 1 is the type of picture that is presented to describe the relevant energy balance for a planet.

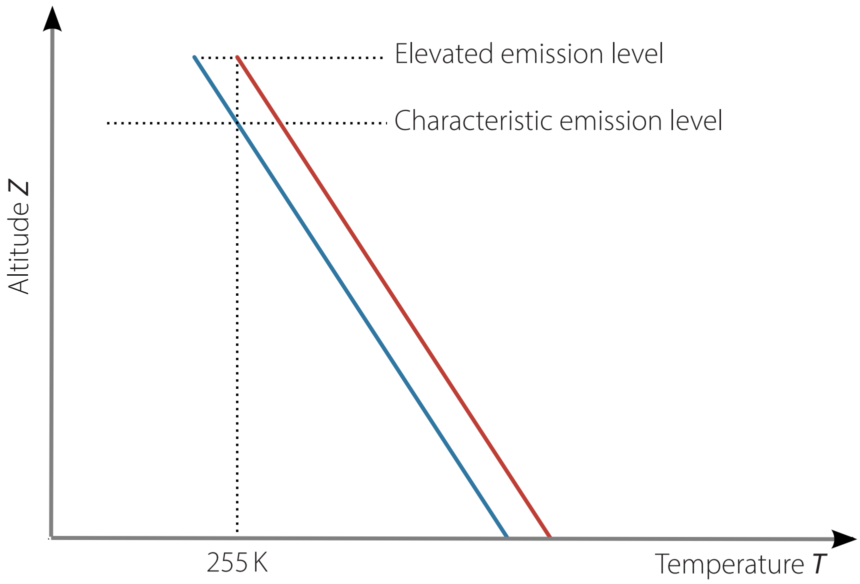
Figure 1: Radiative balance for a hypothetical planet.



Although the planet and the sun look spherical, the numbers represent some sort of average, which will, in fact, be applied to a one-dimensional picture. Thus, the net incoming solar radiation (incident less reflected) must be balanced by the planet's emitted infrared radiation. Because of the high temperature of the sun, its radiation is primarily in the visible part of the spectrum. The Earth's much lower temperature causes its radiation to be concentrated in the infrared. Because of the presence of strong infrared absorbing components in the Earth's atmosphere (mostly water vapour and clouds, with small contributions from CO_2, ozone and still more minor constituents), emissions cannot escape the atmosphere until one gets to a level above which there is so little absorption as to permit the radiation to escape to space. This level is referred to as the 'characteristic emission level'. The characteristic emission level plays a crucial role in the greenhouse effect. Balance is achieved when the temperature at the characteristic emission level is 255 Kelvin (K).

In order to obtain greenhouse warming, one must consider one more process, namely thermal convection. Radiation alone leads to convective instability; the surface becomes sufficiently warmer than the air above it as to lead to convection, which penetrates deep into the atmosphere. Convection in a gas subject to gravity leads to the temperature decreasing at an adiabatic lapse rate. For a dry atmosphere, this is given by g/c_p (where g is the acceleration of gravity and c_p is the heat capacity of dry air at constant pressure; the result is approximately 9.8 K/km); for a moist atmosphere, where condensation accompanies cooling, the situation is more complex, but the associated lapse rate is approximately 6.5 K/km. A review of radiative-convective equilibrium may be found in Goody and Yung (1989). Adding an infrared absorbing gas (i.e. a greenhouse gas) elevates the characteristic emission level and, because of convection, this level is colder than 255K. In order to reestablish equilibrium with net incoming radiation, it must be warmed back to 255 K, thus raising the temperature of the entire atmosphere below this level. This is the essence of the so-called greenhouse effect. It is illustrated in Figure 2.

Figure 2: One-dimensional greenhouse effect.



While the effect is commonly attributed to Arrhenius and even Fourier, this is inaccurate. Those earlier scientists recognised that certain gases absorb thermal radiation, but they did not understand the role of convection.

The one-dimensional approach does provide some insights into the gross differences among the various planets in our solar system, and it should be noted that almost all current discussions of global warming are based on one-dimensional approach, largely because of its simplicity. However, as we will see, it is fundamentally inadequate for describing the Earth's complex three-dimensional nature.

Briefly, one begins with an atmosphere that has a preindustrial value for CO_2, and asks how much warming will be associated with a doubling of that concentration. It turns out that the warming is logarithmic in CO_2 (because the absorption bands of CO_2 are almost saturated, and absorption is associated with line wings), so that each doubling is associated with the same warming. The contribution is about 3.5 W/m^2, or of the order of 2% of the normal flux, and leads to warming of about 1°C.

This result is not considered controversial. Normally, one might consider 2% to be small, since common fluctuations – in upper-level cirrus, low-level clouds, ocean currents, and so on – routinely produce this level of variability in the radiative budget. In other words, consistent with Le Chatelier's Principle, the climate system is amply capable of opposing such forcing. Although the gross inadequacy of our understanding of clouds and other factors is openly acknowledged by the IPCC, concerns over global warming are based on what is essentially the assumption that variations in water vapor, clouds, and so on act to amplify rather than oppose the impact of CO_2; in other words, they are assumed to be positive rather than negative feedbacks. *It is on the egregiousness of these assumptions rather than on the greenhouse effect itself, that most sceptics (including myself) have focused.*

As we have just seen, the focus on the one-dimensional view is understandable. Its particular appeal is to physicists and astrophysicists, since it involves a minimum of detail, while letting them feel that they have mastered the subject. My point here is to simply note that these individuals are often deeply familiar with radiative transfer, but not with fluid dynamics. It was also taken seriously by many of us who should have known better. The reason for this was that even this coarse approach required highly dubious properties for feedbacks and involved insufficiently accurate radiative transfer calculations. In brief, even this oversimplified approach demanded better assessment.

Although the exposition above is the conventional explanation of the greenhouse effect, most projections refer to large-scale models of the atmosphere known as GCMs. The original expansion of this abbreviation was 'general circulation model.' However, increasingly, they seem to be referred to as 'global climate models.' These models do include much of the complexity of the real atmosphere, but they cannot provide the spatial resolution to handle processes such as vertical convection (that is, cumulonimbus towers), clouds in general and turbulence, which, as a result, require the use of questionable parameterisations. They do, however, permit the inclusion of arbitrary feedbacks, which enable models to produce a wide variety of results. Nevertheless, even these models do not predict catastrophic changes due to increasing CO_2. Moreover, they do not adequately describe even the present climate (Boyle, 2006). They do especially poorly at representing the natural internal variability of the atmosphere and the oceans, and almost all of them fail to correctly anticipate changes in the commonly used measure of global temperature. Nor do they simulate past climates adequately. This has been openly acknowledged by some of the modelers who have been most supportive of the global warming narrative (Hausfather et al., 2022).

Virtually all critiques of the global warming issue have focused on feedbacks, the inadequacies of the models, and one other matter: the claims of various things having changed (so-called 'impacts'). I will briefly return to this other matter later.

2. What is the Earth's temperature?

One characteristic of current discussions of climate is the focus on the temperature of the Earth. While this is clear in the one-dimensional picture, the Earth is not one-dimensional, and the notion of the Earth's temperature is, itself, a problematic and highly misleading metric.

Clearly, it is not the average temperature. After all, what does it mean to average Mount Everest with the Dead Sea? What is used instead is the average anomaly (defined as the deviation from 30-year means at each station). This anomaly is actually the small residue of widely spread dense data points. These data points are shown in Figure 3, an update by Lindzen and Christy (2020) of work originally done by the late Stanley Grotch at the Lawrence Livermore Laboratory. Note the temperature scale. It extends over a range of almost 20°C!

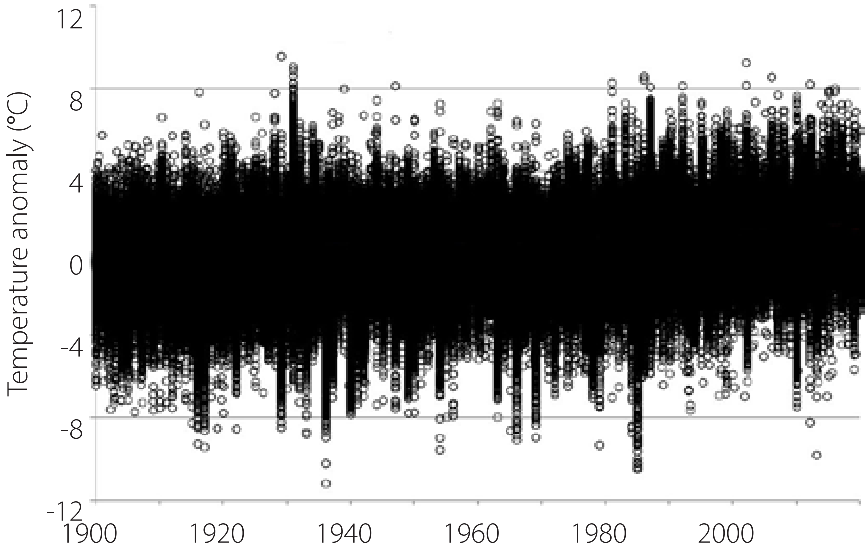


Figure 3: Seasonal temperature anomalies at individual stations.
The Berkeley Earth Surface Temperature Data (BEST) was used because it was conveniently available.

Figure 4 shows both the average and the data points. The average is shown by yellow points with orange boundaries. At any particular time, almost as many stations will be cooling as warming because the anomaly is so small.

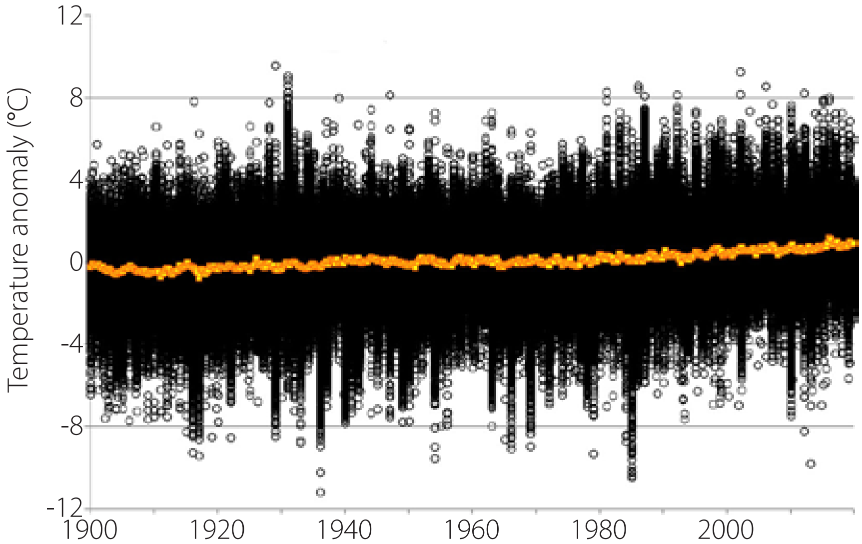
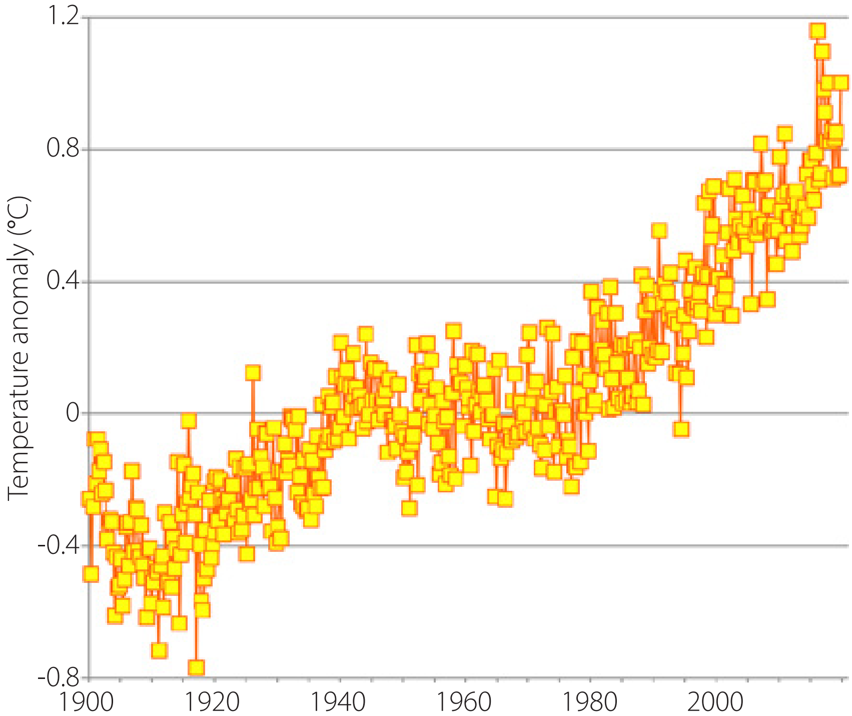


Figure 4: Same as Figure 3, but with average shown.

In order to disguise this, one presents the average without the data points and expands the temperature scale by about an order of magnitude. The result is shown in Figure 5.

Blowing up the scale and omitting the data points serves to

Figure 5: Average temperature anomaly without the data points.



disguise the fact that we are still talking about really small temperature changes. Although we are told that increases of another 0.5°C represent catastrophe, it pays to put such changes into perspective. This is done in Figure 6, where we show the small changes in the mean compared to changes that we routinely deal with.

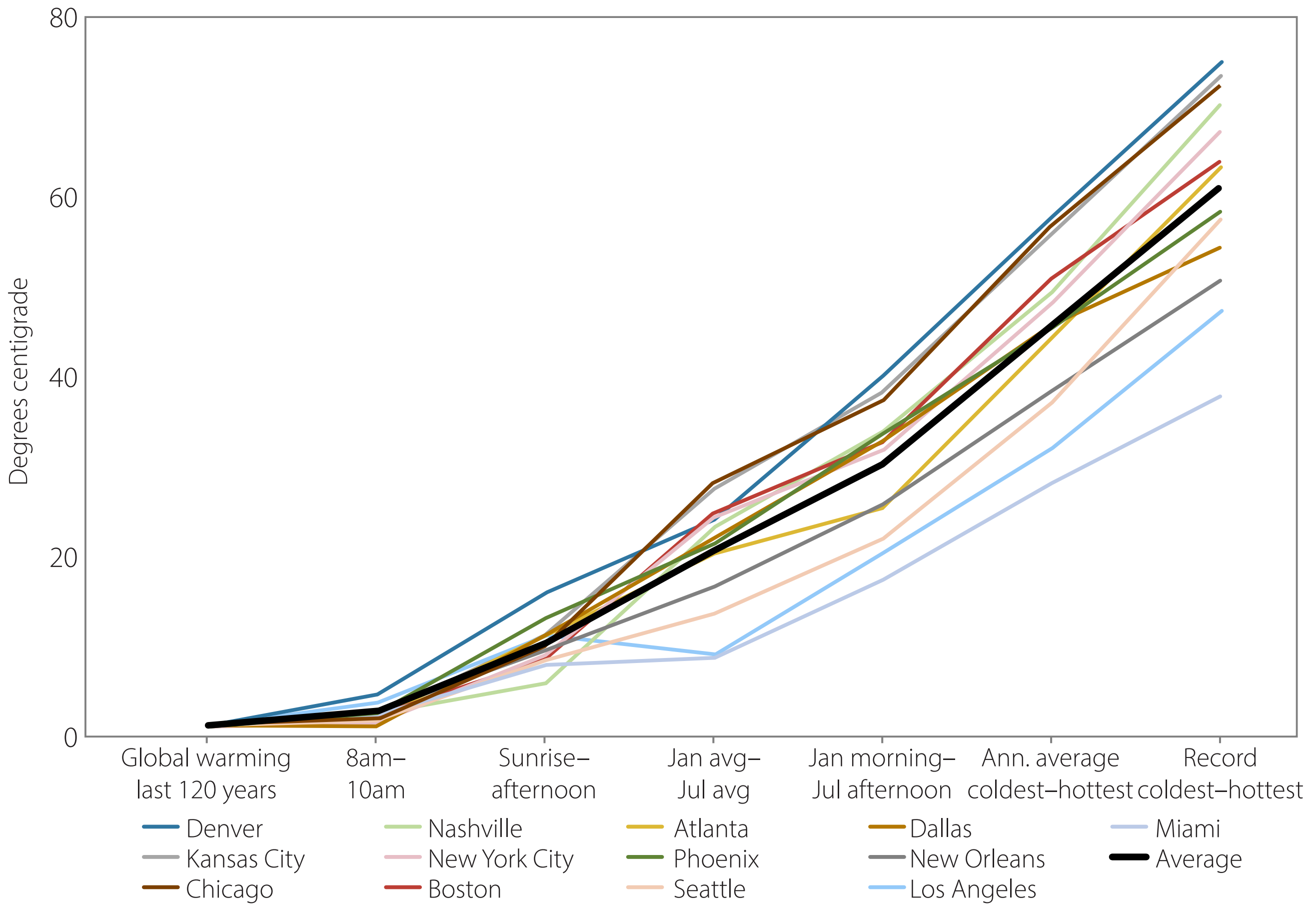


Figure 6: Various temperature changes that people and the rest of nature already deal with.

It may be worth noting that the Working Group I report (the part dealing with the science) of the UN's Intergovernmental Panel on Climate Change never suggests that 0.5°C of additional warming represents an existential threat. Indeed, it doesn't suggest existential threats at all. Where in the world do such claims come from? It seems that despite decades of claims of the certainties around the (at least) public and public policy climate narrative, policy actions haven't been aggressive enough for proponents of the crisis-demands-action camp, and thus there's been an escalation of hyperbole about an imminent apocalypse. Needless to add, this has not served constructively in clarifying the underlying realities of climate science.

3. What is the Earth's climate?

It should be recognised that climate science, prior to about 1980, was a very small field. Indeed, at MIT in 1990, no-one working on climate-related aspects of meteorology, oceanography, marine geochemistry, geology, and so on referred to themselves as climate scientists (although today, all of them do). Indeed, until the 1970s, the meteorological literature on climate didn't emphasise, or even mention, the greenhouse effect (*Climatology*, Haurwitz

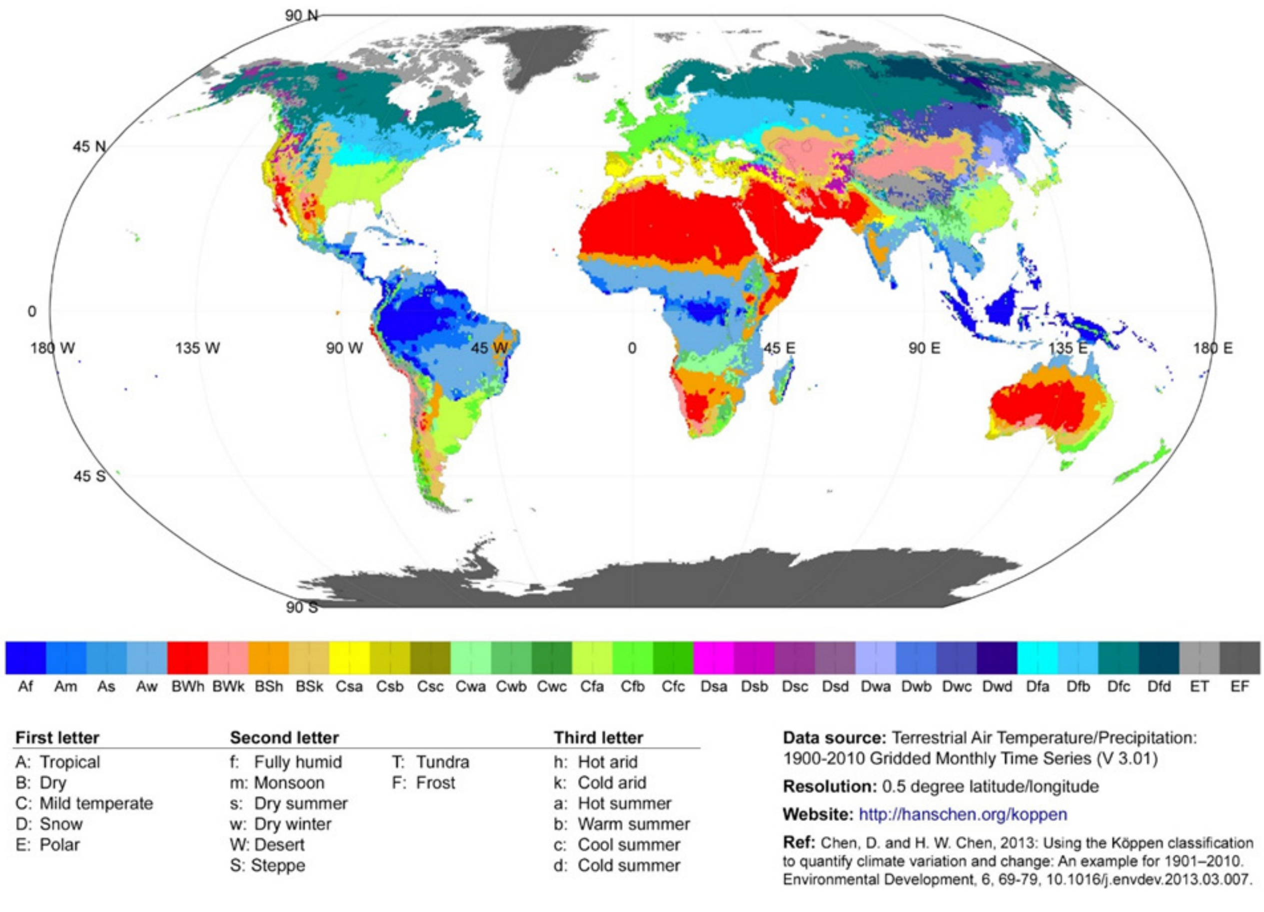


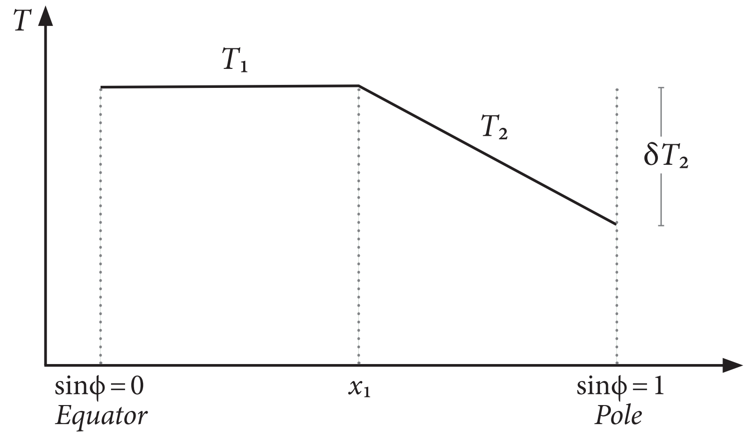
Figure 7: World map showing climatic regimes following the Köppen classification.

and Austin, 1944, *Climate*, Pfeffer, 1960, *Atmosphere, Weather and Climate*, Barry and Chorley, 1970). Instead, they were concerned with understanding the wide variety of climate regimes that were found at the time (and, for that matter, still are). These are commonly described by the Köppen classification, as shown in Figure 7.

Much of the explanation for these regimes consists of largely 'just so' stories, but that isn't unusual in the earth sciences. The approach of theoreticians like myself tends to be more mathematical and focused. We try to isolate features like the Hadley circulations and stationary waves. Oceanographers have their own pet features. Milankovitch insightfully identified orbital variations in producing cycles of glaciation – something substantially corroborated in more recent papers (Roe, 2006, Edvardsson et al, 2002). Interestingly, none of the approaches is so naïve as to assume that there is some mean 'temperature' that determines the numerous features of the Köppen picture – as well as a single primary cause, such as CO_2.

In considering climate change, the Soviet climatologists Budyko and Izrael (1991) noted that it mostly manifested as changes in the tropics-to-pole temperature difference; tropical temperatures changed very little. The change in the mean temperature is almost entirely due to changes in the tropics-Arctic temperature difference. This is illustrated more explicitly in Figure 8.

Figure 8: Simplified picture of meridional temperature distribution between the Equator ($\sin\phi = 0$) and the Pole ($\sin\phi = 1$)



$$\Delta\overline{T} = \Delta T_1 - \Delta(\delta T_2)\,\frac{1-x_1}{2}$$

Note that if ΔT_1 is small, $\Delta\overline{T}$ will be dominated by $\Delta(\delta T_2)$. For major climate changes, this has been the case. The crucial point is that $\Delta(\delta T_2)$ is not a response to ΔT_1; in other words, it is not an amplification of whatever is happening in the tropics. It is of course possible, during periods when $\Delta(\delta T_2)$ is small, that $\Delta\overline{T}$ will be dominated by ΔT_1, but these periods will not represent major climate change.

By the 1980s, with advances in paleoclimatology, several aspects of climate history emerged with increased clarity. We began to see more clearly the cyclic nature of glaciations of the past million years or so (Imbrie and Imbrie, 1979). Warm periods, such as the Eocene (50 million years ago), became better defined (Shackleton and Boersma, 1981). The data suggested that for both glacial periods and the warm periods, equatorial temperatures did not differ much from present values, but the temperature difference between the tropics and high latitudes varied greatly (Table 1).

Table 1: Temperature difference between tropics and high latitudes.

Period	ΔT (°C)
Eocene	≈20
Glacial maximum	≈60
Today	≈40

The variations in equatorial temperatures were much smaller.

4. What determines the tropics-pole temperature difference?

Adherents of today's popular narrative invoke an imaginary 'polar amplification', which some models (to their credit) fail to display (Lee, et al, 2008). However, the physical basis for this difference is, in fact, well known. It is driven by the heat flux from the tropics to the polar region. There are heat fluxes associated with ocean currents and a number of atmospheric processes. However, the controlling heat flux is primarily due to convection, associated with what are called baroclinic instabilities (Pedlosky (1992), Holton and Hakim (2012), Lindzen (1990), or virtually any textbook on geophysical fluid dynamics).

These instabilities are 'controlling' because they work to bring about the temperature distribution that neutralises the instability (Lindzen, 2020, Lindzen and Farrell, 1980). The fact that some of the transport is due to other processes, such as oceanic transport and stationary waves, simply removes the need for transport by baroclinic instability. However, heat transport by baroclinic instabilities will contribute whatever more is needed to achieve baroclinic neutrality.[1]

A better-known example of controlling instabilities is vertical convection due to heating from below. In a laboratory-scale incompressible liquid, convective instability arises from temper-

1 However, for readers who want a quick description, the following short video 'DIYnamics: Baroclinic eddies in a tank and in Earth's atmosphere', provides a sense of how baroclinic instabilities emerge in a rotating tank driven by heat flux from a warm edge to cold center. https://youtu.be/5bnmaYOFerk?list=TLPQMzAwMTIwMjJrK1Y3IlvMXA. The video ends by stating, 'Changes in overall temperature contrast affect the behavior of eddies … so climate change may alter Earth's eddies, and the weather they produce'. It should be noted that in a warmer world, this difference is expected to decrease.

ature decreasing with height – warmer liquid being more buoyant. The convection acts to eliminate the vertical gradient of temperature. The situation is more complicated for a compressible gas. Convection leads to a moist adiabatic lapse rate (i.e. the rate at which temperature decreases with height) for the tropical atmosphere. Radiative-convective equilibrium is largely restricted to the tropics. The stability of the tropical temperature suggests negative rather than positive feedbacks, since the tropical temperatures remain relatively stable despite the varying heat fluxes from the tropics.

An important question is, why does the climate have different tropics-polar temperature differences? Results of theoretical studies show that equilibration only determines the temperature difference at the level of the Arctic tropopause around 6 km (Jansen and Ferrari, 2013). This is, in fact, observed to be about 20°C (*viz* Newell et al.,1972), which is the difference that characterises the Eocene. The differences at the surface seem to be associated with the existence of Arctic inversions, which are in turn associated with the presence of ice and snow, but are currently not fully understood. To be sure, changes in greenhouse forcing may play some role, but with respect to the glaciation cycles, changes due to orbital variations provide changes in insolation of the order of 100 W/m^2 in the Arctic in summer, which is the relevant factor in the Milankovitch theory (Roe, 2006), while changes in CO_2 contribute about 1.5 W/m^2.

Assuming that changes in the mean due to changes in the tropics-to-pole temperature difference result from the role of CO_2 in the greenhouse effect makes no sense. It is, in some ways, a confusion of cause with effect.

5. What produces the stability of the tropical temperature?

As already noted, the relative stability of tropical temperatures is suggestive of negative feedbacks, and there are many ways in which these might arise. Their representation as positive feedbacks in GCMs has little actual basis in observation or theory, despite modellers' energetic searches for evidence to support the idea. One negative feedback for which there is substantial evidence is the so-called iris effect, wherein upper-level thin cirrus clouds (which are powerful greenhouse substances) reduce their coverage as surface temperature increases (Lindzen, Chou and Hou, 2000, Lindzen and Choi, 2021 and references therein). This mechanism is potentially strong enough to account for the Early Faint Sun Paradox (Sagan and Mullen,1972, Rondanelli and Lindzen, 2007). This paradox refers the Earth of 2.5 billion years ago, when solar output was 30% less than today. However, despite this, observations suggest the Earth remained close to the present climate, with no evidence of ice. Recall that doubling CO_2 only produces a 2% perturbation to the radiative budget.

6. Where does CO_2 fit in the climate?

What should be clear is that it is absurd to assume that the complex three-dimensional climate is defined by the small difference of large numbers that is the average temperature anomaly, and that the controlling factor is the small contribution of CO_2. The Earth's climate has, indeed, undergone major variations, but these offer no evidence of a causal role for CO_2. For the glaciation cycles of the past 700 thousand years, the proxy data from the Vostok ice cores shows that cooling precedes decreases in CO_2 despite the very coarse temporal resolution (Jouzel et al.,1987, Gore, 2006). Higher temporal resolution is needed to show that warming preceded the increase in CO_2 as well (Caillon et al, 2003). For earlier variations, there is no suggestion of any correlation with carbon dioxide at all, as shown in Figure 9a, a commonly presented reconstruction of CO_2 levels and 'temperature' for the past 600 million years or so.

To be sure, paleoclimatological reconstructions are somewhat speculative – especially as concerns CO_2, but a notably different reconstruction of the CO_2 record by Rothman (2002), shown in Figure 9b, also offers no suggestion of significant correlation.

CO_2 is a particularly ridiculous choice for a 'pollutant.' Its primary role is as a fertiliser for plant life. Currently, almost all plants are starved of CO_2. Moreover, if we were to remove a bit more than 60% of current CO_2, the consequences would be dire: namely death by starvation for all animal life. It would not likely lead to a particularly cold world since such a reduction would only amount to a couple of percent change in the radiative budget. After all, a 30% reduction of solar radiation about 2.5 billion years ago did not lead to an Earth much colder than it is today, as we earlier noted in connection with the Early Faint Sun Paradox.

7. Impacts

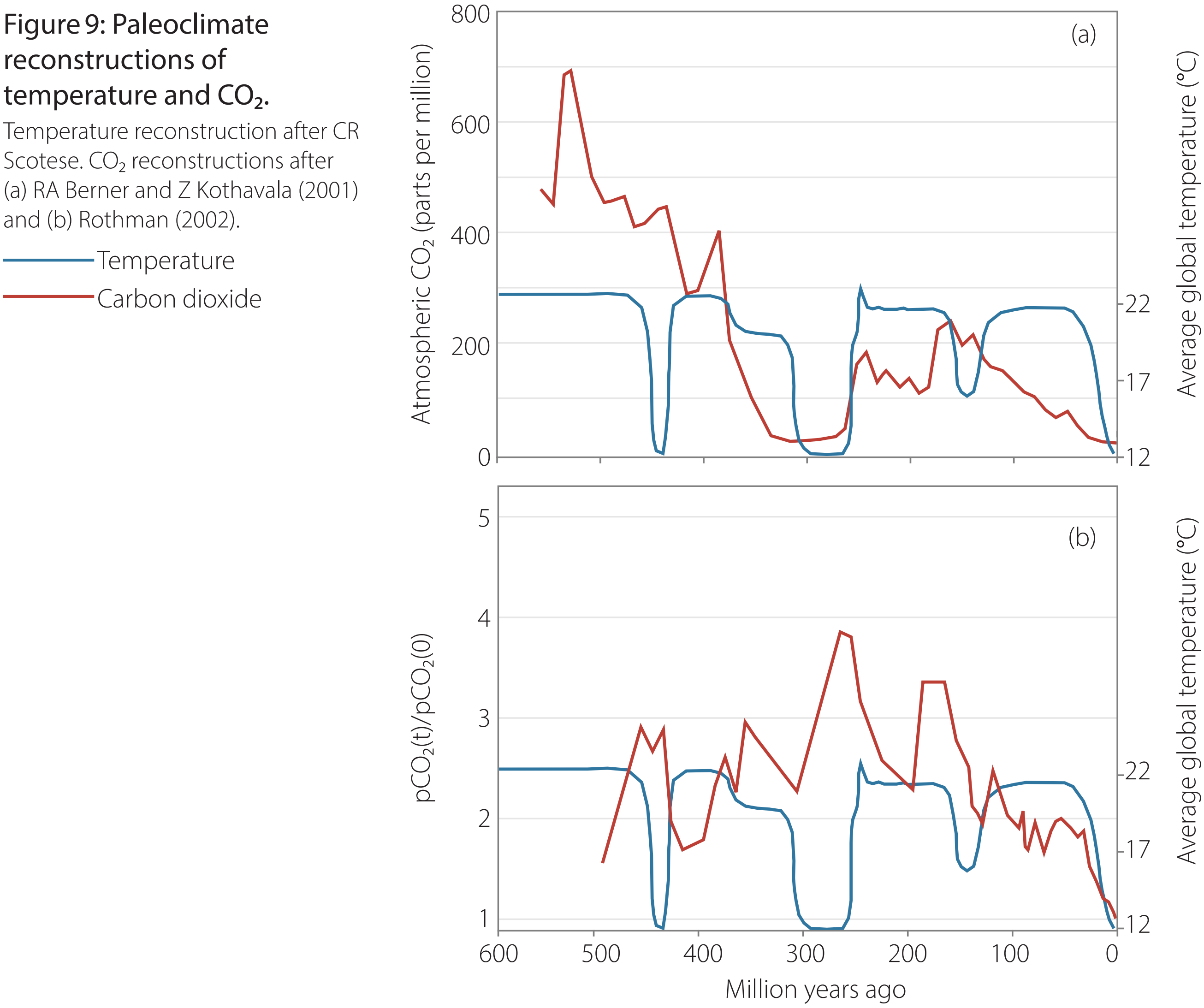
The preceding discussion was restricted to physics. It did not address the issue of so-called 'impacts', whereby any observed change in anything is immediately claimed as evidence for the impact of CO_2. A typical example from the *Boston Globe* of April 19, 2022 follows:

> Despite increasingly urgent international warnings and an onslaught of catastrophic wildfires and weather linked to global warming, fewer Massachusetts residents see the climate crisis as a very serious concern than they did three years ago, according to a new poll.

The inevitable conclusion is that we should be decarbonising. Such ridiculous leaps of irrational inference go well beyond absurdity, although the common sense of Massachusetts residents is heartening. Unfortunately, the understandable temptation of sceptics to point out that the alleged changes are misrepre-

Figure 9: Paleoclimate reconstructions of temperature and CO_2.

Temperature reconstruction after CR Scotese. CO_2 reconstructions after (a) RA Berner and Z Kothavala (2001) and (b) Rothman (2002).



sented (wildfires have decreased greatly over the past couple of generations), leaves in place the bizarre suggestion that had the claimed changes been real, they implied the need for decarbonisation.

8. Where does this leave us?

This all leaves us with a quasi-religious movement predicated on an absurd 'scientific' narrative. The policies invoked on behalf of this movement have led to the US hobbling its energy system (a process that has played a prominent role in causing current inflation), while lifting sanctions for Russia's Nordstream 2 pipeline, which was designed to bypass the existing pipeline through the Ukraine used to supply Germany. It has caused much of the European Union to ban exploitation of shale gas and other sources of fossil fuel, thus leaving it with much higher energy costs, increased energy poverty, and dependence on Russia, thus markedly reducing its ability to oppose Mr Putin's aggressions.

Unless we wake up to the absurdity of the motivating narrative, this is likely only to be the beginning of the disasters that will follow from the current irrational demonization of CO_2. Changing course will be far from a simple task. As President Eisenhower noted in his farewell address in 1961:

> The prospect of domination of the nation's scholars by Federal employment, project allocations, and the power of money is ever present and is gravely to be regarded.
>
> Yet, in holding scientific research and discovery in respect, as we should, we must also be alert to the equal and opposite danger that public policy could itself become the captive of a scientific-technological elite.

As described in detail in Lindzen (2008, 2012), the US government committed itself to the current narrative by the early 1990s and greatly increased funding as a result. Moreover, given the size of the energy sector, any attempt to rebuild it, however unnecessarily and ineffectively, presents immense opportunities for huge short-term profits – opportunities that are obviously tempting and strongly defended. Atop all of this, has been the constant Goebellian repetition by the media of climate alarm. And, this alarm is accompanied by so-called 'solutions' that deal with something, namely decarbonisation, that is, in fact, largely irrelevant to climate change, while imposing great and pointless pain.

It is essential – to western civilization itself – that the harm associated with this totally unwarranted alarm be ended, however difficult the task.

Acknowledgements

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Comment from Nic Lewis

My overall view of this essay is that it makes many good points and will help convey key aspects of the Earth's climate system to non-expert readers, although some may find it challenging to understand in one or two places. While, in my view, its downplaying of the role of changes in CO_2, as amplified by feedbacks, may go a bit too far, that does not negate the main thrust of the essay.

Taking the sections of the essay in turn, Section 1, The Popular Narrative, is mainly uncontentious, although the values for the radiative effect of a doubling of CO_2 concentration and the resulting no-feedback global warming are slightly low relative to current widely-accepted estimates.

Regarding the effects of feedbacks, the view that atmospheric water vapour will increase with global warming, causing a positive feedback, amplifying surface warming, since water vapour is itself a greenhouse gas (albeit one whose concentration is temperature-controlled), is long established. It seems quite difficult to argue against, since the maximum water vapour that air can hold increases strongly with temperature, and there is a lack of good evidence that humidity in the atmosphere as a proportion of that maximum falls strongly with temperature. However, a reduction in the adiabatic lapse rate with increasing water vapour concentration partially counteracts the water vapour feedback, with (in the absence of other feedbacks) the net effect of these two linked factors equating to a 50% or so increase in the basic warming from a rise in CO_2 concentration.

On the other hand, whether cloud changes amplify warming, as IPCC assesses[1] they do (and the vast majority of climate scientists appear to believe so), or attenuate it, remains uncertain. Bjorn Stevens – arguably the most impressive and influential of the current generation of climate scientists, and a very central, senior figure in the 'IPCC consensus community' – has recently argued against cloud feedback being positive, claiming that clouds mute rather than amplify climate sensitivity.[2] The remaining feedback assessed by the IPCC to be significant is a positive feedback due to the albedo of the surface decreasing as high latitude sea ice and snow cover reducing when the Earth warms. However, a recent paper[3] (whose lead author is a very experienced cloud expert), finds that the changes in surface reflection involved have no statistically significant impact on radiation trends at the top of the atmosphere, which are the primary measure of feedback strength. Taken together, this evidence would suggest 1.5°C to 2°C long-term global warming from a doubling of CO_2 concentration ('climate sensitivity') – around half that implied by the IPCC's assessment of feedbacks and barely a third of that implied by a number of the latest global climate models (GCMs) that are used for climate change projections.

Section 2 of Lindzen's essay makes the point that changes in mean temperature that have occurred over the last century or so, thought by most climate scientists to be likely almost entirely due to anthropogenic changes in greenhouse gases and other atmospheric constituents, are trivial compared to those due to seasonal and other natural fluctuations, which humans are used to coping with. Accordingly, claimed existential threats are illusory. These are valid and very important points. They are bolstered by the fact that evidence for increased occurrence of weather extremes (such as droughts, floods, hurricanes, heat waves, etc.) is weak or non-existent, except for there being more high-temperature periods – as one would expect when the average temperature is higher. Similarly, claimed adverse effects of global warming to date often turn out to be illusory. Wildfires have not increased,[45] the polar bear population has not decreased,[6] coral reefs have survived (the Great Barrier Reef has record coral cover[7]), the land area of low lying atoll islands has increased.[8]

Section 3 is uncontentious, but its point that global warming or cooling mainly involves changes in the polar–equatorial temperature differential, with changes in equatorial temperatures being far smaller, is important. It implies that greenhouse gas warming will be much greater in cooler, higher latitudes (where warming has some benefits) than in the tropics.

Section 4 'What determines the tropics-pole temperature difference?' discusses difficult scientific issues that are not fully understood. It is well established that, as Lindzen implies, poleward heat transport from the tropics is mainly by transient, unstable baroclinic eddies. However, it is less clear what controls the magnitude of the heat transported poleward, and hence the tropical–polar temperature differential and changes in it. A 2019 paper[9] argues that it can be best understood from an energetic perspective (balancing latitudinally-varying radiative surpluses and deficits), and that this can explain why temperature changes are much greater at high latitudes than in the tropics. That explanation, if correct, does appear to me to be consistent with the greenhouse effects of changing CO_2 concentration. However, as Lindzen says, the changing magnitude of Arctic temperature inversions also appears to be an important influence on polar amplification of tropical warming; this may slightly increase global warming. Towards Antarctica, however, strong heat absorption by the Southern Ocean is thought to substantially delay warming amplification.

Although many scientists have questioned Lindzen's contention, there does appear to be considerable evidence for the tropical 'iris effect' discussed in Section 5, although it remains unclear how strong this effect is.

The lack of correlation between CO_2 concentration and deep paleoclimate temperatures shown in Section 6 is striking. Over geologically-recent glacial cycles, where CO_2 concentration and temperature do co-vary, there is, however, a complicating factor in determining causation. A rise in temperature is expected to cause a rise in CO_2 (which is less soluble in a warmer ocean), so a timing lag of CO_2 change on temperature change does not rule out a causal role for CO_2 in climate change.

The points Lindzen makes in the final section of his essay concerning climate change related policies and the harm they and the underlying alarmist narrative are causing appear fully justified. Even accepting that reducing net anthropogenic CO_2 emissions, ultimately to a very low level, will be necessary to prevent global temperatures continuously increasing, current policies designed to achieve this at breakneck speed seem likely to cause considerably more harm than good. Indeed, rapid CO_2 emission reductions in the UK will have a negligible impact on global warming, and those by all other Western nations will have only a minor impact. Such reductions will thus serve mainly to make their elites feel virtuous at the expense of their populations as a whole, unless other nations respond by cutting their emissions as deeply and as fast – which appears rather unlikely.

Nicholas Lewis is an independent climate scientist whose work focuses on estimation of climate sensitivity and improving related statistical methodology. He is sole or lead author of ten peer reviewed publications in this area.

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Response by Richard Lindzen

I wish to thank Nic Lewis for his careful reading of my paper. At the very least, he makes it evident where I have not been adequately clear. This is, perhaps, to be expected when one tries to summarize such a complex subject in about 14 pages.

Having said that, Lewis is guilty of using what I referred to as the one-dimensional picture when he discusses the so-called water vapor feedback. In this picture, there is one value of both humidity and relative humidity. However, as I and colleagues have long noted (Lindzen, et al, 2001 and references therein), humidity varies greatly in space and time. Moreover, where there are high cirrus clouds, the cirrus determine the effective emission level, and the cirrus also vary in their spatial coverage. As a result, there really is no meaning to the water vapor feedback as an isolated process; instead one must look at a generalized longwave feedback. This appears to be negative (Lindzen, et al, 2001, Lindzen and Choi, 2021, Trenberth and Fasullo, 2009).

Without the alleged water vapor feedback, it is difficult to account for even the sensitivity that Lewis suggests. Indeed, with high sensitivities, models have generally had to cancel alleged warming with counteracting sulphate aerosols. As I and others have noted, many of these fudges involved more sulphate aerosols than are now regarded as possible. I discuss this in detail in Lindzen (2020). I would also mention that the claim by Lewis that a roughly 2% contribution from doubling CO_2 leading to a warming of about 1°C being a slight underestimate of the resulting warming is open to significant doubt. As shown by van Wijngaarden and Happer (2022), a careful line-by-line calculation suggests that the contribution is about 1.1% rather than 2%. As I also note in the current paper, the climate science community was quite small prior to the initiation of the global warming alarm, which led to a massive increase in the number of individuals identifying as climate scientists. It is somewhat bemusing to hear Nic Lewis speak of the 'vast majority of climate scientists.'

I would add that the notion that any adverse change in anything implies a role for CO_2 is also unjustified. In addition, I would remind the reader that my Section 2 also shows that the globally averaged temperature anomaly bears comparatively little relation to what is going on at any particular station.

Lewis seems to remain attached to the notion of polar amplification (i.e. that changes at the pole are a direct consequence of changes at the equator). As far as I can tell, this is a misreading of how the climate system works – at least for the major climate changes referred to in my paper. With respect to Lewis' remarks on my Section 4, the processes associated with greenhouse response are largely confined to the tropics. The processes leading to changes in the tropics-to-pole temperature difference are associated with changes in the poleward heat flux out of the tropics. The fact that tropical temperatures remain minimally altered by changing heat fluxes out of the tropics strongly points to negative feedbacks in the tropics. It should be added that although changes in the tropic-to-pole temperature difference characterize major climate changes, even the present climate involves a plethora of different regimes, which current models fail to accurately account for.

Lewis seems to ignore the fact that heat transport due to instabilities acts to bring the system to a state that is neutral with respect to the instability. As I note, this state is calculable (R.S. Lindzen and B. Farrell, 1980, Stone, 1978, Jansen and Ferrari, 2013), and provides important insights into the observed tropic-to-pole differences.

When one notes that during the glaciation cycles, changes in temperature precede changes in CO_2, one is talking about the order of a thousand years in the case of glaciation and a hundred years in the case of deglaciation. The case for such a reverse causality becomes quite slim. Moreover, should there be such long lags, it would be problematic to deduce anything from the slight temperature increase over only about 60 years (i.e., the period during which forcing due to increased CO_2 was significant). But, more to the point, the orbital forcing suggested by Milankovitch is almost two orders of magnitude greater than what could be attributed to CO_2 and provides the proper time dependence.

Lewis is right in noting that proposed policies are harmful regardless of what one believes about the nature of climate change. My point is simply that this is doubly true if the underlying premise concerning the role of greenhouse gases is wrong.

My paper represents my assessment of how the climate system actually works. It is the result of almost 60 years of work on the behavior of the physics and dynamics of the atmosphere, and the evolution of my thinking since Lindzen (1993). Of course, like all of science, it is unlikely to represent the final word on the subject. However, I am reasonably confident that the current popular narrative is largely incorrect. The notion that the science is 'settled' is pretty implausible in either case.

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