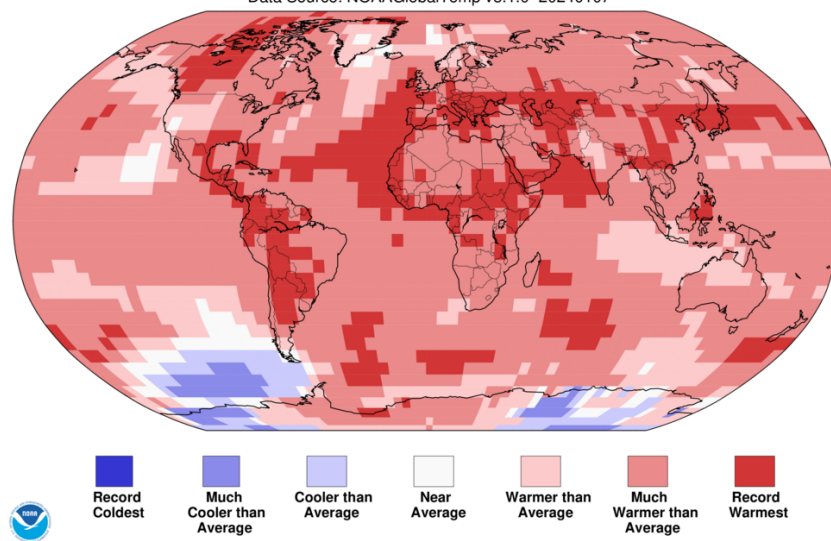


CLIMATE CHANGE: STATUS & TRAJECTORY IN 2025

Land & Ocean Temperature Percentiles Jan–Dec 2023
NOAA's National Centers for Environmental Information
Data Source: NOAA GlobalTemp v5.1.0–20240107



AUSTRALIA

11 August 2025

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1. Introduction

This background briefing discusses the growing concern that the period following 2030 is likely to witness an accelerating deterioration in the world environment because of climate change.

To quote one environmental scientist:

We are witnessing the grim reality of the forecasts as climate impacts escalate, bringing forth scenes of unprecedented disasters around the world and human and nonhuman suffering.

We find ourselves amid an abrupt climate upheaval, a dire situation never before encountered in the annals of human existence.

(Ripple W. December 2024)

Opportunities to prevent it are diminishing, so the focus now needs to be on three core policy issues:

- Understanding the way in which the planet is heating, and the way that its environmental and social consequences will unfold.
- The nature and current levels of the greenhouse gas emissions driving the phenomenon, and their future patterns.
- Concerns about measures that use land management projects to capture and sequester greenhouse gases as an alternative to preventing their emissions in the first place. This also questions aspects of the goal for the world to achieve *Net Zero 2050*.

2. Background

The international scientific community has warned about the causes and trajectory of climate change for over 35 years. But the next decade appears likely to be the forerunner of a catastrophic path for both the natural and human environments across the planet.

Heightening concern is the fact that 2022-2024, was the hottest on record. In fact, the planet now has its highest surface temperature in 2000 years. Its average temperature over the past century was also warmer than at any similar period in the past 11,700 years (*Hansen*).

A consequence is that these extreme heat events led to more than a dozen countries in multiple regions sweltering through temperatures of 48-52 degrees Centigrade. Night-time temperatures often stayed above 35 degrees.

The evidence establishes that there is now sufficient energy in the lower atmosphere to underpin future extreme climate impacts that could be widespread, unanticipated and abrupt. Many will be irreversible.

Notwithstanding, the greenhouse gas reduction plans that will be tabled for endorsement by the United Nations at the meeting on 25 November 2025, will fail badly to reduce emissions by 2035 to the level needed to protect the planet (*Srouji*).

The recent decision by the current US Administration to walk away from climate change management is very significant in this context, especially because of its position as the world's second largest greenhouse gas emitter.

The conflicts in the Ukraine and Middle East also challenge the capacity of nations to act in concert with the urgency that is needed. They are diverting substantial capital away from environmental conservation towards upgraded defence capabilities (*Economist*, 1 July 2025).

2.1 Verifying the data accessed

There is a daily flow of international data and commentary on the current and future impacts of global heating.

The *References and Further Reading* section at the end of this brief lists the material that has been consulted, but priority has been given certain authoritative international entities:

Forster P. (and 60 others) 19 June 2025

Global Carbon Project

International Energy Agency

National Aeronautics & Space Administration

UN International Panel on Climate Change

UN Environment Program

World Economic Forum

World Weather Attribution

World Meteorological Organisation

World Resources Institute

The multidisciplinary nature of climate science makes it complex, especially when its focus is on the degradation of the lower atmosphere across the whole planet over a period of 200 years (namely 1900 -2100).

Analysis of the international data creates further difficulties, because not all countries have adopted the metric system in the *Standard International Units* of measurement.

For example, one *SI* tonne is 1000 kilograms. But in the US it weighs 907 kg, and 1016 kg in the UK. The terms “ton” and “tonne” appear to be interchangeable.

The differences may seem trivial. But as will be discussed they are relevant when the mass of greenhouse gases and melting ice is measured in billions of tonnes.

This paper is written in Australia, which long ago adopted the metric system.

3. Human-Induced Global Heating: The Concept

The concept is essentially a simple one. The rays from the sun transfer energy into Earth’s atmosphere, and this is largely expressed as heat. The energy is either retained there; absorbed by the land and oceans; or reflected back out into space and lost.

A natural energy equilibrium was established over thousands of years between the surface of Earth and the lower atmosphere. This supported the evolution of all of the forms of life currently on the planet.

But the dynamic started to change when nations industrialised in a way that relied on their burning three natural resources - coal, oil and gas - for their energy.

Their dependency grew to the point at which the new human-generated energy was being released from Earth quickly enough to force an imbalance in the lower atmosphere. More was building up than was being dissipated.

The period before 1900 is recorded as having a zero energy imbalance. Human-generated

excess energy changed relatively little from 1900 until 1980, but then grew quickly.

The UN International Panel on Climate Change (IPCC *AR6 2023*) has characterised the relationship between the energy imbalance and temperature increases at the Earth’s surface from 1900.

The energy build-up increased the global *average* surface temperature by +1.52°C in 2024. This makes it the warmest year on record, exceeding that in each year of its prior 10 years. The land surface recorded +1.90°C while the ocean surface recorded +1.00°C (*Forster*),

The 195 countries that have ratified the *Paris Agreement on Climate Change 2016* agreed that the safe maximum temperature increase was to remain below + 1.5 °C out until 2100.

There are however, various ways in which the global temperature can be calculated. The method approved by the Paris Agreement excludes shorter term climate influences such as wildfires. The planet reached +1.24 °C in June 2025 using the Paris approach (*Copernicus*).

It also considered that hazardous outcomes were likely if +2.00°C was exceeded in any single year before 2100 (*IPCC, 2018*).

Vital systems such as freshwater management, food production, biodiversity conservation, and ocean dynamics are already being disrupted. As explained below, the period 2025-2029 is highly likely to continue with this climate destabilisation, and will hasten adverse outcomes that include:

- an acceleration of the loss of the polar ice caps and the glaciers across many regions;
- thousands more people dying each year in areas where heat extremes prevail;
- significant agriculture and freshwater losses that will cause food insecurity, especially in less developed regions;
- a surge in losses from wildfires, violent storms and flooding;
- the exposure of millions of people to inundation of low lying coastal communities

from rising seas, and especially in the Pacific Ocean

- a devastating loss of natural ecosystem habitats and the wildlife they support.

Each additional 0.1°C above the +1.5°C level will create its own new threat profile up to +2.0°C. Exceeding that higher threshold is expected to set the planet on a trajectory that could render future habitation difficult.

4. The greenhouse gases

The excess build-up of energy is driven by human activities releasing certain gases that trap heat at the planet's surface. Some of these greenhouse gases exist transiently in the atmosphere while others accumulate and persist indefinitely.

Universally accepted scientific projections about the pace of extreme climate change have centred on one key variable, namely, the sensitivity of the lower atmosphere temperature to the addition of the next tonne of greenhouse gases that have been emitted by human sources

The dominant gas is carbon dioxide. It constituted 87% of the net 41 billion tonnes of greenhouse gases emitted by humans in 2024, and is released by the burning of coal, natural gas, and oil - the fossil fuels (*Global Carbon Budget, March 2025*).

Carbon dioxide caused 73% of the global heating in that year, with methane 14%. The two differ in that, whilst methane and other gases are relatively short-lived in the atmosphere, carbon dioxide accumulates over very long periods.

Climate change modelling for the period 1900 to 2100 establishes that the atmosphere initially had the capacity to absorb 3800 billion tonnes of carbon dioxide before its temperature would reach +2.0°C. And it would remain at that level until the end of the century if no further greenhouse gases were emitted (*Global Carbon Project*).

The modelling also shows that 2700 billion tonnes have already been emitted. This raises

the question of when the +1.5°C level would be reached within the parameters of this modelling.

The UN IPCC concluded that greenhouse gas emissions must be reduced to below 20 billion tonnes each year, by 2030, for +1.5°C to be stable until 2100 (*IPCC, 2018*).

Two research teams separately concluded that with a 50% level of confidence, the remaining budget was 130 billion metric tonnes from the start of 2025 (*Forster, Item 11*).

Noting that net annual carbon dioxide emissions will inevitably exceed 40 billion tonnes beyond 2030, significant interventions are needed urgently. But they are definitely not forthcoming.

In fact, the UN conference scheduled for November 2025 will be told that annual emissions, as late as 2035, will be 26 billion tonnes greater than the target for remaining below +1.5°C (*Sirologi; COP 30*).

4.1 The stickiness of fossil fuels

Solar and wind provided 30% of the world demand for energy at the end of 2023 and are poised for rapid growth. Hydropower and nuclear provided a further 18% but their future unpredictable. Notwithstanding, the international energy industry reports that a full conversion to a carbon-emissions-free world is unlikely to occur before 2070 (*IEA*), because of factors such as:

- Record global subsidies of US\$7,000 billion paid annually from public sources. They include financial incentives for new production facilities and subsidies for consumers to meet fossil fuel market prices (*Black; Global Subsidies Initiative*).
- The investment during 2025 by large and medium-sized oil, gas and coal companies is projected to be US\$2,000 billion. This includes maintaining and expanding existing carbon fuel supplies (*McKinsey*).

- Growth in the world demand for gas (as LNG) is expected to compound at 2.5% until 2035, largely to cater for population growth.

Coal power generation remains controversial. Coal has the highest carbon emissions intensity of the three fuels, but has been in decline for a decade. It generated 41% of the energy-related carbon emissions in 2024 (*Global Carbon Project*).

But even though the G7 countries agreed in May 2024 to phase out coal power plants by 2035, 69 billion Watts of new coal power capacity came online in 2023. Only 21 billion were retired.

One core policy issue relates to the emergence of new high energy demand sectors across the global economy. Until recently the tertiary industry sector has been a less intensive energy consumer, but electricity and gas producers are now trying to come to grips with the enormous and rapid changes occurring in OECD countries.

Growth over the past 5-7 years in new activities such as video streaming, bitcoin transactions, EV charging, online shopping, and work-from-home arrangements is driving the construction of massive data storage centres that operate continuously.

A study in the US published in March 2024 estimated that by 2030, electricity demand by data centres in that country could triple, using the same power as 40 million homes (*Plumer&Popovich*).

The potential shortfall in renewable energy and the transmission systems to connect their distributed sources, means natural gas could underpin electricity generation in the tertiary sector for years. Yet this demand growth has not been factored into the modelling for global carbon emissions in 2030.

5. The greenhouse consequences

It is possible to view such a small atmospheric temperature increase over a 125 year period from 1900 as trivial. The scepticism could be justified if it were not already for:

- The level of greenhouse gases in the atmosphere is higher now than at any time in the past 2 million years. Most human-induced emissions occurred after 1980.
- The global temperature increase was faster in the last 50 years than at any time in the past 2,000 years (*Rockstrom*). The year 2024 was the hottest in the 175 years for which records are available (*WMO, 2025*).
- The frequency of extreme wildfires across the globe more than doubled during the past 20 years, with recent devastating and widespread incidents in Australia, Greece, Turkey, Siberia, Canada and California.
- Destructive flooding occurred recently in Australia, Florida, Pakistan, China, and Europe. Much was on a scale and intensity never before experienced.

Three additional issues raise the potential for future catastrophic outcomes:

(a.) The oceans: 90% of the excess energy created by humans since 1900 has been absorbed by the top 2,000 metres of the world's oceans. This prevented a planetary temperature-hike great enough to eliminate all life as we know it.

But the oceans are now stressed as well. In 2024, the ocean heat content reached the highest point in its 65-year observational record, questioning the oceans' ability to continue to perform its supportive role in the longer term. (*WMO, 2025, WRI 28 Feb 25*).

A further and grave concern is that their heat gain is accelerating. They are now warming at twice their recent historical rate (*Cuff, Jan 2025*), while some seas such as off eastern Tasmania are warming at four times.

The Australian circumstance is interesting. Tasmania has watched its southern kelp forests disappear under the progressive influence of warm water travelling south from the Great Barrier Reef. There is also a massive algal bloom in South Australia's waters currently causing a devastating impact on a wide range of marine species.

The algal bloom demonstrates a further impact of marine heatwaves, and that is their role in triggering and amplifying damage from other primary causes, such as nutrient pollution from nearby land-based activities.

Estimates are that the potential biodiversity loss from marine heatwaves across the oceans could be greater than with terrestrial species loss over the coming decades.

(b). The diminishing cryosphere: An immediate impact of the heating of the oceans is an acceleration of the melting of the Greenland ice sheet and the Antarctic ice sheet. Together they are losing more than 400 billion tonnes of ice each year.

The scale of the disappearing ice is impossible to visualise, or it was until NASA in the US offered a graphic comparison:

They estimate that the amount of ice the two ice sheets lose, each year, would cover New York City in a layer of ice that is 381 meters thick. This is about the height of the Empire State Building.

But that is only half the story. The glaciers outside the ice caps across multiple mountain ranges are losing a further 335 billion tonnes, annually, as well (*The Gambie Team, Feb 2025*).

Collectively, water from the melting ice is contributing to a sea level rise that is faster than during any other century in the last 3,000 years. This is a serious concern for the one billion people who now occupy land that is less than 10 metres above current high tide lines (*Forster 2025*).

(c). Food Security. The world will gain another 500 million people by 2030. This will add to the competition for the arable land needed to support the 2.8 billion who are currently undernourished.

Circumstances have arisen where arable land or high value old growth forests have been destroyed, and replanted with crops chosen to attract carbon emissions reduction credits that are offered in various financial markets. Soy bean and palm oil plantations dominate the international carbon credits trade.

An increase in extreme heat events and the changed rainfall patterns associated with climate change will reduce global efficiency in growing food staples. The heightened competition for land will also drive further international trade in food to distribute protein to where it is needed.

These international movements currently rely on maritime fossil fuel consumption that causes the same carbon emissions as the world's 6th largest country. The problem is increased when the demand for protein is in remote communities that require additional conveyance.

(d) Negative emissions? Not only is there a need for all fossil fuel emissions to be halved by 2030, but negative emissions are required after 2050 if the planet is to remain habitable in the second half of the century (*IPCC, 2018*).

Negative emissions require processes or technologies that remove carbon from the lower atmosphere to be permanently locked up. But it is unclear exactly how net negative emissions can possibly be achieved when fossil fuel burning is expected to continue well past then, most likely out until 2070 (*Schleussner C*).

This topic is discussed further in # 6.1 *Net Zero 2050*.

5.1 Social and economic impacts

It is already clear that there will be increasing inequality in the capacity of different demographic groups to adapt to these changes as they unfold. Only those regions with the capital to invest in measures to protect against significant loss and damage will escape the worst of the impacts.

But there is another highly influential social risk that is already playing out, and that is the position of the insurance industry worldwide.

The industry has the option of using differential pricing for climate risks based on the location of an applicant for an insurance policy, or on the nature of the hazard expected to be experienced in that region.

In the worst case, any insurance firm can decline to offer risk cover anywhere it considers to be unprofitable.

Global re-insurers such as Munich Re and Swiss Re are fundamental to the financial sustainability of the world's insurance industry. Each has developed a sophisticated platform for monitoring the climate threats and their expected trajectory, and are using these to determine which of the circumstances they will cease to insure and when.

Furthermore Allianz, a major international insurer based in Germany, has argued that climate change is a systemic risk for the very foundations of the whole global financial sector. Loss and damage at +3.0°C would be so great that both governments and markets would be unable to respond effectively (*Carrington D*).

It is possible that the next 5-7 years could see a growing influence of decisions by this industry on the economy of many regions. Global economic losses from weather-related extreme events are estimated to be US\$220 billion a year, while declines in labour productivity due to exposure to extreme heat are reckoned to cost over US\$830 billion a year (*Keeling*).

6. Carbon Offsets - friend or foe ?

The transition from a carbon-intensive world to one with low carbon emissions relies heavily on reducing fossil fuel consumption. Current approaches focus on achieving higher energy efficiency in urban and industrial settings; and fully utilising low-carbon electricity generation from renewable sources linked to storage systems such as lithium batteries and pumped hydro.

Other means, such as replacing fossil fuels with hydrogen from “green energy” may be available to industry in the longer term. But by 2024, fewer than 5000 tonnes of hydrogen had been produced globally, of which only 150 were from green sources (*Brown,S*).

Future generations of safe nuclear energy technologies may be available for large scale production after 2040. But it will then take a further decade before their output can make a

meaningful contribution to resolving the climate threat (*CSIRO*). This is far too late to be considered an option for reducing increasingly hazardous carbon emissions.

However, two highly contentious approaches are being debated that aim to support the continuation of fossil fuel consumption. Their intention is to compensate for substantial ongoing emissions by offsetting them with:

Carbon capture and underground storage (*CCUS or geosequestration*), where carbon dioxide emissions are buried underground, or .

Biosequestration, where vegetation and soil are exploited to extract the gas from the atmosphere and incorporate it into their living and growing matrix.

There is extensive literature on the pros and cons of each, but essentially:

Carbon capture and underground storage

CCUS has not yet worked at a relevant scale, despite trials over 20 years at great expense, often funded from public sources.

Only 375 million tonnes of carbon dioxide were captured over the past decade, during which time 375 billion tonnes were released to the atmosphere from fossil fuel burning (ie 0.1%).,

In other words, the CCUS projects reduced some of the carbon emissions associated with the extraction, processing and distribution of the fossil fuels, but offered no relief for the emissions caused by their burning. This implies a wasted opportunity for investments to have sponsored carbon-neutral renewable energy.

CCUS remains very expensive, technically complex, and in many circumstances creates unacceptable environmental risks. Nevertheless more than 50 new projects are in the pipeline around the world.

The topic is the subject of two recent reviews at *Gaurav; & WRI (16 May 2025)*.

Biosequestration faces other issues.

The greening of the planet generally profits from the uptake of carbon by vegetation and soil. Nevertheless, the terrestrial environment is neither a reliable nor efficient entity for the wide-scale or long-term capture and storage of greenhouse gases.

The carbon flows between land and the atmosphere resulted in a *net* 4 billion tonnes of carbon dioxide being emitted from all vegetation, water and soil sources in 2024. That is, in excess of the mass sequestered by them at the same time (*Global Carbon Project*).

Manipulation of this dynamic is challenging over the mid-to-longer term because (*Doolan*):

- measurable carbon capture and retention can take a decade to start after planting native trees or grasses, during which time fossil fuel combustion continues unabated.
- biosequestration effectiveness can be fickle. Variable microclimates; sporadic threats like bushfires, alien species invasion, and floods all reduce its long term efficiency and resilience
- the suitability of the plant species nominated for a site may be inappropriate, and especially so in the face of a changing climate that could become more hostile to its growth.

In response, sustainable investment groups are investigating the credibility of conserving high value native forests because they are known to be effective in locking-up carbon permanently .

The intervention needs to accelerate. Tropical primary rainforest lost 6.7 million hectares of cover in 2024. Driven largely by massive wildfires, the loss is the highest in the last two decades (*Goldman*).

Human activities such as clearing or burning native forests for agriculture, mining, and wood harvesting further threaten standing forests, as do drought, pests and pathogens. Each can turn sustainable ecosystems from carbon sinks to emitters, sometimes rapidly.

On the other hand, projects that regenerate degraded agricultural lands to their original natural

state may be able to achieve reasonable carbon sequestration effectiveness in the medium term.

But they require complex science-backed planning to manage all of the relevant environmental variables at a specific location, with reliable water availability being a dominant factor.

They also need a long term commitment to the conservation of high value ecosystems which can be difficult for private capital that is often mobile.

It is technically difficult to quantify and then verify the carbon sequestration performance and resilience claimed for forest conservation and land improvements. Audits of the value of both have repeatedly found them to be questionable at best, and controversial on some occasions.

Fortunately this is being considered within the United Nations following a meeting in March 2025 of its Supervisory Body on Carbon Credits. This group is to prepare technical standards to satisfy Article 6.4 of the *Paris Agreement on Climate Change 2015* relating to international carbon credit trading. The standard will be mandatory for member nations of the *UN Framework Convention on Climate Change*. (*UNFCCC*).

6.1 Net Zero 2050

An international policy issue is being created by the recognition that the long term future of fossil fuel burning appears to be guaranteed. And especially so noting the massive investment occurring in new supplies of natural gas (McKinsey).

This conflicts with the understanding that carbon emissions must be reduced significantly before 2030 for the future health of the planet.

The hallmark response by governments and business around the world to this policy conflict is their highly publicised commitment to achieve *Net Zero* carbon emissions by 2050. In some circumstances this represents a significant aspect of their international environmental credentials.

Common measures for delivering on the goal include shutting down high emitting activities; replacing fossil fuels with renewable energy plus

electricity storage; or improving energy efficiency with the deployment of new process technologies.

Not surprisingly noting the complexity of the issue, the policy framework underpinning the Net Zero is immature. Its basic definition varies widely, as do views on how it should be achieved. The latter includes a reliance on carbon offsetting that faces significant technical problems.

Added to this is the fact that industries such as steel and aluminium smelting find it technically hard to abate their emissions. The absence of a global carbon price in their energy supply markets also weakens pressures for providers to find high volume, 'base load' renewable energy that their intensive energy users need.

The common approach for industries facing abatement difficulties is to participate in carbon markets where credits that have been authenticated by governments can be purchased to offset a defined level of their carbon emissions. The Australian Carbon Credit Units Scheme (ACCUS) is one such system.

Unfortunately other credits are traded in unregulated offshore voluntary carbon markets. The quality of many is very questionable, notwithstanding the efforts of *The Integrity Council* to improve their reputation internationally (*ICVCM*).

Arguably, carbon credits serve to postpone the closure of high carbon emission sources. Whilst it is clear that the +1.5°C threshold is no longer avoidable, there is wide agreement that measures must be implemented to prevent the lower atmosphere energy level reaching +1.6°C, and certainly not +1.7°C.

The frequency and severity of the climate impacts accelerate progressively as these levels are breached. But continuing with the world's current emissions without further abatement could see this occur in 2033 and 2037 respectively (*Zickfeld S*).

As stated earlier, the world is on a path to emit 26 billion tonnes of carbon dioxide above the level needed to stay below +1.5°C in 2035.

Should however, the +1.6°C be reached, a further reduction of 217 billion tonnes would be needed to return to the +1.5°C maximum acceptable point (*Zickfeld S*).

7. Comment

A comprehensive climate change impact surveillance program is in place across the planet that utilises a fleet of satellites to monitor, in real time, the progress of global heating in the oceans, lower atmosphere, and on the land.

The data generated is integrated by collaboration between research centres in over a dozen countries,. Its analysis is conducted in accordance with a rigorous UN IPCC data quality assurance protocol that ensures international consistency (*Bindoff, 2013*).

However, even though there is a highly sophisticated international framework for predicting future climate change trajectories, the acceleration of compounding and cascading impacts is enhancing their unpredictability and consolidating their inevitability over the next critical decade.

It is therefore unfortunate that the total of the carbon emissions reductions proposed by all nations in 2025 comes nowhere near providing a suitable response.

Regrettably, the blocking by the USA in April 2025 of their provision of critical climate data, will seriously challenge efforts to understand and manage future impacts across the globe.

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