Why 2°C is too hot to handle

Martin Siegert highlights the dangers posed by the rise in global temperatures and says urgent action is needed now to avoid the risk of runaway heating

Since the Industrial Revolution of the mid-nineteenth century, the surface of our planet has warmed by more than 1°C, at a rate that is increasing over time. That might not sound like very much, but this warming has led to a sea-level rise of more than 20cm globally as well as more heatwaves, wildfires and floods. These have affected countless lives and permanently damaged ecosystems on which many species rely.

It is sometimes not appreciated what a further 1°C of global warming would mean. Many scientists regard 2°C of warming above pre-industrial levels as the threshold at which irreversible 'runaway' climate change could happen.

At present, the Earth has a natural cooling system, keeping temperatures down even though emissions are high. It does this by storing CO_2 in plants and animals on land and at sea, and also by storing heat in the ocean.

That cooling system is not new. Indeed, the world has gradually become cooler over the past 55m years because greenhouse gases were removed from the atmosphere and stored within sediments such as limestone, and as fossil fuels. But since 1850, a period of just 170 years, we have been digging up many of the carbon stores laid down over millennia and pumping the CO_2 directly back into the atmosphere.

> *Massive ice sheets that once occupied Scandinavia and North America melted and sea levels rose by 130 metres*

Global warming is not a blip

In the thousand years prior to 1850, global temperatures were fairly static – if anything cooling slightly with time. In 1850, the level of atmospheric CO_2 was around 280 parts per million (ppm). Since then, it has risen year-on-year. Today it stands at more than 415ppm.

Scientists have known since the nineteenth century, ironically as the Industrial Revolution began, that CO_2 is a greenhouse gas that can lead to climate warming or cooling, depending on its concentration in the atmosphere. John Tyndall, a prominent Irish physicist, demonstrated the effect in 1859, for example.

Our appreciation of the fundamental association between atmospheric greenhouse gases and global temperatures has been largely unchanged since then – although we understand the details of the problem much better these days.

The snows of yesterday

One reason why our knowledge is now so much better is that the Antarctic and Greenland ice sheets serve as a time machine. Snow accumulating on their surfaces contains air. After a few decades of burial by subsequent snowfall, the air becomes cut off from the atmosphere – and is then a time capsule.

In Greenland, the oldest ice formed around 100,000 years ago, but in Antarctica it goes back about 1m years. The greenhouse gas records recovered from Antarctic ice cores unequivocally support Tyndall's theory. Over the past million or so years, CO_2 values have oscillated between 180ppm and 280ppm, forcing ice ages when at low-points and so-called 'interglacials' when high.

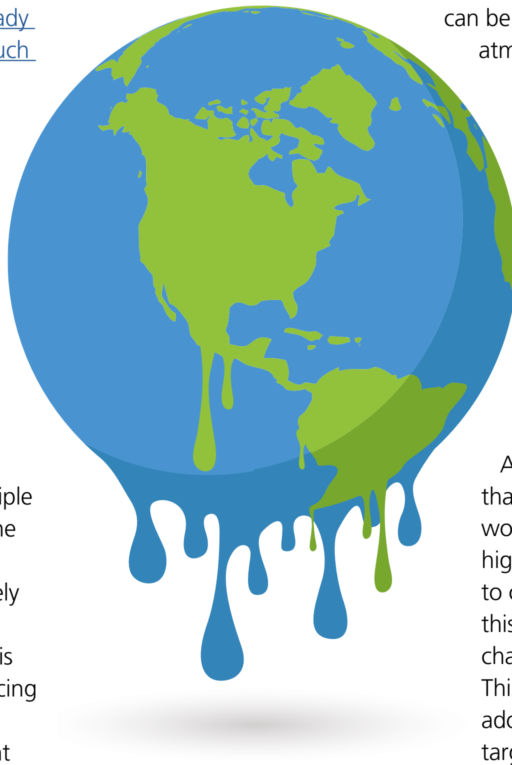
The last ice age was only 20,000 years ago – too recent to be considered as 'geological time'. In the 10,000 years that followed it, atmospheric CO_2 increased by 100ppm, to around 280ppm and forced planetary warming of about 5°C. That melted the massive ice sheets that once occupied Scandinavia and North America and sea levels rose by 130 metres.

Today's CO_2 value is more than 415ppm. Ice core samples can tell us nothing about when the Earth last experienced similar levels, because it hasn't been that high for at least the past 1m years. But examination of carbonate rocks tells us that when the planet last had CO_2 levels similar to now, around 4m years ago, global average temperatures were 4°C warmer than today and sea levels were 20 metres higher.

If that is not alarming enough, there is more. Because the amount of CO_2 in the atmosphere is still increasing (in spite of all our attempts to reduce it), it is possible that the atmosphere could contain 1,000ppm of CO_2 by 2100. That is a level not seen on the Earth for 55m years, when continents were in different positions, the dinosaurs has just become extinct, the temperature was 12°C warmer than now and there was no ice on the planet. With today's continental distribution, global sea levels in a world of 1,000ppm of

CO_2 would be 60 metres higher than they were then. Hundreds of large cities are already threatened by a rise in sea levels at much lower levels of CO_2.

But a return to past climate states may not be our biggest problem. Instead, it is likely to be the speed at which it is happening. In the past 50 years, about 100ppm worth of CO_2 has been injected into the atmosphere. In other words, the current rate of change in atmospheric CO_2 is 200 times greater than at the end of the last ice age.



The science could not be clearer. Multiple lines of independent evidence point the same way. The direction in which we are headed, and for which we are solely responsible, is a world that is far less habitable than today. The good news is that this future is not inevitable. Reducing greenhouse gas emissions to net zero (that is, we stop increasing the amount of CO_2 in the atmosphere by capturing and burying the same amount as we emit – through natural processes or mechanically) could halt further dangerous warming in its tracks.

The first meaningful international agreement to reduce global CO_2 emissions was the 2015 Paris Climate Agreement, where nations offered their reduction 'contributions' to meet a global warming target of less than 2°C by 2100. But when we add up the contributions, assuming they are implemented in full, global warming of around 3°C by 2100 is likely.

Avoiding the irreversible

The Arctic is currently warming at three times the rate of the rest of the planet. It is here that a series of runaway processes might start.

The first of these concerns the thin layer of ice that floats on the Arctic Ocean – the sea ice. Because the ice is white, it reflects the sun's radiation back into space, so acting to keep temperatures down. But as the ice melts, more of the ocean's dark surface is exposed, which absorbs rather than reflects the radiation, retaining and building warmth. This warming melts more ice, and so on.

The second is about the methane held in Arctic permafrost. Methane, a much more potent greenhouse gas than CO_2, is trapped within frozen soils. As the soils thaw, it can be released, leading to rapid and sudden atmospheric warming.

The third process concerns the Arctic Ocean itself. It is remarkably still because of the sea ice 'lid' that stops winds from stirring the water. As the ice melts, the ocean will mix and draw up warmer water that currently resides undisturbed below the surface. If this water were to reach the surface, it would release enough heat to melt all the sea ice ten times over.

Although we don't know for certain that 2°C of average global warming would lead to runaway heating, it's a highly risky and unnecessary experiment to conduct. Stabilising global warming this side of 2°C gives us a much better chance of keeping the planet habitable. This is why the 1.5°C scenario has been adopted by many countries as a climate target. Such a scenario requires us to reach net-zero emissions by around 2050, and to achieve around 50% of that by 2030.

The upcoming Glasgow climate summit is likely to have both 'net zero by 2050' and '50x30' as goals to be agreed. Agreeing them is one thing. Delivering them is, however, quite another. But if we do not meet this challenge, we will knowingly and willingly expose our children, and the generations that follow, to a world that is, at best, less able to support them and, at worst, heating beyond our ability to control it.

CO_2 is not the most potent greenhouse gas but it has a characteristic unlike no other: it stays in the atmosphere for a long time. That's why CO_2 emissions today have consequences far into the future, well beyond our lifetimes. We must accept responsibility and make the necessary changes. If we succeed, it will be the greatest achievement in human history. If we don't, it will surely be our greatest failure. ■

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