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What is the Climate Emergency?

Key Themes

- What is the history of Earth?
- What is the greenhouse effect?
- What is carbon?
- What about temperature?
- Is it more complicated?
- What are the impacts of global heating?

Introduction

Think about the chances of you being born. What series of events have happened leading to you, a living breathing person sitting here, now? Scientist Mel Robbins calculated that the odds of being born as 1 in 400 trillion (Robbins, 2018). That's 400 with 12 zeros. Compare that to the 1 in 14 million, 14 with 5 zeros, chance you have of winning the lottery and you may start to feel incredibly fortunate to be here at all.

Dr Ali Binazir (2011) explored the probability more in a *Huffington Post* blog. Could the chances be even higher? The odds of your parents meeting and an egg successfully encountering a sperm, is 1 in 400 quadrillion, 400 with 15 zeros. A number bigger than the number of cubic metres of water in the Atlantic Ocean. Next, factor in the chances of every single one of your ancestors, all the way back to the beginning of life itself, living to an age where they reproduce. That gets us to 1 in 10 to the power of 2,685,000. That's a 10 with 2,685,000 zeros after it. This number is so big, it's a miracle you were ever born. Numbers like these emphasise just how precious life is.

Think about it more and you might start to wonder about the probability of the Earth existing as a planet and the chances of life existing on Earth. It is a fluke that Earth exists as a planet in the Milky Way and even more so that humans evolved as a species of animal. The probability of these events lining up is so small they are almost zero. Against all the odds Earth evolved into a rich tapestry of living things.

What is the history of Earth?

We live on a small blue-green planet, orbiting a seemingly insignificant star, in one of the hundred billion galaxies in the Universe. Planet Earth has existed for more than 4.5 billion years, an amount of time so long it's difficult for humans to fully understand.

A really effective way to explore the history of Earth is using an outstretched arm with your fingers pointing out. Brooke Johnson, geologist at the University of Oxford, explains this more in his blog post, *The History of the Earth at an Arm's Length* (St Edmund Hall, 2019). Place the tip of your index finger, from your spare hand, on the middle of your chin – this is the formation of the Earth, about 4,560 million years ago. The next checkpoint, where your neck and shoulder meet, is the moment the Earth's surface first solidifies and is then destroyed when an object the size of Mars collides with Earth. The debris from this collision forms the moon. Next, your armpit, around 3,800 million years ago, is when the first life appears most likely at hydrothermal vents dotted across the ocean floor. About 2,700 million years ago, around your upper bicep, two cells merged together creating the template for all complex life. Biologists call this *The Fateful Encounter*. Two thousand four hundred million years ago, oxygen was suddenly more abundant in the Earth's atmosphere and the chemistry of our planet changed forever. A new type of bacteria evolved to carry out photosynthesis with oxygen as a by-product.

For a while nothing much happens until we get to your elbow, around 1,600 million years ago. A bacteria swallows another bacteria and doesn't kill it. This is the beginning of complex life. There's another period of not much happening which lasts from your elbow to your wrist, about a billion years. From around 800 to 600 million years ago, from the base to the top of your wrist, a lot has happened. The first seaweeds form which evolve to carry out sexual reproduction. Some amoeba start eating other amoeba, who in response learn to swim. At 542 million years ago, the middle of your thumb pad, life enters its nuclear age developing at an incredible rate.

By the top of your palm, large life forms are everywhere. But 65 million years ago, an asteroid collided with Earth. Over half of all life on Earth was wiped out, including most of the dinosaurs. Very quickly they were replaced by furry and warm-blooded mammals.

Around the middle of the last segment of your index finger, 1 million years ago, the Earth's vast tropical forests were replaced by grasslands. Some of the apes started walking upright to see over the grass. By the last quarter of the last segment of your index finger, human intelligence was born in the Great Rift Valley of East Africa, as our ape ancestors evolved increasingly bigger brains. It may have been that this was caused by past climate change when adaptability and intelligence would have been a huge evolutionary advantage. Suddenly Earth gets very cold and the upright apes decide to leave their warm homeland and travel to some of the coldest parts of Earth.

This brings us to the very end of your index finger, the final millimetres of your fingernail. This thinnest sliver of your body, and of Earth's history, represents all recorded human history and civilisation; it represents every 'modern' human who has

ever lived. Around the last 300,000 years or so. Human populations thrived during a very small window of Earth's history when the climate was relatively stable.

Thinking about time on the scale of geologic events is a challenging concept. 'Deep time' is the name given to the vastly, almost unimaginably, long time much greater than the length of a human life. A great way to immerse young people in the reality of deep time is to go for a walk. The award-winning *Deep Time Walk App* is a ground-breaking tool that enables anyone, anywhere to experience a walking audio history of the living Earth. As you walk through time, the dramatised audio narrative combines scientific evidence with poetry to tell the story of Earth's formation, providing a unique and educational perspective of deep time. You can easily move through the stages and direct young people to specific times and events. The experience encourages you to focus away from the digital screen and connect with the natural world around you.

Another way to put Planet Earth in perspective is the Pale Blue Dot of Earth, an image taken on Voyager 1 on 14 February 1990, just as the spacecraft was departing our galaxy on the fringes of the solar system. Voyager 1 was about 6.4 billion km away when it captured this image. Inspired by this photograph, Carl Sagan, the American astronomer wrote his famous speech. The words are incredibly powerful and help to put into perspective human life. You might like to read these words aloud.

Look again at that dot. That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives ... on a mote of dust suspended in a sunbeam. (Sagan, 1994: 6–7)

What Carl helps us realise is that *there is no planet B*. We must do everything we can to live in harmony with all living things and protect the delicate balance of planet Earth.

What is the greenhouse effect?

Did you know Earth is a Goldilocks planet? It's not too hot, not too cold, just right for life to thrive. Like Goldilocks and her porridge, our planet sits in the habitable zone, where conditions are perfect for liquid water, a key ingredient for life. With the right atmospheric composition, a protective magnetic field and stable ecosystems, Earth provides the ideal environment for sustaining life.

In fact, Earth is the only place we definitely know which supports life in the expanse of the Universe and it's due to our atmosphere. We can think of this as a thin blanket of gases which keep the earth at a comfortable temperature by trapping solar energy. A helpful way to communicate this to children is with a blow up globe and a couple of spare jumpers. Ask one person to hold the globe whilst another wears a head torch to symbolise the sun. Try narrating the story of the greenhouse effect.

The sun is a ball of gas releasing energy out into space. Some of that energy reaches Earth and warms us. We can feel that on a sunny day on our skin. While 30% of the solar energy that reaches us is reflected back to space, 70% passes through the atmosphere to Earth's surface, where it is absorbed by the land, oceans and atmosphere, and heats the planet. This heat is then radiated from Earth back out as a slightly different type of energy, which is more likely to be trapped. While some of this infrared light continues on into space, the vast majority – some 90% – gets absorbed by greenhouse gases, and redirected back toward the earth, causing more heating. You can model this greenhouse effect by throwing a jumper or blanket over the inflatable globe. This process is completely natural and good. Without it the world would be much much colder, with an average global temperature of -18°C , 33°C colder than the average temperature of Earth today.

The atmosphere is in fact much more complex than a simple blanket or jumper and instead is made up of lots of different layers of gases. The troposphere is the closest to the ground, where all the weather happens and most greenhouse gases are contained. The exosphere is the furthest, more than 1,000 miles from the surface of Earth. You might be surprised to know that the majority of greenhouse gases – about 95% – are water vapour. Carbon dioxide makes up just under 4% of greenhouse gases in the atmosphere whilst methane and nitrous oxides make up the rest. Carbon dioxide is the gas we're really worried about because it's the one we've released the most. Carbon dioxide makes up nearly 85% of all the greenhouse gases produced by human activity. At the moment there is more than 420 ppm (parts per million) of carbon dioxide in the atmosphere. That means if you took a million molecules of air there'd be 420 particles of carbon dioxide. Does this sound like a big number? Not really. This is one of the problems of the climate emergency, the numbers alone don't communicate the urgency.

A few thousand years ago humans discovered coal, which is approximately 90% carbon. They started digging it up and burning it for energy. Then we found oil and gas, and did the same with even more enthusiasm. Burning these fossil fuels releases massive amounts of energy but also takes carbon buried in the ground and releases it as carbon dioxide into the sky. This increases the amount of greenhouse gases in the atmosphere, trapping even more heat and making the world warmer. Since 1850, the world has become warmer by 1.5°C (2025). This process is called the enhanced greenhouse effect caused by human actions. Humans have added another blanket or jumper to the Earth. Imagine wearing two jumpers all day, how would you feel? Really hot! That's exactly what we've done to the Earth.

What is carbon?

Carbon is an element present in all life. It's the fifth most abundant element on Earth and the second in the human body after oxygen. Rocks store 99.9% of Earth's carbon. Oceans are another important carbon store, and of all the land stores, soil is the largest. Carbon word association is a great game to play: ask what word or image first

Classroom Activity 1.1 Carbon dioxide experiment

There is a simple experiment anyone can do to observe the heat trapping properties of carbon dioxide. All you need are two lamps and glass jars.

- 1 Pour 2 cm depth of vinegar into each jam jar.
- 2 Add a thermometer to each jar, put the lid back on and place it in a sunny window or underneath a lamp (not an LED) for about 10 minutes.
- 3 Record the temperature of both thermometers.
- 4 Add about half a teaspoon of bicarbonate of soda to one of the jars and quickly screw the lid back on.
- 5 Put both of the jars underneath the lamp again for about 10 minutes.
- 6 Record the temperature of both thermometers again.

The jar with the vinegar and bicarbonate of soda should heat up most. This is because the reaction between the vinegar and the bicarbonate of soda releases carbon dioxide – the greenhouse gas – which absorbs infrared radiation, in this case heat from the sun or lamp.

comes to mind when someone says the word carbon. People often think of a black lump of coal or carbon dioxide in the sky. Today the word carbon is used as shorthand when referring to carbon in its many forms often as carbon dioxide in the atmosphere.

In his book *Grass, Soil, Hope*, Courtney White (2014: 13) wrote, 'carbon is the graphite in our pencils, the diamond in our rings, the oil in our cars, the sugar in our coffee, and the life in our soils'.

Carbon naturally moves between the land, sea and atmosphere. The fast carbon cycle describes the movement of carbon through living things, on a daily basis, as plants and animals die and living things breathe and digest food. The slow carbon cycle takes hundreds of millions of years and involves the movement of carbon between rocks, soil, ocean and atmosphere through chemical reactions and tectonic activity.

When we burn fossil fuels we release carbon which has been stored for millions of years, under intense heat and pressure at the bottom of ancient oceans. Humans have pumped around 2,500 GtCO₂ into the atmosphere since 1850. But how big is a gigatonne? And what do these numbers mean?

A gigatonne is 1,000,000,000 tonnes, and is a common number used when discussing human carbon dioxide emissions. A gigatonne is roughly the mass of all land mammals, excluding humans. It's also roughly twice the mass of all of the people in the world. A gigatonne is also about the mass of 200 million elephants or 5.5 million blue whales or million Boeing 747 jets or 2 million International Space Stations or 20,000 RMS Titanic ships.

To help explain the carbon cycle we can imagine a bath with one tap running; the water flowing into the bath is like the carbon released from decomposing plants and animals. The plug is open and the water drains away, this represents the absorption

of carbon by seaweed and trees through photosynthesis. Imagine what might happen if the other tap was turned on. That's exactly what humans have done by digging up fossil fuels and burning them to release more carbon dioxide into the sky or in this case water into the bath. Over time the water can't drain quick enough and the water level, or carbon dioxide, begins to increase. Eventually the bath might overflow. What would you do if your bath was overflowing? Would you reach for a mop and bucket? No, you would just turn off the tap. The simplest and easiest solution is to stop burning fossil fuels. Unfortunately that's not what we're doing. We've reached for the mop and bucket of carbon capture and storage and other tech fixes whilst continuing to release more carbon dioxide into the atmosphere than we ever have.

This is an example you could do with young people, using a spare sink or bath outside or even a plastic bucket. Use two watering cans or hoses to represent the taps. The Royal Meteorological Society has a great interactive version of the bath analogy. We've used it in assemblies and started the explanation with the sound of a bath running from YouTube. Just tell the children you're starting a bath.

Fossil fuels signalled the start of the Industrial Revolution which began in Great Britain in the 18th century. This was a series of monumental events including the invention of the steam engine and the shift of labour from the fields to factories. The Industrial Revolution changed the way land was used and moved carbon from the ground to the atmosphere.

For decades we've released more and more carbon dioxide each year. Carbon dioxide is often represented by the chemical formula CO_2 representing one atom of carbon bonded to two atoms of oxygen. In 1850, humans released only 0.2 GtCO_2 but 100 years later in 1950 the world emitted 6 GtCO_2 . By 1990 this almost quadrupled, reaching more than 22 GtCO_2 . Emissions have continued to grow – we now emit over 34 GtCO_2 each year. The Covid-19 pandemic slowed the growth of emissions over the last few years, but worryingly they have yet to reach their peak.

It's surprising to learn just how much carbon dioxide was added to the atmosphere in only the last few decades. For someone aged 15 it's 30% of all human-produced carbon emissions. For someone 30 years old it's 50%, for someone 50 years old, 75% and for someone who's 85 years old more than 90% of all human-produced carbon emissions happened whilst they were alive.

Since 1958, the Keeling Curve has communicated the daily record of global atmospheric carbon dioxide concentration – the amount of carbon in the sky. The measurements are taken at Mauna Loa on the island of Hawaii in the middle of the Pacific Ocean by Scripps Institution of Oceanography.

Each year there's a peak and trough where the carbon dioxide reaches a minimum and then a maximum. Any ideas what might cause this? It's completely natural. It's to do with there being a larger landmass in the northern hemisphere. Next time you look at a world map check to see where the equator runs and you'll see it's much further south than you might think. When it's the northern hemisphere's summer it means all the trees and plants are full of leaves and through photosynthesis pulling in carbon dioxide out of the sky. When it's the northern hemisphere summer there's a global

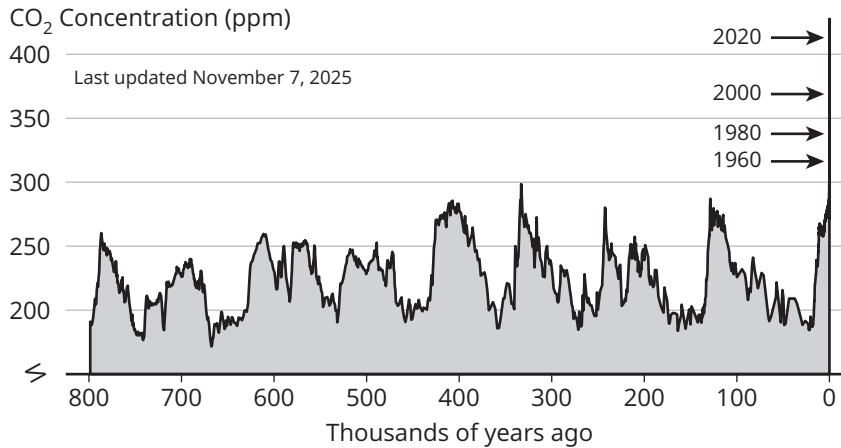


Figure 1.1 The Keeling Curve based on data from Mauna Loa Observatory since 1958

Source: The Scripps Institution of Oceanography at UC San Diego (using data from Keeling et al., 2001)

dip in carbon dioxide in the atmosphere. When it's the northern hemisphere winter and all the leaves have fallen to the ground and decomposed, that carbon dioxide is released back into the sky corresponding with a global annual peak in carbon dioxide.

Since 1958 atmospheric carbon dioxide concentration has increased from 315ppm to approximately 430ppm – this can be seen in Figure 1.1. The Covid-19 pandemic had no discernible impact on the amount of CO₂ recorded in the atmosphere.

We understand the makeup of the atmosphere going back 800,000 years, using ice core records from Antarctica and Greenland (see Figure 1.2). The longest ice cores extend 3km deep. The ice traps small bubbles of air that contain a sample of the

Carbon dioxide concentration at Mauna Loa Observatory

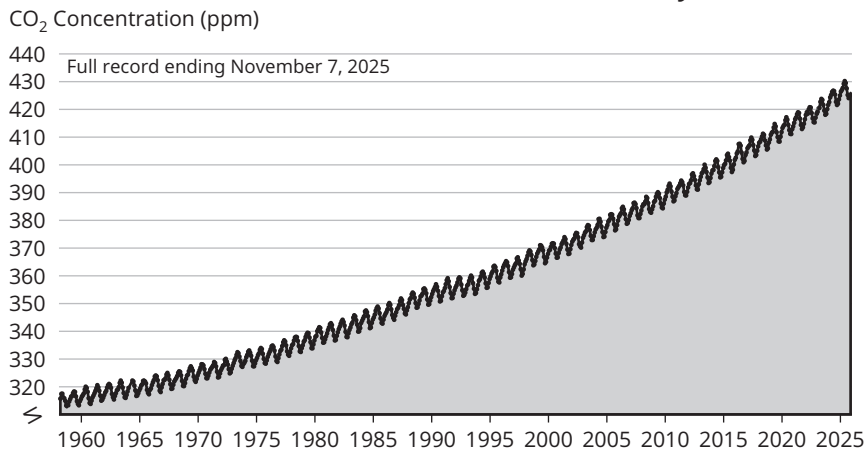


Figure 1.2 The Keeling Curve based on data from Mauna Loa Observatory for 800,000 years

Source: The Scripps Institution of Oceanography at UC San Diego (using data from Lüthi et al., 2008)

atmosphere. Zooming out and seeing carbon dioxide concentrations over hundreds of thousands of years provides context to the situation we find ourselves in. Over hundreds of thousands of years, Earth experienced predictable cycles of more ice (glacial periods) and less ice (interglacial periods). We're now far outside those cycles. You'd need to go back more than 3 million years to find carbon dioxide concentrations the same as they are now.

An interesting way to engage people with carbon dioxide concentrations is to use the website 'co2.350.org' telling you exactly how much carbon dioxide was in the atmosphere on the day you were born. Meryl was born at 327ppm and Paul 350ppm. Many teachers, campaigners and academics choose to share this number at the bottom of their email signature or on their social media profile. It's a great opportunity to start a climate conversation. You could also ask children to explore the carbon dioxide concentration for them, their parents and grandparents and add it to a living graph.

We've known the fundamental science underpinning the climate emergency since 1856 when Eunice Foote researched the relationship between carbon dioxide and temperature. The historian and science communicator Alice Bell explores the history of climate change in her book *Our Biggest Experiment: A History of the Climate Crisis (2021)*.

What about temperature?

Since 1850 the global average temperature of the world has increased by more than 1.3°C. Again, part of the problem is that 1.3°C doesn't sound like much – we're used to the temperature changing by much more on a daily basis between night and day. As educators we have a responsibility to help people understand the significance of this number. Also, this average number hides how some parts of the world have experienced much greater change, whilst others less. In the UK we've warmed by more than 1.5°C. The Arctic has seen the greatest heating of anywhere in the world with more than 3°C.

The Warming Stripes created by Professor Ed Hawkins at the University of Reading is the perfect tool to initiate conversations and communicate the heating over the last 170 years by visually representing global heating. The graph starts in 1850 on the far left and as you move right you move through time all the way to the present day. The years are coloured blue, white and red. The darker the blue the colder the year and the darker the red the warmer year, all from a 1961–1990 baseline. Through the warming stripes website it's possible to find the graph for different regions of the world. I used an online print company to print the graph as a wall sized banner I could mount at the back of my classroom or take outside as a teaching tool.

To bring the stripes to life we can place people along the timeline. In 1850 at the start of the graph, there was 285ppm of CO₂ in the atmosphere. Someone born in 1920 was born into a world with 301ppm. Someone born in 1980, 341ppm. Now there's more than 430ppm. When looking at graphs like this it's important to understand

that just because the amount of carbon dioxide in the sky has gone up over the last 170 years, it doesn't mean it has to continue into the future. We choose what happens by the choices and actions we take today. This is a fundamental idea to share.

It's important to understand that throughout the 4.5 billion years of Earth's history, the temperature and concentration of carbon dioxide in the atmosphere has always changed. What is different about the recent changes is the dramatic rate of change. The amount of carbon dioxide in the atmosphere and the average temperature of Earth has never increased so rapidly.

Is it more complicated?

In the climate system there are numerous *feedback loops*. A feedback loop is a situation where an event changes the chances of the event happening again. Negative feedback loops make it less likely for something to happen again, whilst positive feedback loops increase the chances of something happening. Matthew Shribman, science communicator extraordinaire, explains these in the *AimHi Earth Climate and Sustainability Training*. The ocean absorbing excess heat, acting to balance the excess heat from rising global temperatures is a good example of a negative feedback loop. Scientists have determined that the ocean absorbs more than 90% of the excess heat caused by greenhouse gas emissions. Another good example of a negative feedback loop is when we sweat it cools us down.

Melting ice is an example of a positive feedback loop. The cold ice covered poles act as the world's air conditioning system, helping to cool the world down partly through a process called the albedo effect. The white surface of the ice caps act as a big mirror, reflecting the sun's energy back out into space. As the ice melts less energy is reflected. The dark ocean is exposed and more energy is absorbed by Earth and remitted. As Earth becomes warmer, more ice melts leading to a cycle of heating.

Matthew uses t-shirts to help explain. Imagine it's a sunny day, you have the choice of two different t-shirts, one white in colour – the colour of ice – and another black – the colour of open ocean. Which of the two t-shirts would you prefer to wear on a sunny day? Most people would prefer to wear the white-coloured t-shirts knowing it's much better at reflecting heat and keeping you cool.

Classroom Activity 1.2 Albedo effect

Another way to show the albedo effect is with coloured balloons and a magnifying glass. Stand outside in direct sunlight, hold a dark-coloured balloon and using a magnifying glass focus the light on the balloon. See how quickly the balloon pops. Try the same experiment with a white-coloured balloon. Does it pop? You should find that the white balloon does a much better job at reflecting heat and so doesn't pop.

A piece of A4 paper is also a useful tool to explain the dynamics of the climate system. If you hold a piece of paper at the sides with a small section above your fingers, this represents the atmosphere or climate system. If you slowly pass more paper through your fingers, this models adding more carbon dioxide or energy into the system. Soon the paper wobbles, the system becomes less stable until suddenly the paper flops and the climate flips to another state. We call this a tipping point. Scientists have identified nine tipping points, where a changing climate could push parts of Earth's system into abrupt or irreversible change. These include melting ice, disappearing forests, dying coral reefs and changing ocean currents. Another way to share this with young people is through the game of Jenga. The increase in global temperature is like removing block after block from the tower and placing it on top. As time goes on, the tower becomes more and more misshapen and unstable. Eventually, the tower can no longer support itself and it tips over.

For decades, the oil industry, led by major players like Exxon, Chevron and Shell, knew about the catastrophic effects of burning fossil fuels. Internal research dating back to the 1970s accurately predicted the role of carbon emissions in global warming, yet rather than act responsibly, these corporations buried the evidence, funded misinformation campaigns and worked to sow doubt among the public. Meanwhile, politicians, often influenced by industry lobbying, hesitated to implement meaningful climate policies. Year after year, urgent scientific warnings were met with half-measures, delays and missed opportunities, allowing the crisis to escalate to its current state. This toxic mix of deception and political inaction has left us with a planetary emergency that educators must now address in classrooms across the world.

We are trying to find ways to remove carbon dioxide from the atmosphere. Carbon capture and storage (CCS) technology is designed to reduce carbon dioxide emissions from the exhaust gases of industrial sources and power plants. The captured CO₂ is then compressed and transported, usually via pipelines, to a storage site where the CO₂ is injected deep underground into geological formations, where it is stored 'permanently' although there are concerns about the long-term storage capacity of geological formations. Currently, CCS is implemented at a relatively small scale, capturing just 0.1% of global emissions. To make a substantial impact on climate change, it would need to be deployed much more widely.

What are the impacts of global heating?

It's important to acknowledge that we already experience the impacts of the climate emergency, every day. Regardless of who we are or where we live, all living things have for decades experienced a changing climate. We especially like the phrase 'the climate our parents grew up in no longer exists'.

People often get confused about the difference between weather and climate and use a short snap of really cold weather as evidence to suggest climate change isn't happening. Weather is the day-to-day atmospheric conditions, what we experience on a daily basis, whilst climate is the longer term (30-year average) and larger scale

weather a place experiences. When we watch weather forecasts they work on the basis of probabilities, telling us what weather is most likely. Weather presenters are increasingly taking a leading role in helping to communicate the climate emergency. Laura Tobin is the ITV weather presenter, with more than 200,000 social media followers, regularly making great videos to help explain changes in climate.

Each year, the Met Office releases the *State of the UK Climate* report providing an up-to-date assessment of the UK climate (Met Office, 2025). Highlights of the most recent report suggest the UK's climate is changing, showing the impact of global temperature rises on the climate in the UK, reaffirming that climate change is not just a problem for the future and that it is already influencing the conditions we experience on Earth's surface.

The UK's climate is continuing to change and records are being broken more frequently. Recent decades have been warmer, wetter, windier and sunnier than the 20th century. All of the UK's top 10 warmest years, in the time series from 1884, have occurred this century.

The best way to understand all these changes is to focus on how a warming world changes the likelihood of experiencing different weather events. Just 1.5°C of heating dramatically increases the chances of experiencing more extreme hot weather and reduces the chances of cold weather. More energy in the atmosphere also increases rates of evaporation and means that rainfall patterns shift, leading to more intense downpours and prolonged droughts in different regions. Storm systems will become stronger and more frequent as warmer ocean temperatures fuel their development. In simple terms, a small shift in climate can make a big difference in the weather conditions.

The relatively new field of climate-science research – ‘extreme event attribution’ – explores the human fingerprint on extreme weather, such as floods, heatwaves, droughts and storms. Carbon Brief has produced a great website which maps scientific reports with specific events telling us how much human-caused climate change affects extreme weather events. The research has the power to link the seemingly abstract concept of climate change with personal and tangible experiences of the weather. For children in classrooms across the world, those ‘tangible experiences’ are increasingly what they need to be prepared for.

Although climate science can appear complicated, the important things to remember are that the amount of carbon and global average temperature has never increased this quickly whilst humans have been around. In fact, the numbers are changing so quickly, this book is almost certainly out of date by the time you read it. You can get lost in the details of the science but you don't need to be an expert to understand the flaws in our relationship with nature.

References

- Bell, A. (2021). *Our Biggest Experiment: A History of the Climate Crisis*. Bloomsbury.
- Binazir, A. (2011, June 16). Are you a miracle? On the probability of your being born. *HuffPost*. www.huffpost.com/entry/probability-being-born_b_877853

- Keeling, C. D., Piper, S. C., Bacastow, R. B., Wahlen, M., Whorf, T. P., Heimann, M., & Meijer, H. A. (2001). *Exchanges of Atmospheric CO₂ and ¹³CO₂ with the Terrestrial Biosphere and Oceans from 1978 to 2000*. Global aspects, SIO Reference Series, No. 01–06.
- Lüthi, D., Le Floch, M., Bereiter, B., Blunier, T., Barnola, J.-M., Siegenthaler, U., Raynaud, D., Jouzel, J., Fischer, H., Kawamura, K., & Stocker, T. F. (2008). High-resolution carbon dioxide concentration record 650,000–800,000 years before present. *Nature*, 453(7193), 379–382. <https://doi.org/10.1038/nature06949>
- Met Office. (2025, July 14). *State of the UK climate*. www.metoffice.gov.uk/research/climate/maps-and-data/about/state-of-climate
- Robbins, M. (2018). *How to stop screwing yourself over* [Video]. TEDxSF. www.ted.com/talks/mel_robbins_how_to_stop_screwing_yourself_over/transcript
- Sagan, C. (1994). *Pale Blue Dot: A Vision of the Human Future in Space*. Random House.
- Scripps Institution of Oceanography. (n.d.). *The Keeling Curve*. UC San Diego. <https://keelingcurve.ucsd.edu/>
- St Edmund Hall. (2019, October 30). *The history of the Earth at an arm's length*. www.seh.ox.ac.uk/blog/the-history-of-the-earth-at-an-arms-length
- White, C. (2014). *Grass, Soil, Hope: A Journey Through Carbon Country*. Green Publishing.