MetLink
Royal Meteorological Society

# Weather and Climate

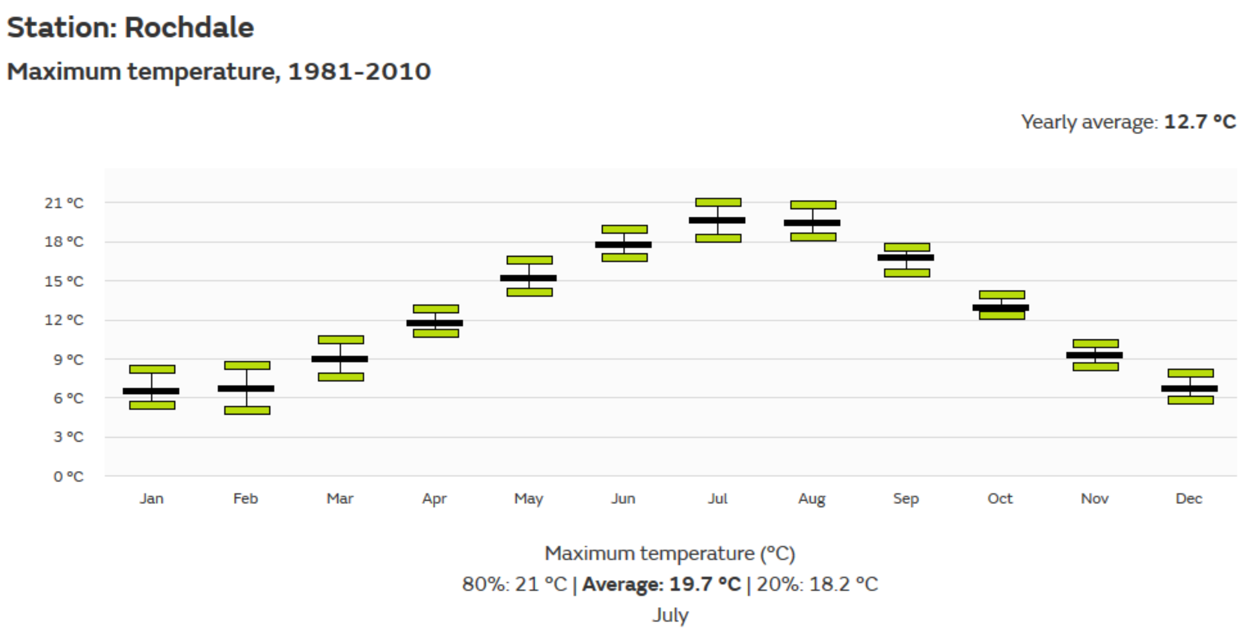
# Background Information for Teachers

## Climate is What we Expect, Weather is What we Get

‘Weather’ is the day-to-day state of the atmosphere, and its short-term variation in minutes to weeks. This includes factors such as temperature, humidity, precipitation, cloudiness, visibility, and wind.

Climate is the average weather for a given place. Usually, that’s the same as saying that it’s the weather we get most often in a given place and a given time. Climate information includes the statistical weather information that tells us about the normal weather as well as the range of weather extremes for a location. Usually, the climate is taken to be the 30-year average of the weather.

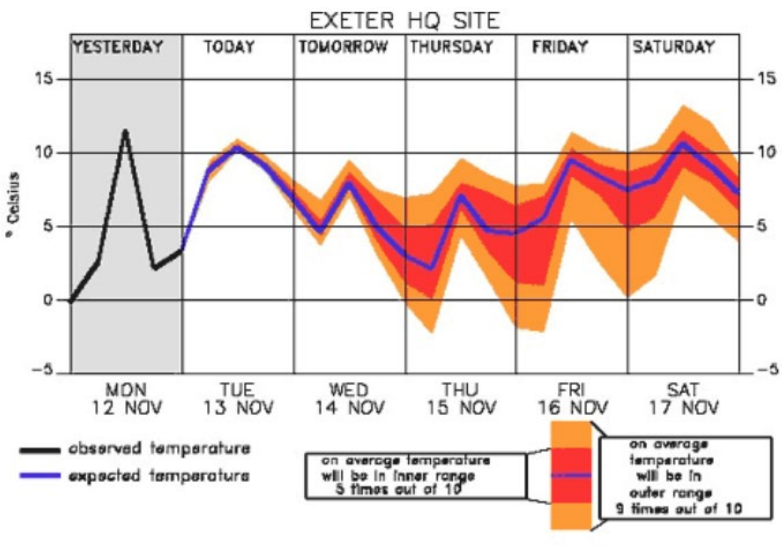
So, for example, this temperature ‘box and whisker’ graph shows that the July maximum temperature ‘climate’ for Rochdale is 19.7°C. This is the black line. The green lines show that 60% of the time, the temperature is between 21.0°C and 18.2°C, 20% of the time it is warmer than 21.0°C and 20% of the time it is colder than 18.2°C. So, on a given July day in Rochdale, the maximum temperature might be 29°C – but if you were asked what you thought the maximum temperature would be on the same day in a year’s time, the answer should be 19.7°C.



**Why is it so hard to predict the weather a week in advance and how can scientists tell us what they think the climate will be like in 50 years' time?**

First of all, it's important to understand that weather isn't random; it's chaotic. If the weather were random, it would mean that there would be no possible way of knowing what it was going to do next. However, the weather does obey the laws of physics and every change in the weather has a cause. The problem is that since there are so many possible causes, we can't know about them all.

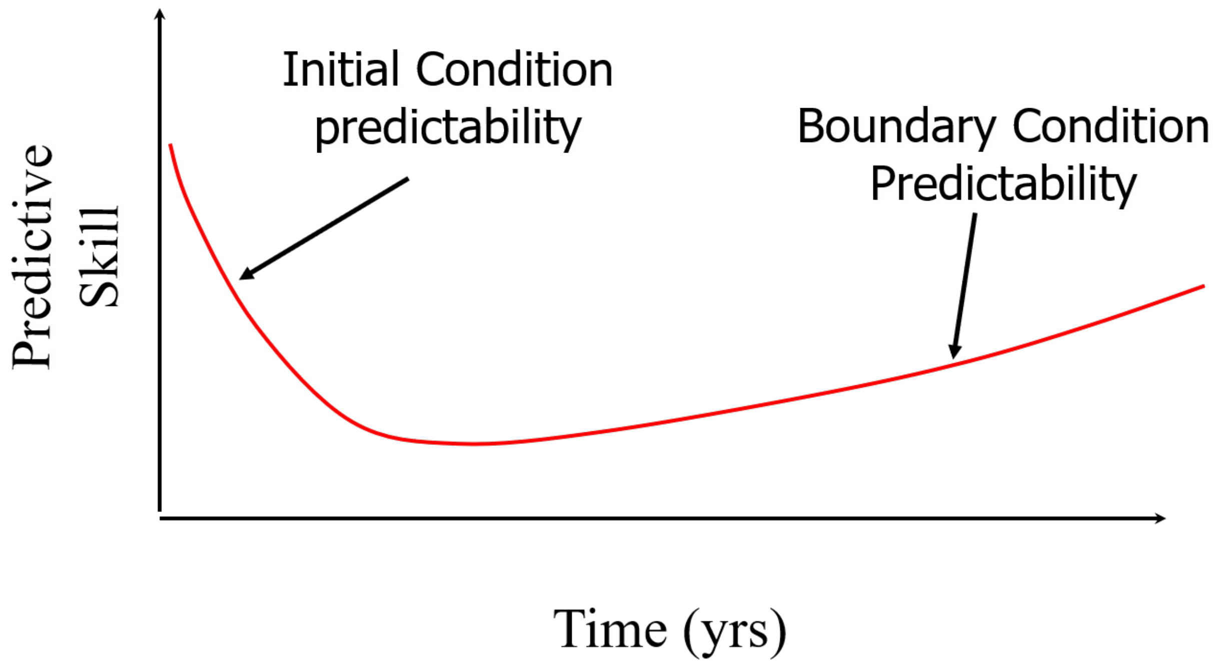
You may have heard of the butterfly effect (first proposed by Ed Lorenz in the 1960s): A butterfly flapping its wings in the Amazon rainforest might, through a long line of unlikely but possible consequences, cause a storm over Texas. In a similar vein, if we don't know what's going on in the atmosphere and on the Earth's surface down to the detail of a butterfly flapping its wings now, we can't hope to know how that will affect the weather in a week's time. The possible range of consequences grows with time – and the ability to accurately forecast the weather will decrease with time. Of course, some weather situations are much easier to predict than others. For example, High pressure (Chapter 16) is easier to predict than the snow showers which can be caused by an Arctic Maritime air mass (Chapter 7), but in general tomorrow's weather forecast is much more likely to be accurate than one for 10 days' time.




This figure shows the growth of the range of possible temperatures in a 5-day weather forecast

Modern forecasting techniques try to capture the range of possible future weather by making an 'ensemble' of weather forecasts. Rather than making one forecast with one set of starting or 'initial' conditions (the weather now) they make many forecasts, each with tiny but plausible differences in the weather now. Each difference represents the effects of all the possible 'butterflies' or other tiny details about the climate system that we can't possibly measure. The ensemble of forecasts gives forecasters a range of possible weather forecasts and provides some indication of what is most likely, and what might happen. This leads to weather apps now frequently giving the probability of rainfall for a given place.

The climate, unlike the weather, is not chaotic. Remembering that climate is 'average weather', if large scale factors which control the climate (referred to as 'boundary conditions' in the figure below) are known – the composition of the atmosphere, the location of the continents, the Earth's position in relation to the Sun etc. - then it's possible to predict the climate. Climate is to weather as the bank is to the roulette wheel: The statistics of the system are simpler than the system itself and so it is easier to be right in the long run than in the short.




So, why do we use a 30-year period to define the climate? According to the WMO (World Meteorological Organisation) (https://usermanual.wiki/Document/NormalsGuidetoClimate190116en.853739083/view ) this period was first chosen because, at the time, only 30 years' data was available for many places. “The optimal length of record varies with element, geography and secular trend. For example, the optimal period for temperatures is often substantially shorter than 30 years, but the optimal period for precipitation is often substantially greater than 30 years. In that sense the 30-year averaging period represents a compromise for the sake of consistency.”

The ‘current’ climate is changed every ten years – so our current climate will change from 1981-2010 to 1991-2020 in early 2021.

In between weather forecasts and climate forecasts come seasonal forecasts – the ‘what will the weather be next winter’ type questions. As the weather is chaotic, this is very hard to do, but there is some skill to be found in looking at the large scale influences on the weather – for example, if there’s a strong El Niño occurring, then certain weather patterns are more likely to form around the world than others.

The North Atlantic Oscillation (or NAO) is another of the many factors which can be looked at. Meteorologists look at the pressure difference between Iceland and the Azores. The pressure is always lower in Iceland than in the Azores because of the large-scale circulation of the atmosphere (chapter 4), however the difference in pressure can vary. A large difference in the pressure (a positive NAO) leads to stronger westerlies, bringing moist air to Europe. Consequently, summers are cool and winters are mild and wet in Central and Western Europe. In contrast, if the pressure difference is small (a negative NAO); westerlies are suppressed; winters are cold and dry in northern European areas and the depressions track southwards toward the Mediterranean Sea. This brings increased storm activity and rainfall to southern Europe and North Africa.

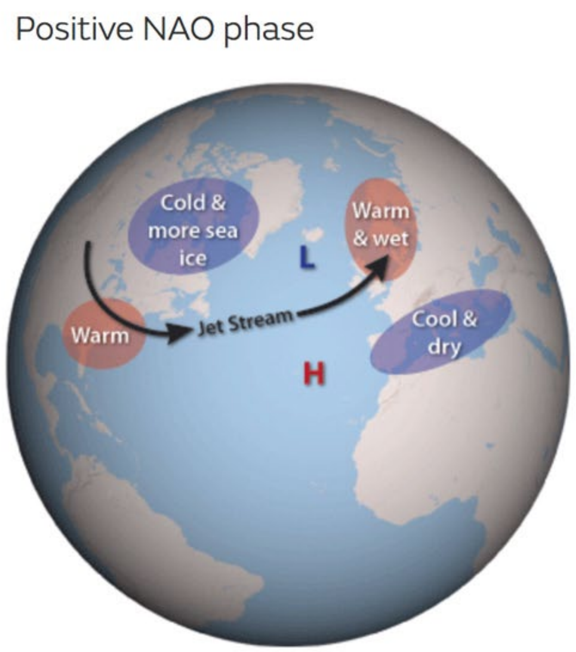



Image source: Carbonbrief.org

## The Central England Temperature Record

The Central England Temperature Record is the longest instrumental record of temperature in the world.

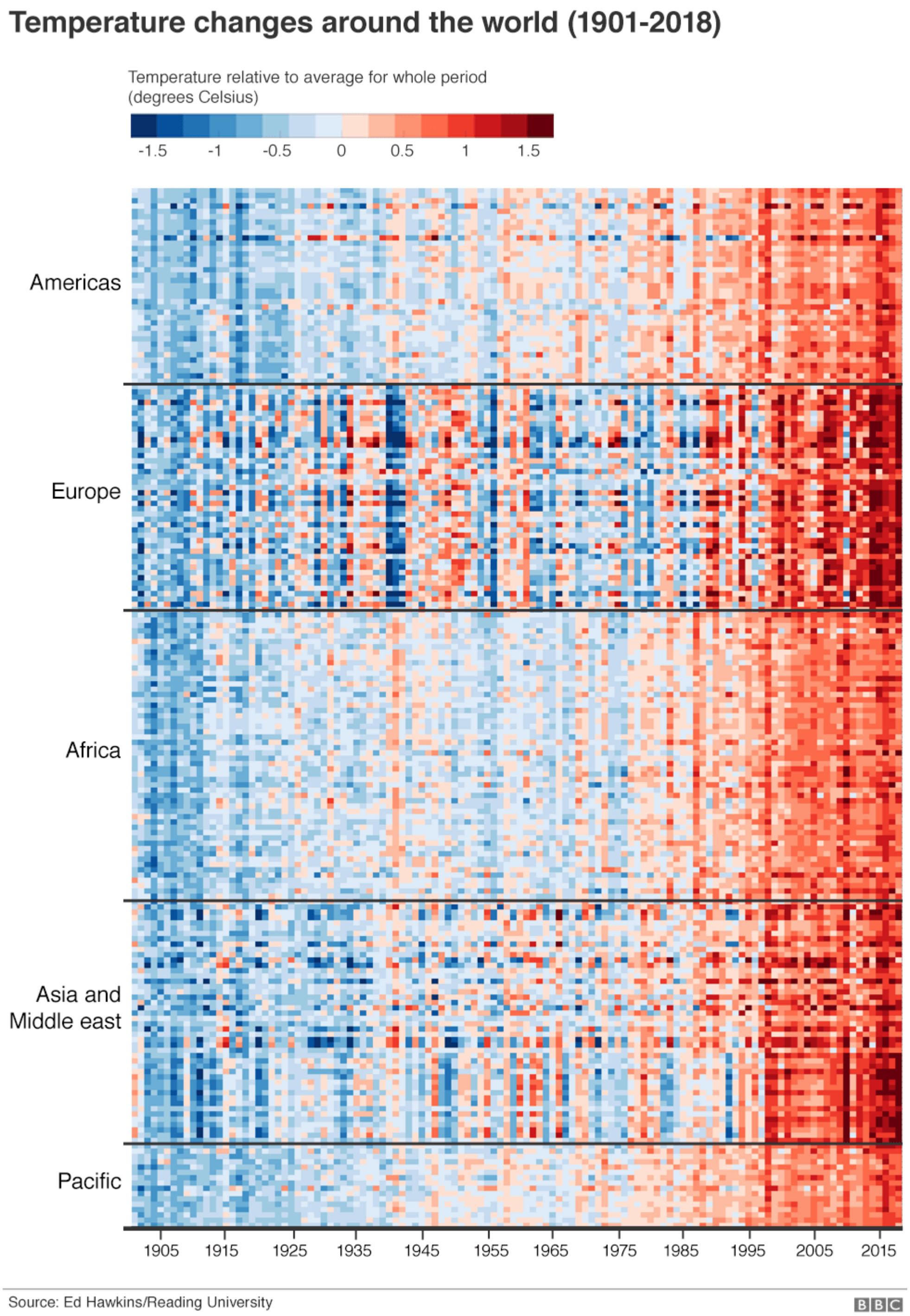
The data represents the temperature in a roughly triangular area of the United Kingdom enclosed by Lancashire, London and Bristol.

The sources of the data include records kept by individuals around the country, all carefully combined and corrected for factors such as changing instruments over time, the growth of urban areas etc. The precision of the data published for each year reflects the number, accuracy, reliability and geographical spread of the temperature records that were available for that year – so early in the record, the data may only have a precision of 1°C or 0.5°C, whereas more recent data has a precision of 0.1°C.

The mean monthly temperature record starts in 1659, with daily data being available from 1772 and maximum and minimum daily and monthly data beginning in 1878.

The CET allows us to study both the changing weather and the changing climate of central England.

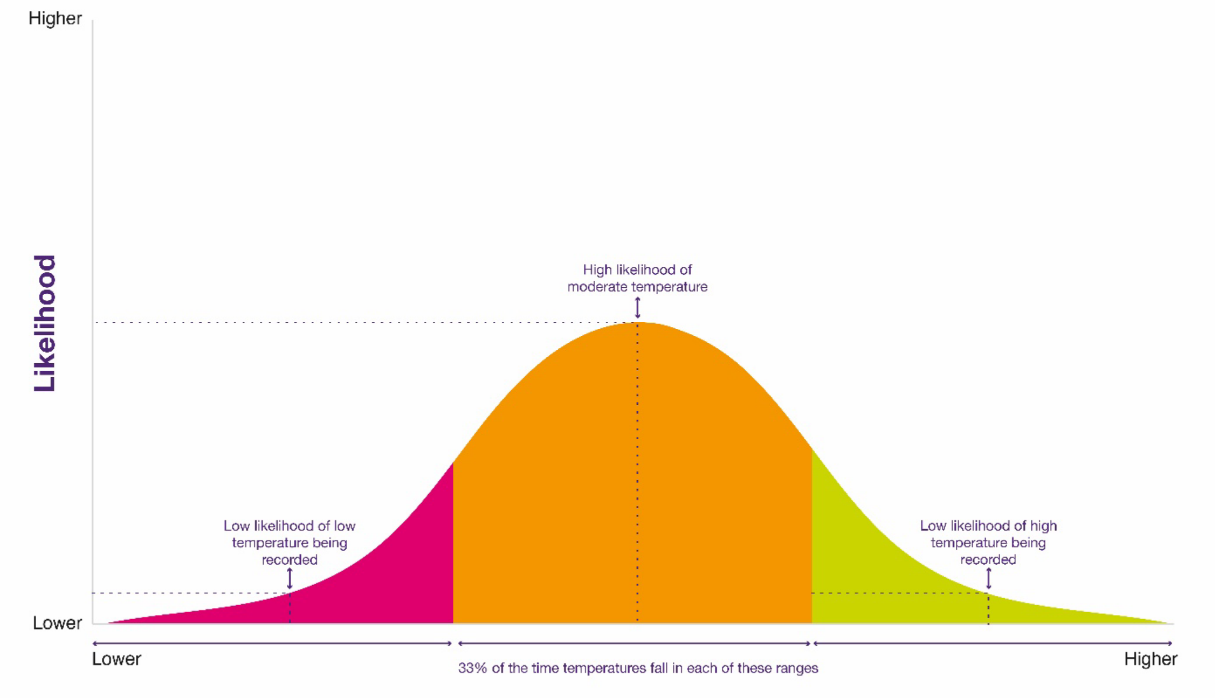
The full dataset and references can be found at www.metoffice.gov.uk/hadobs/hadcet



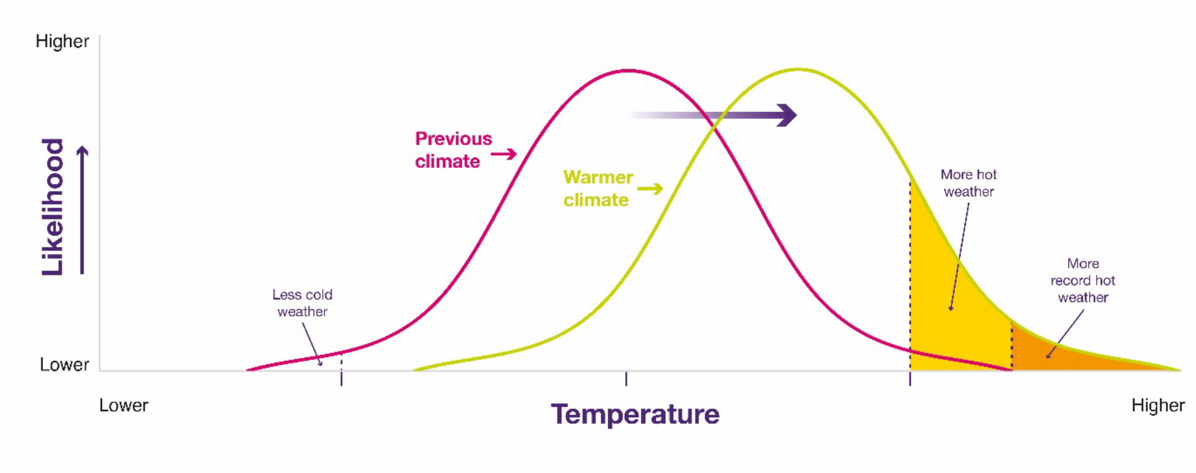

This image both shows the variability of weather from year to year and the change in climate over time. Both the variability and change are different from country to country.

## Climate Change and Changes in Extreme Weather

The climate of a particular place for a particular time of year is most fully described as a probability curve showing the temperatures (or rainfall or any other climate variable) which are most likely as well as those more extreme temperatures which may occur.




As the climate changes, this whole distribution changes. For example, in a warming climate, you would expect fewer extremely cold temperatures, and more extremely warm ones. However, extremely cold weather events can still happen, just less frequently.




## Sources of Further Information

https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages - maps, graphs and data

https://earthobservatory.nasa.gov/global-maps - global past weather maps

https://www.weatherobs.com – current weather observations from around the world