Climate change explained

Contents

Evidence that the climate is changing

It is unequivocal that human influence has warmed the atmosphere, ocean, and land[1]. Measurements of the average temperature at the Earth's surface show it has risen by about 1.1°C since the pre-industrial period[2]. Each of the last three decades have been hotter than the previous one and the seven warmest years on record have occurred between 2015 and 2021[3]. This change in temperature hasn't been the same everywhere. It has increased more over land than over the oceans and has been more than twice as fast in the Arctic[4].

The United Kingdom (UK) is experiencing rising temperatures. The most recent decade (2012-2021) has been on average 1.0°C warmer than the 1961-1990 average. All ten of the warmest years in the UK have occurred since 2003[5]. 2022 was the UK's hottest year on record, with an average year-round temperature above 10°C seen for the first time[6].

While the climate is warming, temperatures aren't expected to rise every single year. Natural fluctuations will still cause unusually cold years and seasons, but these events will become less likely[7].

Along with warming at the Earth's surface, many other changes in the climate are occurring, such as:

- Warming oceans
- Melting polar ice and glaciers

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[1] IPCC, 2021, Climate Change 2021: The Physical Science Basis, Summary for Policymakers, Paragraph A.1

[2] IPCC, 2023, Synthesis Report of the Sixth Assessment Report, Section 2.1

[3] 2021 continues warm global temperature series - Met Office

[4] IPCC, 2021, Climate Change 2021: The Physical Science Basis, Summary for Policymakers, Paragraph B2.1, B2.3

[5] Kendon et al. 2022. State of the UK Climate 2021, International Journal of Climatology, Executive Summary

[6] Climate change drives UK's first year over 10°C - Met Office

[7] The Met Office report 'Too hot, too cold, too wet, too dry: Drivers and impacts of seasonal weather in the UK' explains from a UK perspective how seasonal and annual variability in our weather might be affected by changes to the climate.

- Rising sea levels
- More extreme weather events

Warming oceans

It's not only the temperature at the Earth's surface that is rising. The temperature of the oceans has been increasing too. This warming has been seen all the way down to 2 km beneath the surface[8].

The chemistry of the oceans is also changing. They have absorbed about one third of the total carbon dioxide emissions since 1980. This is causing the acidity of the oceans to increase ten times faster than at any point in the last 65 million years[9].

Melting polar ice and glaciers

Over the past few decades, the ice sheets (the great masses of land ice at the poles) in Greenland and the Antarctic have shrunk. Glaciers have shrunk too, losing over 6000 giga-tonnes of ice over the last 30 years[10]. Arctic Sea ice has decreased in area since the 1970s, by about 40% in September and about 10% in March. There is no significant trend in Antarctic Sea[11] ice, likely due to other regional effects[12].

Rising sea levels

Melting land ice and the expansion of water in warming oceans have caused sea levels to rise. Global sea level has risen by around 20 cm over the past century, likely faster than at any point in the last 3,000 years. The rate of sea level rise increased over the 20th Century and sea levels will rise further this century. The extent to which they rise will depend on future amounts of greenhouse gas emissions[13].

More extreme weather events

More damaging extreme weather events are being seen around the world[14]. Heatwaves, heavy rainfall events and droughts are occurring more often, and they are more severe[15]. We expect these trends to continue as greenhouse gases emissions and global temperature continue to rise[16].

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[8] WMO, 2023, State of the Climate 2022. Chapter: 'Ocean' Page 6
[9] IPCC, 2021, Climate Change 2021: The Physical Science Basis, Chapter 2, Section 2.3.3.5
[10] WMO, 2023, State of the Climate 2022. Chapter: 'Cryosphere' Page 13
[11] IPCC, 2021, Climate Change 2021: The Physical Science Basis, Summary for Policymakers, Paragraph A.1.5
[12] A full explanation can be found at https://nsidc.org/cryosphere/seaice/characteristics/difference.html
[13] IPCC, 2021, Climate Change 2021: The Physical Science Basis, Technical Summary, Box TS.4
[14] WMO, 2023, State of the Climate 2022. 'Extreme Events', Page 24 and BAMS, 2022, Explaining Extreme Events of 2020
[15] IPCC, 2021, Climate Change 2021: The Physical Science Basis, Summary for Policymakers, Section A.3
[16] IPCC, 2021, Climate Change 2021: The Physical Science Basis, Summary for Policymakers, Section B.2

Causes of climate change

Rising levels of carbon dioxide and other greenhouse gases (such as methane) in the atmosphere enhance the 'greenhouse effect'. More of the Sun's energy is trapped, causing the Earth to warm. Heating of the ocean accounts for over 90% of the trapped energy. Scientists have known about this greenhouse effect since the 19th Century[17].

The more greenhouse gases there are in the atmosphere, the warmer the Earth becomes. While the plants and the oceans absorb about half of the carbon dioxide from human activities, the rest goes into the atmosphere[18]. Recent warming is being driven by:

- Burning fossil fuels for energy.
- Changes in land use and deforestation which reduces the numbers of trees available to absorb carbon dioxide.
- Agricultural production which releases greenhouse gasses from energy use, from the number of livestock and the amount of fertiliser applied to land
- Manufacture of cement, chemicals and metals, which releases greenhouse gases into the atmosphere

Natural influences on the climate, such as changes in the strength of the sun, or volcanic eruptions, can affect global temperature. But they have not contributed significantly to recent warming[19].

Past climate change

Ancient ice from the polar ice sheets is used to understand how temperatures have changed over hundreds of thousands of years. In addition, air bubbles trapped in the ice show that higher levels of greenhouse gases in the atmosphere correlate with warmer global temperatures.

Ice cores also show that greenhouse gases have rapidly increased over the last 350 years to levels not seen for at least 800,000 years. Meanwhile, records from ocean sediments show that current levels of carbon dioxide are higher than they have been for at least 2 million years[20].

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[17] Who discovered the greenhouse effect? | Royal Institution (rigb.org)
[18] Global Carbon Project (2022): Carbon budget and trends 2021
[19] IPCC, 2021, Climate Change 2021: The Physical Science Basis, Summary for Policymakers A.1.3
[20] IPCC, 2021, Climate Change 2021: The Physical Science Basis, Summary for Policymakers Paragraph A.2.1

Natural fluctuations in climate

Over the last million years or so, the Earth's climate has had a natural cycle of cold glacial and warm inter-glacial periods. This cycle is mostly caused by gradual changes in the Earth's orbit over many thousands of years. These changes affect the amount of energy that reaches the Earth. But they can be amplified by changes in greenhouse gases from natural causes, such as volcanic eruptions[21].

We know that climate change has always occurred. But greenhouse gases produced by human activity are altering this cycle beyond this natural variation.

Complex computer models show a clear human 'fingerprint' on recent global warming[22]. The latest Synthesis Report from the Intergovernmental Panel on Climate Change (IPCC) states that it is unequivocal that human activities, principally through emissions of greenhouse gases, have warmed the atmosphere, ocean and land, and that widespread and rapid changes to the climate have occurred[23].

Climate models and future global warming

Looking at changes that have already happened on Earth can tell us a lot about the future effects of climate change. But we can learn much more using mathematical models of the climate.

Supercomputers (such as those at the Met Office) solve complex mathematical equations based on well-established physical laws to model the behaviour of the weather and climate[24].

These models cannot provide very specific forecasts of what the weather will be on a given day more than a few days in the future. But they can predict large-scale changes in global climate in the future.

Climate models can also show us the effects of changing our global greenhouse gas emissions. For example, if we reduce emissions to net zero around or after 2050, followed by negative carbon dioxide emissions, we could see average global temperatures limited to 1.5°C warmer than the pre-industrial period by the end of this century[25].

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[21] IPCC, 2021, Climate Change 2021: The Physical Science Basis, Summary for Policymakers, Figure SPM,1
[22] IPCC, 2021, Climate Change 2021: The Physical Science Basis, Summary for Policymakers, Figure SPM.2
[23] IPCC, 2023, Synthesis Report of the Sixth Assessment Report, Summary for Policymakers, A.1
[24] The Met Office has an explanation of climate models. The American Institute of Physics provides an overview of how the first simple climate models were developed.
[25] IPCC, 2021, Climate Change 2021: The Physical Science Basis, Summary for Policymakers, Table SPM.1

But if greenhouse gas emissions continue to increase, the average global temperature could become 4.4°C warmer over the same period[26]. Because these are global averages, the temperature in regions such as the Arctic will likely be even higher[25].

For more information, see https://www.metoffice.gov.uk/weather/climate-change/what-is-climate-change.

Impacts of climate change

We can already see the effects of climate change. They are projected to become more severe and widespread as greenhouse gas emissions and global temperatures continue to rise[27]. How big these impacts are depends on the degree to which we reduce greenhouse gas emissions, and on our ability to adapt to these changes.

Some of the effects of changes to our climate include[28]:

- Risk to water supplies
- Localised flooding and flooding in coastal regions
- Damage to marine ecosystems and associated failure of fisheries
- Loss of biodiversity
- Heat stress, affecting human health and habitability
- Increased risk of wildfires
- Food insecurity as conditions for growing crops change and habitable region of pests expands

Developed countries produce most greenhouse gas emissions. But we expect developing countries to experience some of the most severe effects of climate change. With fewer resources to adapt to these changes, the impact on people in developing countries is likely to be higher.

For more details, see https://www.metoffice.gov.uk/weather/climate-change/effects-of-climate-change

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[26] IPCC, 2021, Climate Change 2021: The Physical Science Basis, Summary for Policymakers, Table SPM.1
[25] IPCC, 2021, Climate Change 2021: The Physical Science Basis, Summary for Policymakers, Figure SPM.5
[27] IPCC, 2022, Climate Change 2022: Impacts, Adaptation and Vulnerability, Summary for Policymakers, Section B.2
[28] IPCC, 2022, Climate Change 2022: Impacts, Adaptation and Vulnerability, Summary for Policymakers, Section B.3 and B.4

The effects of climate change on the UK

The UK's climate is changing already. As greenhouse gas emissions continue to rise, climate models project that we will see[29]:

- Warmer and wetter winters
- Hotter and drier summers
- More frequent and intense weather extremes

The UK's weather will continue to be variable, and we will still experience much of the weather we do today. But it is likely that we will see more of the weather listed above.

If greenhouse gas emissions continue to increase, then by 2070, UK winters are forecast to be between 0.6 and 3.8°C warmer and between 3 to 39% wetter, depending on the region, compared to our climate in 1990[30]. This is because warmer air can hold more water. We will likely experience heavier rains and more rain could fall during winter storms[31].

Similarly, by 2070, UK summers are projected to be between 1.3 and 5.1°C warmer, depending on the region[32]. Higher summer temperatures will likely cause more severe heatwaves. This will be a risk to public health, particularly vulnerable people[33].

In July 2022, UK temperatures exceeded 40°C for the first time on record[34]. Temperatures remained above 20°C overnight and the highest daily minimum record was also broken. The chance of the UK seeing 40°C days could be 10 times more likely in the current climate than in the past[35]. By 2070, regions in the south could have average hottest days reaching 40°C[36]. Warmer, drier summers are likely to increase the risk of wildfires in the UK, as seen in the summer of 2022.

Climate change will also affect summer rainfall events in the UK. Flash flooding events are more likely, especially in urban areas. By 2070, the UK is forecast to experience flash floods twice as often as it did in 1990[37]. Increased flooding will negatively affect the environment, infrastructure, transport and water systems.

Please click on the links for advice on staying safe and well in hot weather and floods.

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[29] Climate change in the UK - Met Office
[30] UK Climate Projections: Headline Findings 2022
[31] Climate change in the UK - Met Office
[32] UK Climate Projections: Headline Findings 2022
[33] Climate change in the UK - Met Office
[34] Record breaking temperatures for the UK - Met Office
[35] Chances of 40°C days in the UK increasing - Met Office
[36] Climate change in the UK - Met Office
[37] Climate change in the UK - Met Office

The role of the IPCC

The Intergovernmental Panel on Climate Change (IPCC) is a scientific body of the United Nations. It was created in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). It is the UN body for assessing the science of climate change. The IPCC provides policy makers with regular scientific assessments on climate change, its implications, and potential future risks. It also provides options for adaptation and mitigation. These reports are relevant to policy, but they are politically neutral and not prescriptive.

IPCC Assessment Reports are released on a roughly seven-year cycle. During the sixth assessment cycle, the IPCC published three flagship Working Group (WG) reports:

- Working Group I: The Physical Science Basis of Climate Change
- Working Group II: Climate Change Impacts, Adaptation and Vulnerability
- Working Group III: Mitigation of Climate Change

as well as three Special Reports and a Methodology Report:

- Global Warming of 1.5°C (2018)
- Climate Change and Land (2019)
- The Oceans and Cryosphere in a Changing Climate (SROCC; 2019)
- 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2019)

The Sixth assessment cycle concluded with a synthesis of all the reports of the cycle, published on 20 March 2023.

- Synthesis Report

The IPCC report preparation and approval process

The UK Government fully supports the work of the IPCC. It regards the IPCC's assessments as the most authoritative view on the science of climate change. IPCC reports undergo an unparalleled, rigorous and transparent international preparation and peer-review process by scientific experts and governments before they are published. The governments of the IPCC's 195 member countries, which includes the UK, are involved in all major steps. This includes agreeing the scope of a report, nomination of experts as authors, reviewing the reports, and their final approval.

IPCC assessments are highly influential. They informed the creation of the United Nations Framework Convention on Climate Change (UNFCCC), and the subsequent Kyoto Protocol. They drove the Paris Agreement's goal to limit temperature rises to

well below 2°C and pursue efforts to limit the increase to 1.5°C,[38] as well as underpinning the Glasgow Climate Pact agreed at COP26. The 2018 IPCC Special Report on Global Warming of 1.5°C was a major influence on the UK's net zero 2050 target and led to net zero targets being set around the world.

Tackling climate change

In 2015, the 196 parties of the UNFCCC adopted the Paris Agreement. Its overarching goal is to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change". Limiting global warming to 1.5°C or 2°C requires reduced global carbon dioxide emissions to at least net zero by the 2050s and 2070s, respectively. Deep and sustained reductions in the emissions of all other greenhouse gases are also required[39].

There are many benefits to limiting global warming, with each fraction of a degree making a substantial difference. The severity of the impacts of climate change increases with temperature and many changes are irreversible for centuries to millennia[40]. Reducing greenhouse gas emissions will always reduce risk, regardless of specific temperature goals.

To minimise the negative effects of climate change, actions to mitigate and adapt need to be taken in this decade. Mitigation and adaptation action can provide other benefits. For example, reduced methane emissions will limit near-term warming *and* improve air quality. The benefits of such actions will be felt globally, such as improving agricultural productivity, increasing innovation, better health, and wellbeing, increasing food security, and reducing biodiversity loss[41].

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[38] The Paris Agreement | United Nations
[39] IPCC, 2023, Synthesis Report of the Sixth Assessment Report, Summary for Policymakers, Box SPM.1
[40] IPCC, 2021, Climate Change 2021: The Physical Science Basis, Summary for Policymakers, B5
[41] IPCC, 2023, Synthesis Report of the Sixth Assessment Report, Summary for Policymakers, C2