Climate Change FAQs

Guidance to answer commonly asked questions about climate change provided by the Royal Meteorological Society

Contents

Please note that this document will be updated as the science progresses. This version was updated in November 2022 by Ellie Highwood from the version produced in July 2019 by Caroline Coch, and reviewed by Ellie Highwood, Liz Bentley, Ed Hawkins and Peter Stott.

Acronyms

CO_2	carbon dioxide
ENSO	El Niño-Southern Oscillation
IPCC	Intergovernmental Panel on Climate Change
NOAA	National Oceanic and Atmospheric Administration
WMO	World Meteorological Organisation

1. The world has globally warmed only 1.1°C. This is not much, is it?

Short answer: Actually, this is quite a lot if you think about it as the whole world having warmed by that amount. 1.1°C may not seem much on a day-to day basis. However, at a global scale, 1.1°C of warming has already led to tremendous changes on Earth including the loss of glaciers and ice sheets, rising sea levels or the intensification of extreme events like heatwaves.

Background Information:

The world has warmed about 1.1°C compared to pre-industrial levels. This number might seem small as a difference of 1 degree on a day to day basis will not affect us much. There are several possible options in approaching this question, including: 1) pointing out the changes we have already seen within 1.1°C of warming, 2) emphasising that the warming is not uniform around the world.

To point out the numerous changes that already have happened with 1.1°C of warming we can look at the climate indicators established by the WMO (Fig. 1). All of these parameters are monitored and are the foundation for the WMO Statement of the State of the Global Climate report published annually. Temperatures at the surface and in the sea have increased leading to terrestrial and marine heatwaves. There are thresholds in the natural world, where even 1 degree of warming makes a particularly big difference, for example the melting point of ice, or the resilience of organisms to withstand high temperatures. High concentrations of CO_2 in the atmosphere also increase the ocean uptake of CO_2 leading to Ocean Acidification (lowering of the pH). Sea level is rising at about 3.7 mm per year and is nearly three times as fast as during the first half of the 20th century. The sea ice extent in the Arctic and Antarctic is decreasing and glaciers and ice sheets are losing their mass.

The impacts of 1.1°C of warming are already felt in the UK: Buckling train tracks and sagging electric cables, heatwaves, flooding just to name a few.

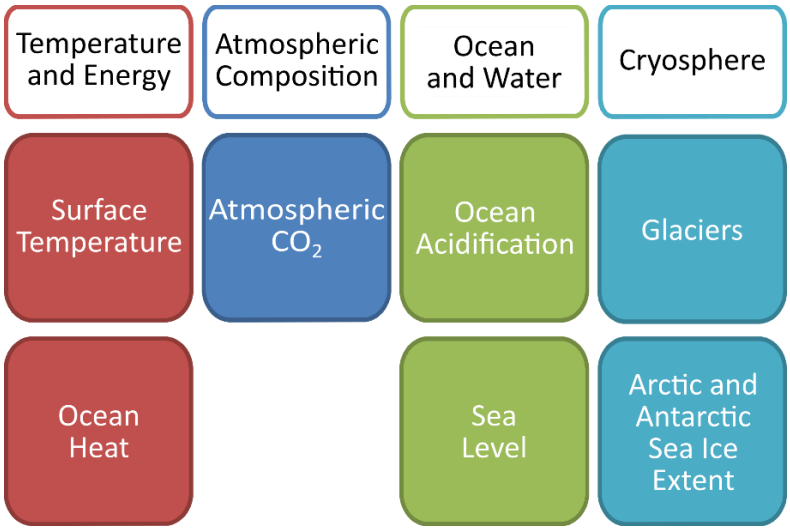
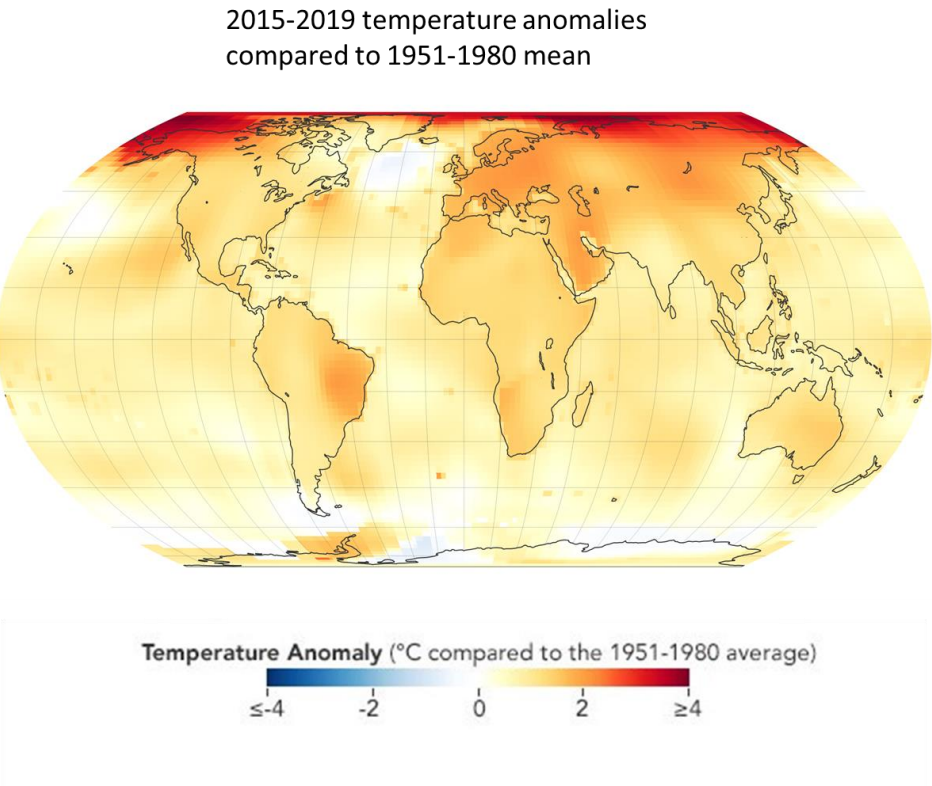


Figure 1. WMO Global Climate Indicators. (Source: https://gcos.wmo.int/en/global-climate-indicators)

Warming of 1.1°C globally does not mean that all parts of the world are warming at the same rate. For example, warming is strongest on continents, and the Arctic is warming more than

twice as fast as the rest of the world, also described as Arctic Amplification. The UK is warming slightly faster than the global average but many of the continental interiors are warming much faster, in many places twice as fast.

Anomaly (difference) maps can help to visualise that the rate of warming is different across the world.



NOAA produces state of the climate reports (including anomaly maps), which can be found here: https://www.ncdc.noaa.gov/sotc/

The UK Anomaly maps are found here: https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-actual-and-anomaly-maps

2. Why is the Arctic warming faster than the rest of the world?

Short answer: This has to do with the so-called ice-albedo feedback. Melting land and sea ice uncovers darker surfaces, which reflect less sunlight and so heat up faster leading to even more melting. This feedback loop amplifies warming in the Arctic.

Background:

Rises in global mean temperature are amplified at the Earth's Polar Regions. The Arctic, but also parts of Antarctica (i.e. the region around the Antarctic Peninsula) have shown a temperature increase at an accelerated rate compared to the global average.

The accelerated observed warming is called Arctic Amplification or Polar Amplification. Normally, white surfaces of the sea ice reflect much of the Sun's energy back into space,

returning much of the Sun's energy to the atmosphere and space rather than allowing it to warm up the land. The scientific term for reflectivity is albedo. We all experience the effects of different albedos in the summer – wearing dark coloured clothes (with a low albedo) in the summer will heat you up more than light coloured clothes (with a high albedo). Warming of the Arctic leads to a melting of sea ice, exposing darker surfaces of the underlying Arctic Ocean. The exposed dark surface now can absorb the sun's energy heating up the ocean and leading to even more melt. This is termed a "positive feedback loop".

3. What is the difference between 1.5 and 2 degrees of warming?

Short answer: Climate-related risks for humans and the environment are higher in a 2 degree warmer world compared to a 1.5 degree warmer world. Every bit of warming matters.

Background:

A warmer world will lead to a higher frequency of extreme weather events such as heatwaves, powerful summer and winter storms and extended droughts. Persistent ocean heatwaves cause coral reefs to bleach and die, which leads to the loss of habitat to myriads of marine species. Sea level rise will continue to affect coastal communities.

The IPCC special report on the impacts of global warming of 1.5°C looks at the different impacts a 1.5 and 2 degree warmer world (in relation to the pre-industrial period) would have. It is important to bear in mind that there is no known sharp threshold at 1.5 and 2 degrees of warming, where it is 'safe' below and 'dangerous' above. Every bit of warming will increase the risk of climate change impacts on humans.

Every amount of warming will lead to stronger impacts on natural and human systems, such as more extreme heat, higher number of ice-free summers in the Arctic, a higher proportion of species going extinct or a stronger decline in coral reefs.

The IPCC report can be found here: https://www.ipcc.ch/sr15/.

A comprehensive Q&A about the report is found here: https://www.carbonbrief.org/in-depth-qa-ipccs-special-report-on-climate-change-at-one-point-five-c.

4. Climate has always changed, hasn't it?

*This question is similar to the phrases/questions such as "*This is all due to natural *variability", "Climate change is natural", "It's the sun", and can be* approached in a similar manner.

Short answer: Yes, Earth's climate has always changed. However, the dominant factor for current rates of warming are greenhouse gas emissions through human activity. Burning fossil fuels releases carbon dioxide into the air. Physicists have known for centuries that carbon dioxide absorbs infrared radiation, which is the basis of the greenhouse effect. We can be very sure that CO_2 from human activities will trap infrared radiation and lead to warming of the planet.

Background:

A number of factors can influence Earth's climate. Natural factors include variations in the Earth's orbital cycle (Milankovitch cycles), variation in the sun's output, volcanic eruptions, plate tectonics and asteroids. If we take all natural factors together, we would actually expect the Earth to be gradually cooling currently (although it's worth noting that the next ice age would not be expected for many centuries to come). The primary human factors influencing the climate are greenhouse gases, sulphate aerosols and changes in land use. The current rate of warming can only be explained by taking all natural and human factors into account.

The rate of change that we currently see is much faster than throughout the past 800,000 years. No natural factor can explain this rate of change.

Other evidence for human induced climate change is that the stratosphere is cooling. This is because the greenhouse gases in the atmosphere are trapping the heat, prohibiting the heat from reaching the stratosphere. If greenhouse gases did not play a role in the current warming, we would expect the stratosphere to warm as well. This can be considered as another piece of "independent" evidence of the warming climate due to greenhouse gas emissions.

One could emphasise here that it would be much scarier if the world was warming but human activities were not causing the climate to change, as we can influence our activities but not the natural factors.

Importantly, natural climate change in the past is strong evidence that the climate is sensitive to changes in different factors. There is no logical reason to assume that it would only respond to all natural factors (e.g. the sun), but none of the human factors.

5. Can we rely on the temperature records?

Short answer: Yes, we can! Similar trends have been measured by different methods, including thermometers and satellites, at different places across the globe and this gives us confidence in the measurements. Indirect measurements from the natural world, e.g. melting glaciers, thawing permafrost and melting sea ice, also give a consistent story.

Background:

There are different aspects to this statement: On the one hand, it refers to the relatively short period of instrumental record in relation to Earth's history. Longer back in time, we have natural archives (ice cores, sediment cores, fossils etc.) that indirectly tell us about past climate conditions. The longer we go back in time, the larger the uncertainties.

The argument is further used to suggest that the global rise in temperatures is somehow spurious. There is no way to obtain the Earth's temperature by a single measurement – global temperatures are obtained from thousands of individual measurements. This data needs to be processed and adjusted for consistency (as temperatures have not always been measured in the same way) in order to obtain a long-term estimate how global temperatures are changing. Sceptics claim that these adjustments are "tweaked" in a way that they would amplify the warming, but the total effect of all the adjustments is actually to reduce the warming.

There are four major global records, independently produced by NASA, NOAA, the Hadley Centre and the Berkeley Earth group. All these data sets are constantly checked and improved. Despite the different methods, they all tell the same story: the Earth has warmed by just over 1C since the mid-19th century.

Moreover, the consistent changes in the natural world can be seen as a further "independent", natural piece of evidence. Using the Climate Indicators (section 1) will support this argument.

6. If we cannot predict the weather next week, how are we going to project the climate?

Short answer: Weather is chaotic, making prediction difficult. Climate, as the long-term average of weather, reduces the chaotic element significantly making climate projections possible.

Background:

Weather forecasts have greatly improved in recent years – yet, there is a greater element of uncertainty (when compared to climate predictions). The reason is that weather forecasts focus on the precise evolution of the atmosphere, which is very variable and chaotic in nature.

However, for doing climate predictions, the ocean plays an essential role. Scientists can account for these variables and also other factors (rising greenhouse gas emissions, solar variations etc.). These factors have an influence on the time scale of months and years unlike atmospheric patterns that can change within hours. One important factor affecting the variations in climate is the El Niño Southern Oscillation (ENSO), which is explained in this RMetS briefing paper: https://www.rmets.org/briefing-paper-el-nino.

The main factor driving variations in global temperature from decade to decade are "external" climate factors such as explosive volcanic eruptions and changes in atmospheric greenhouse gas concentrations.

As another example, we can be confident that next summer will be warmer than next winter without predicting the weather in those seasons. There are large-scale factors which are predictable, even if we can't forecast the weather that far ahead.

7. Why do we know that human-induced climate change made some events more extreme and more frequent?

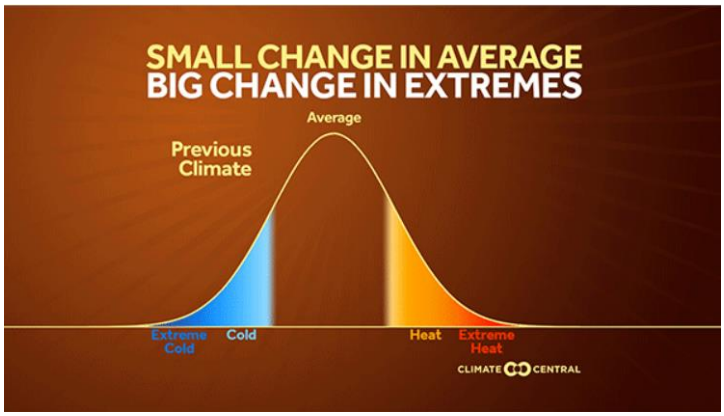
Short answer: Using computer models, scientists simulate the current world with and without human-induced climate change and compare the two. This shows that some events are being made more extreme and frequent.

Background:

This knowledge is based around the field of event attribution (see also RMetS Briefing note with detailed explanations on this: https://www.rmets.org/news/how-does-climate-change-affect-weather).

Using computer models, scientists are able to simulate the likelihood of extreme events such as heatwaves in today's climate, and also for a world without human-induced climate change. These models are not looking into the future, but at the past and present climate. Essentially, they take the human influence out of the world and see what the world would have looked like without human-induced climate change. Using these methods, scientists found that for example heatwaves are made more likely and more intense.

To explain why extreme events become more extreme can also be explained using the Gaussian distribution curve (GIF available, screenshots below). Small changes in the average temperature mean a big change in the extremes.



8. What can we do about climate change?

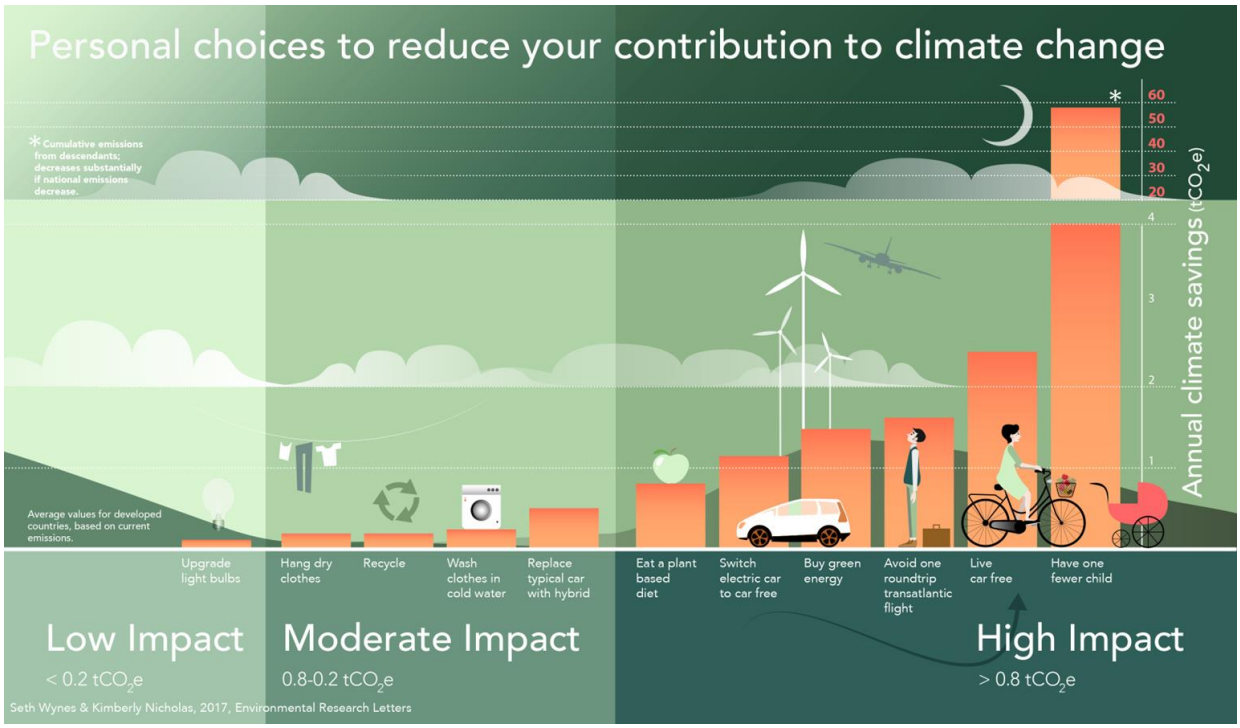
Short answer: Current policies and actions (as of November 2022) are not enough to meet either the 1.5 or 2 degree target set out by the Paris Agreement. Many countries have made pledges to reduce CO2 emissions and if all these are met, then we may be able to restrict warming to around 1.8 degrees, but there is a big gap between these stated pledges and the actions being taken (as of November 2022). If we want to fulfil the Paris Agreement, measures need to be taken to drastically reduce CO_2 emissions.

Background:

This question is coming up more and more, also aiming at what individuals can do. It is hard not to be “prescriptive” in answering this question. Doing something about climate change will involve reducing emissions – everybody can look at their own lifestyle and assess where they are able to cut down emissions (food, transportation, energy consumption etc).

The Grantham Institute has put together a list of things individuals can do: https://sway.office.com/F9BFgqQUudOtTOIJ?ref=Link

There has also been some research completed on the most impactful actions by Wynes and Nicholas, Environmental Research letters, 2017. People tend to overestimate the impact of low and moderate impact actions (e.g. recycling) and underestimate the impact of the high impact actions (car free, plant based diet)



Trusted Material

Source	Comment
Royal Meteorological Society https://www.rmets.org/ladybird https://www.rmets.org/briefing-papers	The ladybird annex contains additional information to the Ladybird expert book “Climate Change”. The briefing papers are 1-page summaries of important aspects of climate science.
CarbonBrief www.carbonbrief.org	Great daily and weekly newsletters, covering climate science and policy. This website is trusted by climate scientists and covers in-depth Q&As about reports and climate science. They also provide very useful visuals.
Royal Society www.royalsociety.org/topics-policy/projects/climate-change-evidence-causes/	The Royal Society produces reviewed material on climate change evidence, but also summaries of IPCC reports with relevance to the UK.
British Antarctic Survey https://www.bas.ac.uk/data/our-data/our-publications/?ptyp=246&pdate=all	Briefing papers on topics related to the Arctic and Antarctica.
Climate Stripes graphics https://showyourstripes.info/s/globe	Place where you can produce the climate stripes graphic for different locations
Climate Lab Book www.climate-lab-book.ac.uk	Great resource for climate change visuals by Ed Hawkins.
Climatecentral.org https://coastal.climatecentral.org	Interactive tool to allow you to see the effect of future climate change on sea level rise and flood risk
Intergovernmental Panel on Climate Change www.ipcc.ch	IPCC reports are THE resource to look for specific numbers and the state of the science.
UK Met Office https://www.metoffice.gov.uk/weather/climate-change/climate-change-in-the-uk	Good summary of likely impact of climate change on the UK
DESMOGUK https://www.desmog.co.uk	Website listing individuals and organisations, who deny human induced climate change.
World Weather Attribution https://www.worldweatherattribution.org	Website to provide timely and scientifically reliable information on how extreme weather events may be affected by climate change – within a couple of months of the event happening.
Climate Action Tracker https://climateactiontracker.org/	Website that tracks progress towards the globally agreed aim of holding warming well below 2 degrees, and pursing efforts to limit warming to 1.5C.

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