Edexcel A Geography GCSE

Topic 2 - Weather Hazards & Climate Change

Detailed Notes

Global Atmospheric Circulation

The way our **atmosphere** circulates around the Earth impacts **global weather and climate patterns**, as the movement of air around the globe influences the **temperature** and **humidity**.

What is Atmospheric Circulation?

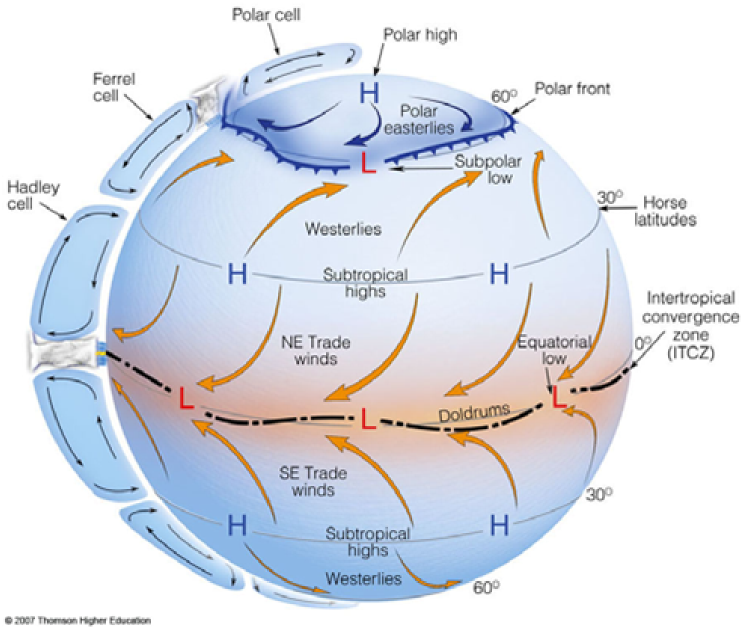
The **atmosphere** is the layer of air **surrounding the Earth's surface** which extends **hundreds of kilometres high**. Our atmosphere contains different **gases** (such as oxygen, nitrogen, water vapour and carbon dioxide), water droplets and particles.

Within the Earth's atmosphere, the air is **constantly moving** in **different directions** because of the sun's **energy**, differences in **pressure**, and the **rotation** of our Earth. These movements cause air to **circulate** around our world, following generally quite **predictable** movements. These **patterns** can be **illustrated** by a model of **global atmospheric circulation**.

Atmospheric Circulation Model

The Global Atmospheric Circulation Model can be seen in the diagram below.

There are **three** distinct patterns of **air circulation** on either side of the equator (0°). These circular air movements are called **cells** (which are the blue sections with black arrows in the left of the diagram). The three cells are:



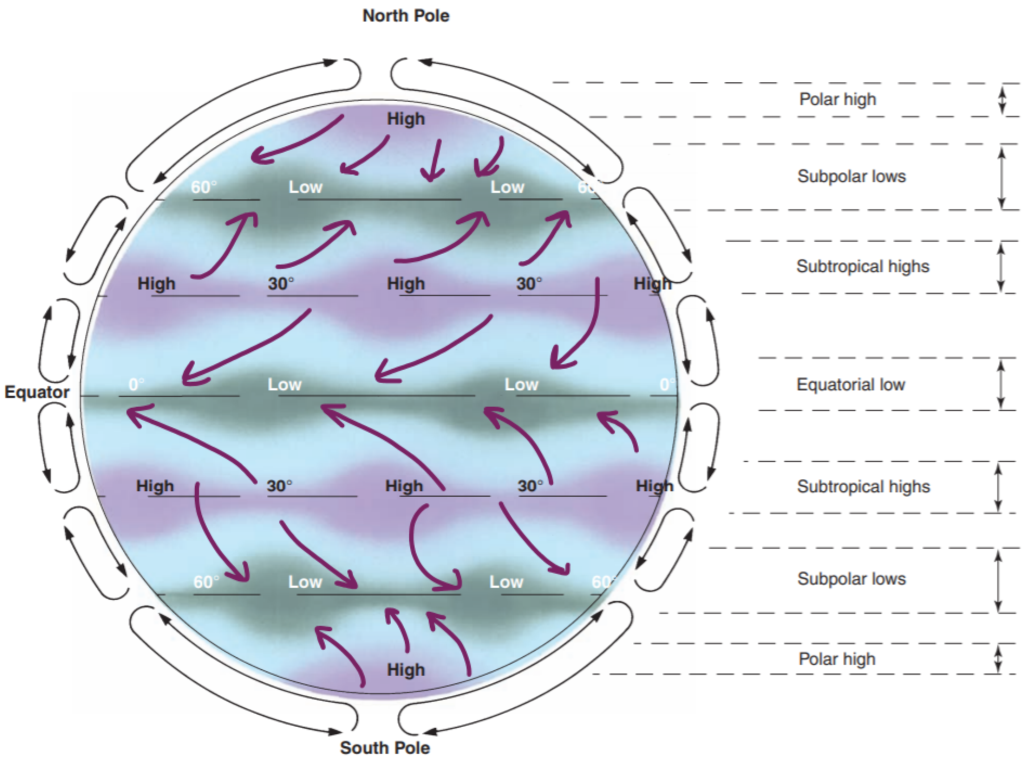
- **The Hadley Cell:** At the **equator**, hot, moist air rises, moves to higher latitudes (30°) and sinks.
- **The Ferrel Cell:** At around **60°** either side of the equator, moist air rises, and travels to lower latitudes at around 30° where it sinks, along with air travelling from the equator.
- **The Polar Cell:** At 60° north or south of the equator, moist air rises, and travels to the poles (90°), where it sinks.

Pressure Belts

These air circulations create **different areas of pressure**.

- When air **rises**, it creates an area of **low pressure underneath**.
- When air **sinks**, it creates an area of **high pressure**.

A diagram of the **global pressure belts** can be seen below.



(Source: adapted from Cengage Learning)

One way to remember these patterns is to think of it like this - when the air is **sinking**, there are obviously more air particles **pushing downwards**, meaning there would be **higher pressure here**.

In contrast, if air is **rising**, the pressure will indeed be **lower** as the air particles aren't **pushing down**.

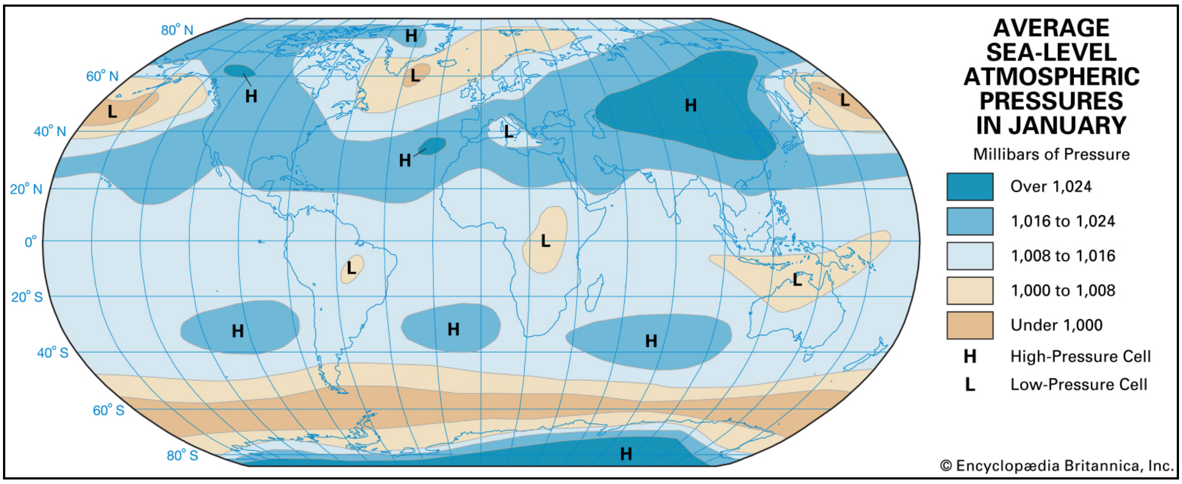
Pressure Differences in Land and Sea

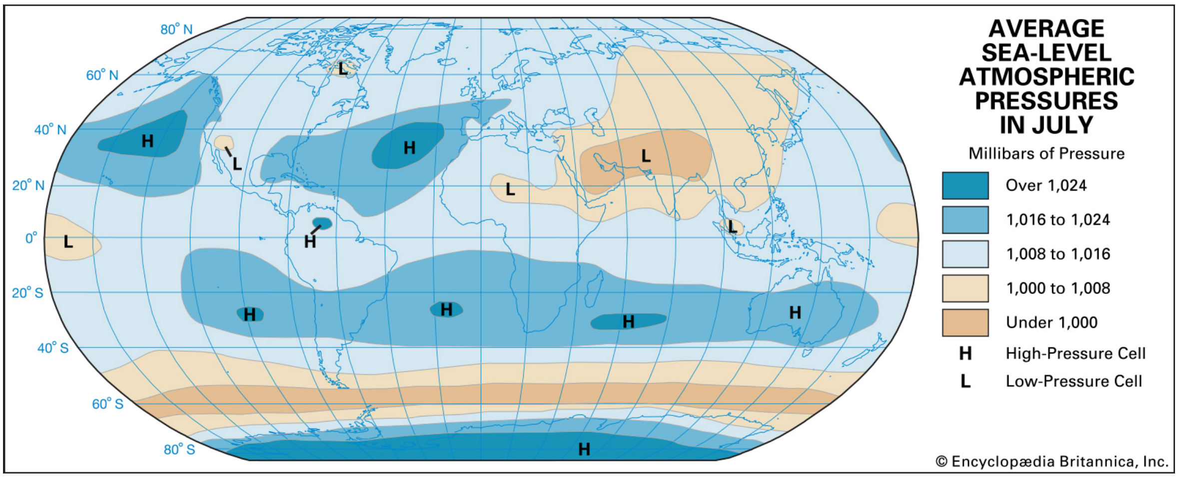
Oceans behave differently to **land** when they absorb the Sun's energy and heat up, which causes **pressure differences** between the **land** and the **sea**.

Land generally absorbs sunlight more and heats up **quickly** in **summer months**, causing **low pressure over land** as the **hot air is rising.** The sea **reflects more heat** and therefore takes longer to heat up, forming areas of **high pressure**.

The opposite happens in **winter**, as the land loses energy quickly causing **high pressure over the land**, whereas the seas take longer to cool, meaning they are relatively **low pressure**.

Maps showing the **differences in pressure between summer and winter** can be seen below. Remember that in January it is winter in the Northern Hemisphere, but summer in the Southern Hemisphere (and vice versa in July) which is why the patterns are reversed.

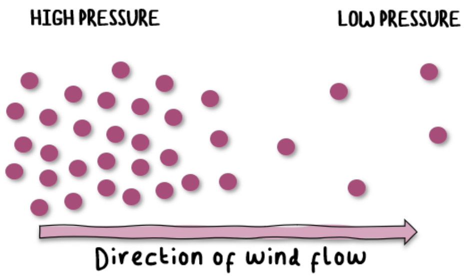




As a result of **atmospheric cells** and **pressure differences in the ocean**, **pressure belts** are formed across the globe. In general, there is **low pressure** at the equator and at 60° either side of it due to the **air rising** here. There is **high pressure** at the poles and 30° either side of the equator due to air sinking here. This can alter seasonally depending on the oceans.

What about Wind?

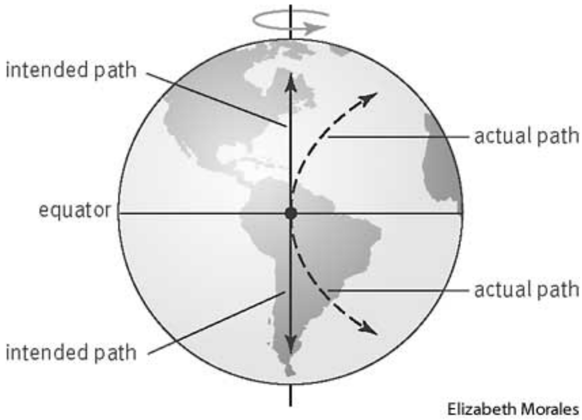
Wind is created when air particles **move**. Air particles will always move from an area of **HIGH PRESSURE** to an area of **LOW PRESSURE**.



This pattern can be seen in the **atmospheric circulation diagrams** mentioned earlier; the arrows will always move **from high pressure areas to low pressure areas**. For example, the patterns of surface wind move **from** 30° which is high pressure **towards** the **equator** which is **low pressure**.

However, you may also notice that **these winds do not move in a straight line**. Instead, the winds are **deflected** in different directions.

This is because the **earth is spinning**, so the winds end up travelling in a curved direction. This effect is known as the **Coriolis Effect**. So, the winds are **deflected right** in the northern hemisphere, and **left** in the southern hemisphere.

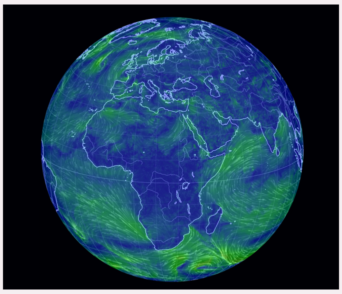


Elizabeth Morales

Thinking Further: Global Winds

[This website](earth.nullschool.net/#current/wind/surface/level/orthographic) allows you to look at the **global surface winds** in real time. Try to spot the **overall patterns** that you can see on the **atmospheric circulation models**, but also spot any differences in these trends.

Hopefully you can see that **surface winds are not always that simple**, and sometimes don't stick to these patterns.
earth.nullschool.net/#current/wind/surface/level/orthographic

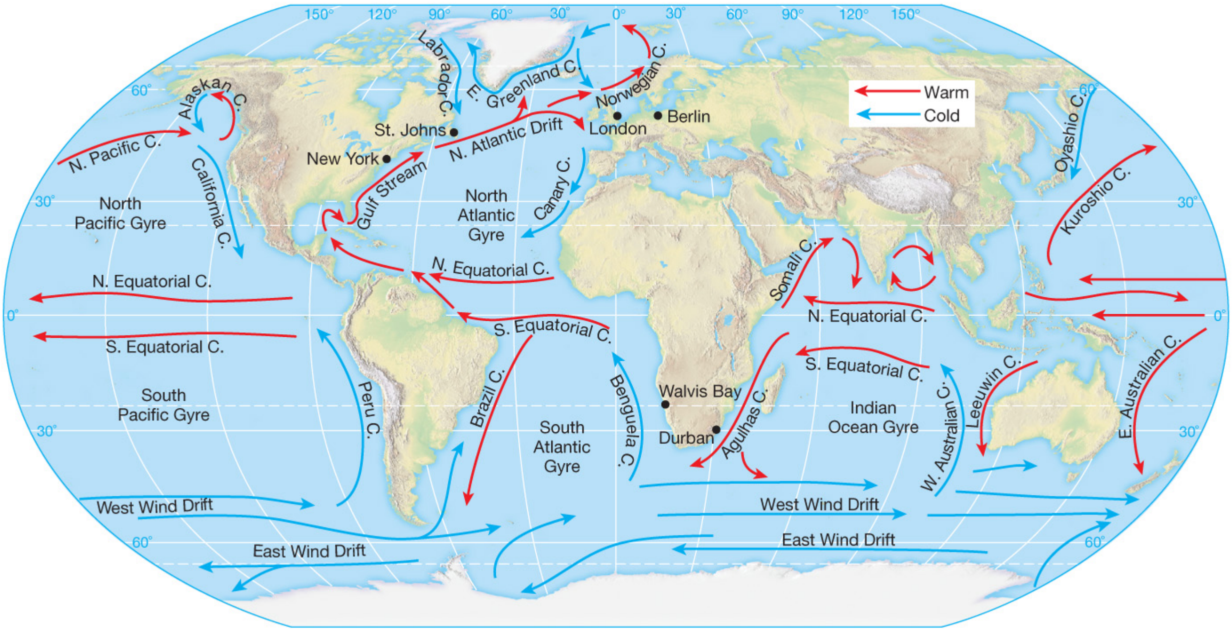


Ocean Currents

Ocean currents are the **predictable**, **continuous** movements of water in the **ocean**. There are several **major ocean currents** that move around the world, transferring **energy** to other regions.

Ocean currents can have major effects on the **climate** of a region, as they can transfer **warmer water to colder regions**, and **colder water to warmer regions**.

The Gulf Stream is an example of an **ocean current** that influences the climate. Warm water from the **equator** flows up to the **North Atlantic** via the **Gulf of Mexico**, which causes the climate in Europe to be **warmer**. Without this ocean current, Europe would be 5-10°C colder!

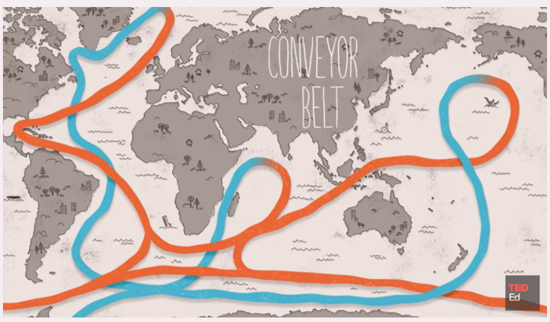


Thinking Further: Drivers of Ocean Currents

Ocean currents are driven by **winds**, the **Coriolis Effect**, the **tides**, and **density differences** (temperature and salinity).

[This video](https://www.youtube.com/watch?v=p4pWafuvdrY) explains how ocean currents are set up and sustained around our world.

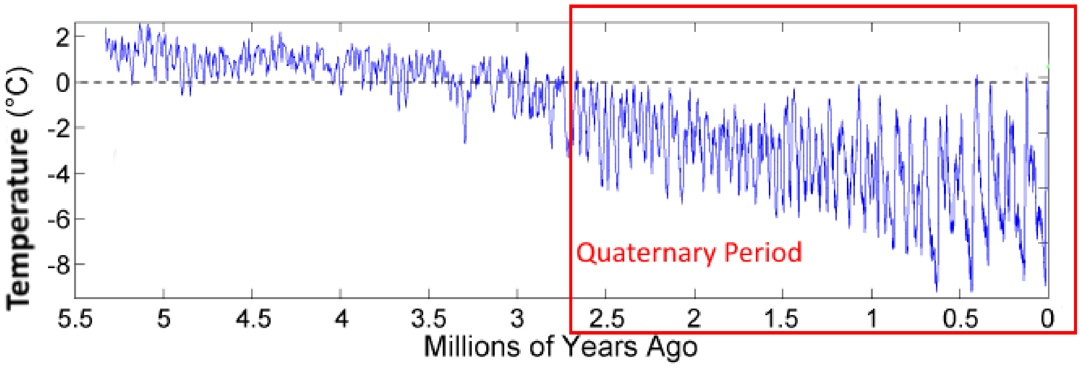
https://www.youtube.com/watch?v=p4pWafuvdrY

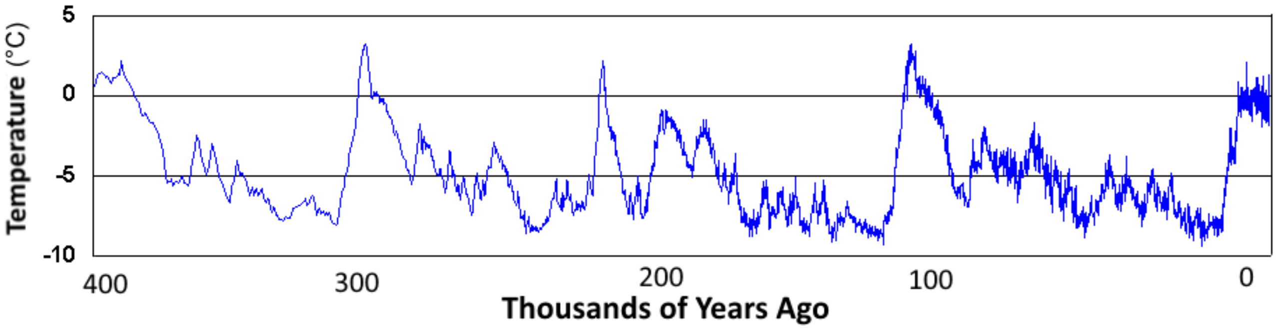


Climate Change During Earth's History

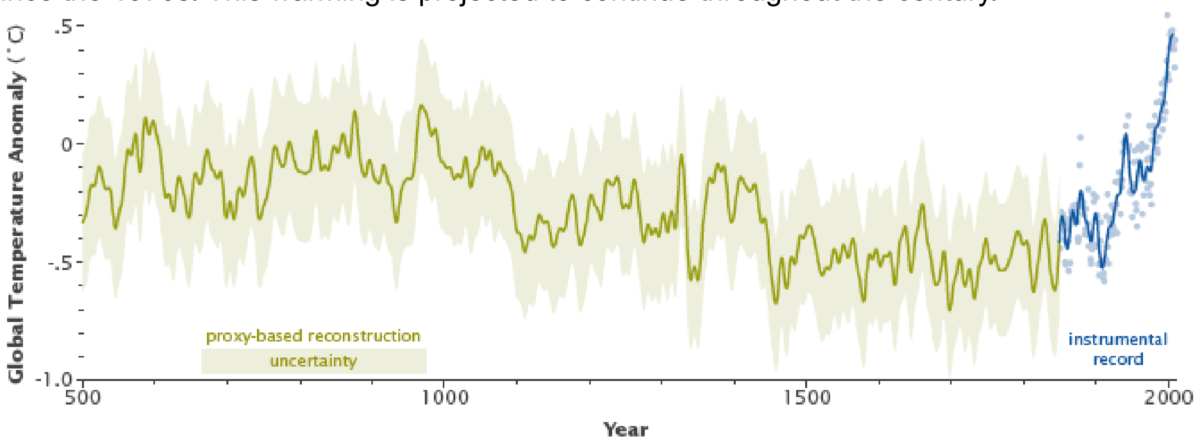
When we hear the phrase **'climate change'**, we might think about the changes in our climate **over the last few decades**: rising **temperatures** in the **air** and the **sea**, more **intense tropical cyclones**, severe **droughts** etc. However, the climate of the Earth has gone through **dramatic changes** throughout its **history**. Some **major fluctuations in temperature** have occurred in the ***Quaternary Period.***

The **Quaternary Period** is the **geological time period** that started **2.6 million years ago**, and extends into the **present**. During the Quaternary period, there have been many fluctuations between the colder **glacial periods** and warmer **interglacial periods**. We can see these fluctuations on the graphs below, which show the temperature relative to our current average temperature (which is displayed as 0°C on the graphs).





Over the last few hundred years, our climate has been warming **rapidly**. Average global air temperatures have risen by **0.85°C since 1880**, and the majority of this warming has occurred since the 1970s. This warming is projected to continue throughout the century.



(Source: https://earthobservatory.nasa.gov)

Natural Causes of Climate Change

There are several **natural factors** that have caused **changes in Earth's climate** for millions of years. The main natural influences on climate change are:

- Variations in the **Earth's orbit** around the Sun (Milankovitch cycles)
- Variations in **solar output**
- The effects of **volcanic eruptions**

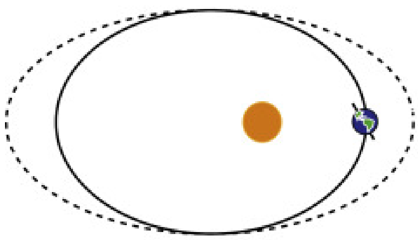
Orbital Changes

The way in which the **Earth orbits around the Sun** changes over **thousands of years**. These orbital changes affect **where the Sun hits the Earth**, and how **intense** the Sun is, which in turn controls the seasons and affects the climate. Orbital changes follow **very similar patterns** to **glacial** and **interglacial** periods, and scientists theorise that orbital changes caused major **temperature fluctuations** throughout Earth's history.

The influence of Earth's orbit on the climate is known as '**orbital forcing**' and the cycles are commonly referred to as **Milankovitch cycles** after the Serbian geophysicist Milutin Milankovitch who discovered them. There are **3 distinguishable orbital changes** that the Earth goes through:

Eccentricity:

- The orbit of the Earth around the Sun changes from a **near-perfect circle** to an **ellipse** (squashed circle/oval).
- This affects how **intense** the Sun's rays are on Earth. If the Earth is orbiting in an **elliptical shape**, it will be **further away from the Sun** at certain points than if it was orbiting in a **circle**.
- 1 cycle takes around **100,000 years**.



Eccentricity
~100,000 years

Obliquity (tilt):

- The **tilt** of the Earth's **axis**, which changes from **21.5° and 24.5°** (currently 23.5°).
- Affects the contrast between summer and winter **seasons**.
- To change between 21.5° and 24.5° takes around **41,000 years**.

Obliquity
~40,000 years

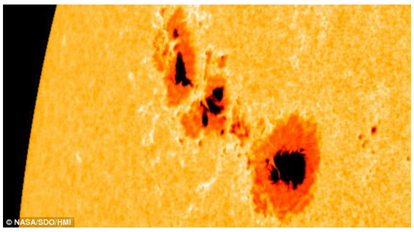
Precession:

- Describes the **wobble** of the Earth's axis (imagine the movement of a **spinning top** when it starts to slow down - the Earth wobbles on its axis in a similar way).
- Affects the **length of days**, especially in the poles.
- A full cycle takes just over **20,000 years**.

Precession
~20,000 years

(Images source: www.sciencedirect.com)

Solar Output



There are **variations** in the amount of **solar energy** that the Sun **emits** which are thought to have an effect on the **Earth's climate**.

One example of a variation in solar output is the **sunspot cycle**. The **sunspot cycle** is an **11-year cycle** where the amount of **sunspots** on the Sun's surface (darker spots with reduced temperatures) varies from a **minimum** to a **maximum**, and then back to a **minimum**.

At the sunspot cycle's **minimum**, there is **reduced solar output**. At the sunspot cycle's **maximum**, there is an **enhanced solar output**.

There is an identifiable **relationship** between **the Earth's climate** and the **amount of sunspot activity present** on the Sun. There have been incidences of **temperature change** on Earth that are linked to these **cycles**, so it appears that **solar output variations** do affect the temperature on Earth, although this is only a **theory**. It has been hypothesised that temperatures during a cold period called the '**Little Ice Age**' plummeted further during sunspot minimums.

Volcanic Activity

Very large **volcanic eruptions** have had an effect on the **Earth's climate** in the past. The **ash** and **gas** that erupts into the atmosphere when there is a huge eruption can cause a **cooling effect** on the Earth's climate. This reduction in surface temperatures caused by an eruption is known as a **volcanic winter**. Volcanic eruptions do this in two ways:

- Large amounts of **volcanic ash** can stay in the atmosphere and **block out the sun**. This is usually a **short term cooling**.
- Volcanic eruptions can emit **sulfurous gases** which react to form aerosols which **reflect solar radiation**. This effect can last several years.

Thinking Further: Volcanic Winters

There have been many examples of large volcanic eruptions causing **volcanic winters**.

- **1783 - Laki, Iceland**. The year after the eruption, Northern Hemisphere temperatures fell by about **1°C**, resulting in severe weather. 8,000 additional deaths in the UK were recorded in the winter of 1783-1784. **Severe weather** continued for several years in Europe.
- **1815 - Mount Tambora, Indonesia.** The eruption caused global temperatures to fall by **0.4-0.7°C**, resulting in crop failures and famines. 1816 was commonly referred to **'The Year Without a Summer'**.

Artistic representation of the 1815 eruption.
(Source: Greg Harlin/Wood Ronsaville Harlin)

Evidence for Climate Change

In the present day, we measure **air** and **sea** temperatures using **thermometers**. Scientists started taking these measurements around 100 or so years ago, meaning we have a **reliable record** of global temperatures starting around the late 1800s (which is known as the **instrumental temperature record**).

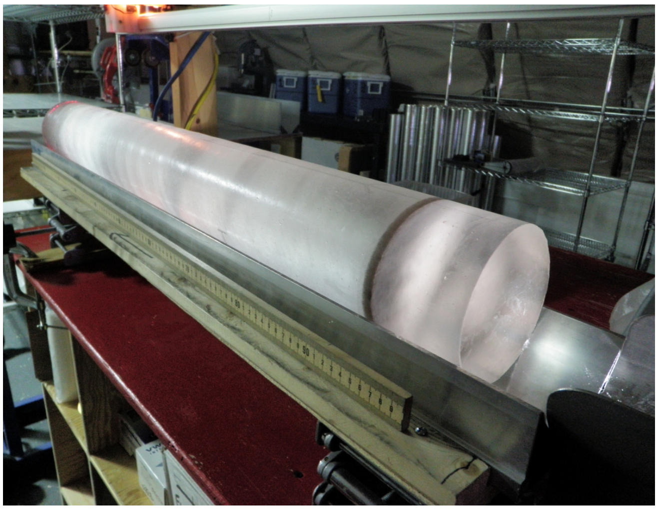
However, this means there is **no instrumental data** of global temperatures **before people started taking these readings**. Scientists have therefore had to discover other ways to **indirectly** calculate global temperatures **in the distant past**. Methods for gathering evidence of climate change include:

- Ice cores
- Pollen records
- Tree rings
- Historical sources

Ice Cores

The Antarctic ice sheet and the Greenland ice sheet are the largest **and the oldest** ice sheets in the world. They contain ice crystals that were formed **hundreds of thousands** of years ago. When snow falls on top of these ice sheets, it buries and **traps older snow** below. Over thousands of years, this snow builds up and compacts into **thick ice**.

Scientists have been able to **drill down** inside the ice sheets and extract **large cylinders** of ice called **ice cores**, which can be seen in the image to the right. Scientists use these ice cores to calculate **gradual changes in temperature** over thousands of years. Right at the top of the ice core is the **youngest ice**, and as the scientists work down the ice gradually becomes **older**.



(Source: icecores.org/about-ice-cores)

The **composition of water** can be analysed to calculate (with extreme accuracy) what the **temperature of the atmosphere** was when that water fell as snow. Air bubbles **trapped in the ice** can also be analysed; levels of CO_2 and other gases can tell us more information about the climate at that time.

Ice cores provide evidence of the climate stretching back **hundreds of thousands of years**. The furthest back in time an ice core has been able to go was 400,000 years!

Pollen Records

Similarly to ice cores, scientists extract cylinders of **sedimentary rock** from the continental and oceanic crust, which are called sedimentary cores.

Sedimentary cores will contain **compacted material** spanning decades, as dead vegetation and material compacts under pressure at the bottom of the ocean to form sedimentary rocks.

Surprisingly, **pollen** is a very strong natural structure and has a **tough outer layer** which can withstand high pressures.

(Source: Earth Change Media)

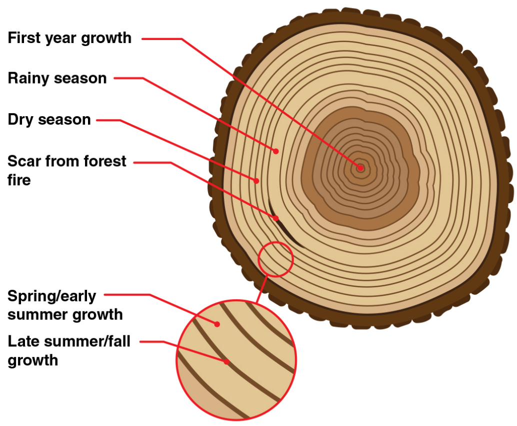
This means pollen molecules can become trapped and protected within sedimentary cores. Scientists extracting these cores can analyse the **composition of pollen** to determine what **vegetation** was on the Earth's surface at different times in history. This information can be used to work out the **climate** at a certain time, as certain plants grow under certain climates.

Tree Rings

Tree rings can be used to **reconstruct** the climate that those trees **grew in**. Each year, a tree gains another **ring** when it grows; if a tree ring is **larger**, it means the tree grew **more** that year.

Scientists can use tree rings to work out when temperatures were more **favourable for growth** (warmer, wetter), and therefore **reconstruct past climates**.

Although the majority of trees only last a few hundred years, **data from the distant past** can be gathered using fossilised tree trunks that have been preserved (e.g. in peat bogs).



(Source: NASA)

Historical Records

Historical records and sources that **people** have created can be used to gain an understanding about climate **before accurate temperature measurements** were taken and recorded. These sources are especially relevant from the past 2000 years when civilisation began to develop.

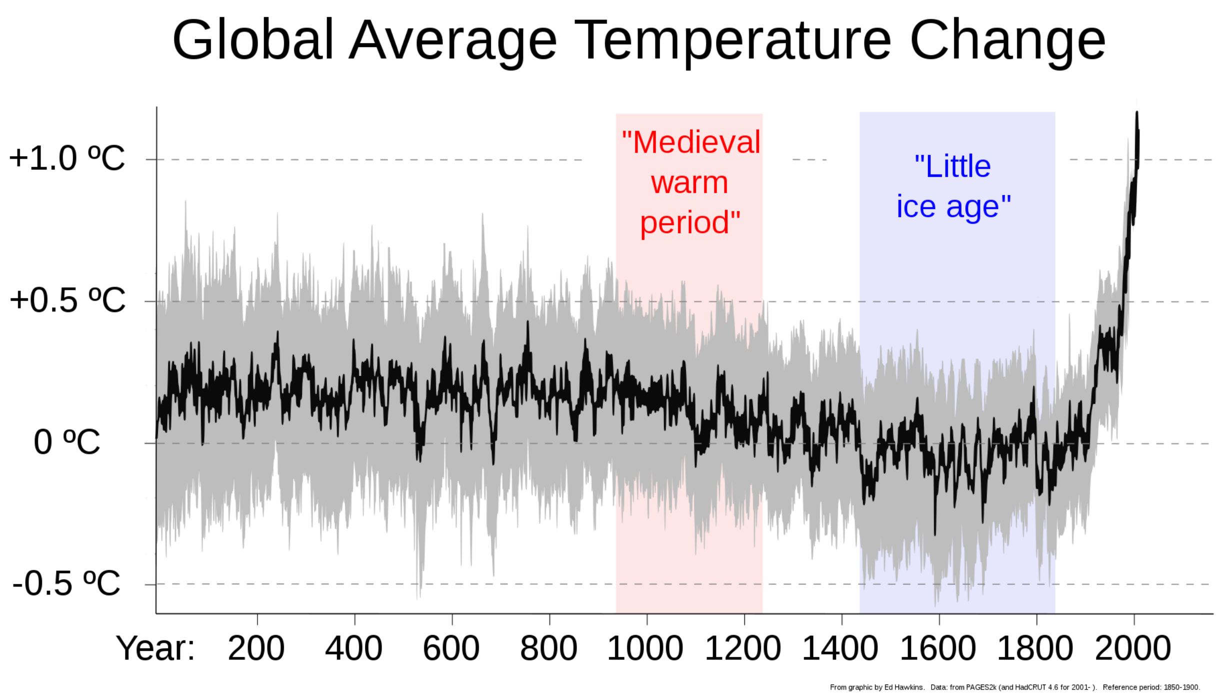
For example:

- Photos, illustrations and paintings can show what the **past landscape** was like. There are many paintings of the period around the Little Ice Age that depict a **cold** climate, with **lakes** and **seas** frozen over.
- Records of **animal behaviour/migrations** or the dates that trees **flower** can indicate temperatures at the time.
- Books, journals and newspapers can be used to understand the climate, or date any weather events such as extremely cold winters.

Historical sources can not be used as **accurate** sources of climate data as they were not **intended to be reliable sources**, but they can be used to gain an idea of temperature trends.

A painting during the Little Ice Age, H. Avercamp, c. 1620.

These sources of information combined have made it possible to reconstruct temperature changes throughout Earth's history.



(Source: By RCraig09 - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=87832845)

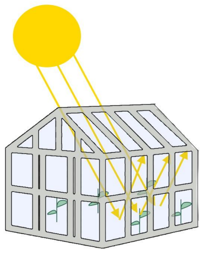
Human Causes of Climate Change

There is **overwhelming evidence** to suggest that **humans** have been a major cause of **climate change**, especially the **rapid warming** since the 1970s. This is due to **human activities** that influence how much **energy is in the Earth's atmosphere**. The main ways that humans are thought to have caused global warming are:

- The **burning of fossil fuels** during **industrial processes, transport, and energy production** which has released **greenhouse gases**.
- **Different farming methods**, which release **methane** (a powerful **greenhouse gas**).
- **Deforestation**, which has **reduced the CO_2** taken up by trees, contributing to higher levels of **greenhouse gases in the atmosphere**.

The Greenhouse Effect

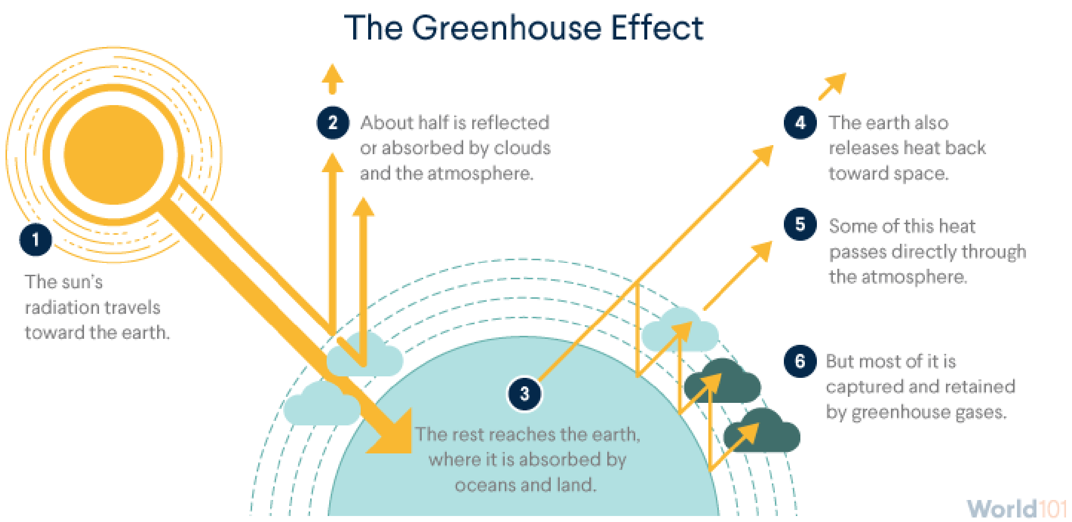
Human activities have contributed to global warming through the release of **greenhouse gases**, but **how has this caused recent climate change?**



The Greenhouse Effect is a natural process where **greenhouse gases** (mainly carbon dioxide, methane, water vapour, and nitrous oxides) trap the energy from the Sun inside the Earth's atmosphere, which heats the Earth. This effect is similar to what happens in a **greenhouse**. In a greenhouse, the **Sun** shines through the glass, which **heats up the air** inside. This heat cannot escape as it is **trapped** by the glass, which keeps it **warm** inside.

A similar effect happens when the **Sun** shines on our **Earth**:

- **Solar radiation** from the Sun (short-wave radiation) travels to our Earth and **heats up the Earth's surface.**
- The Earth **gives off heat** (long-wave radiation) when it cools.
- Some of this heat **leaves our atmosphere and goes into space.**
- Some of this heat is **trapped by greenhouse gases**, which keeps our Earth warm.



The Greenhouse Effect is the reason the Earth is **warm enough** to live on. Without it, Earth would be far too cold for life as we know it.

The Enhanced Greenhouse Effect

The Enhanced Greenhouse Effect

Human activities release **greenhouse gases** into the atmosphere at a **higher rate than natural processes**, which has resulted in an **enhanced greenhouse effect**.

As there are higher amounts of **greenhouse gases** in the atmosphere, more heat is **trapped** and cannot escape into space. This heat is **reradiated around the Earth** and causes the air to heat up more and more. This process has led to **increased warming** in recent years.

The main human activities that have caused an **increase in greenhouse gas levels** in the Earth's atmosphere are outlined below:

Fossil Fuels

Fossil fuels - such as coal, oil and gas - are fuels that are made up of **the remains of organic material**. We burn fossil fuels for **energy**, which produces our **electricity**, fuels our **cars**, and heats our **homes**.

When fossil fuels are burnt, **greenhouse gases** are released, such as carbon dioxide, nitrous oxides and methane. These greenhouse gases concentrate within the atmosphere, contributing to the **enhanced greenhouse effect**.

The vast majority of **CO_2** comes from the burning of fossil fuels.

Agriculture

Another source of **greenhouse gases** is due to **farming** activity.

Agricultural activities produce a lot of **methane**. **Methane** is a **more effective greenhouse gas** than CO_2, so it is **better at trapping heat**. About **25%** of global warming is thought to be caused by methane emissions, despite there being **much** less methane in the atmosphere than CO_2.

Rice Farming

In a paddy field (a flooded field where they grow rice) there are the right conditions to release a **lot of methane**. As rice is **heavily cultivated** across the world, rice farming is a **large contributor** to the levels of methane in the atmosphere.

(Source:www.nationalgeographic.org)

Livestock

Some **farm animals**, such as cows and sheep, **produce methane** when they digest food. One of these animals on average produces 250-500 litres of methane a day!

Animals are kept all over the world **as livestock** to meet the population's demand for **meat and animal products**, which contributes to **huge methane emissions**.

Agricultural fertilisers also produce **nitrous oxides**, which can be up to **300 times** more effective in capturing heat than carbon dioxide.

Deforestation

Deforestation is the process of **cutting down trees**. Deforestation occurs all over the world, mainly to **make space** for **agriculture**, or to **collect wood** to use for other means or to **burn** as fuel.

Trees take in **CO_2** from the atmosphere and store it inside them as **carbon**. Deforestation removes **large amounts of trees**, which in turn **reduces** the amount of **CO_2** that is being taken in and stored, resulting in higher levels in the atmosphere.

Also, forested areas are often **burnt** to make space quickly, and chopped wood is also burnt for fuel. The burning of wood **releases CO_2** that was originally stored in the trees and puts it in the atmosphere.

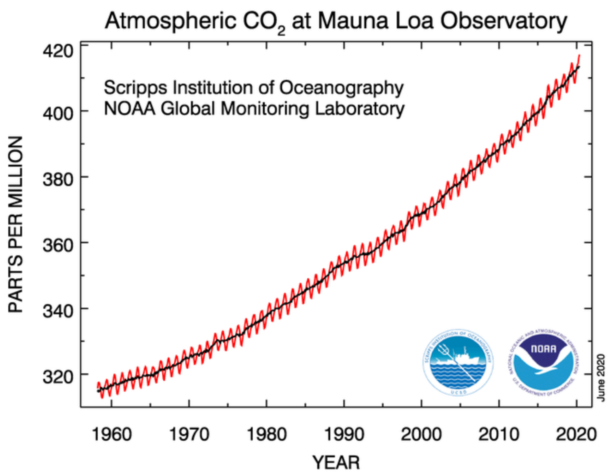
(Source: AFP via Getty Images)

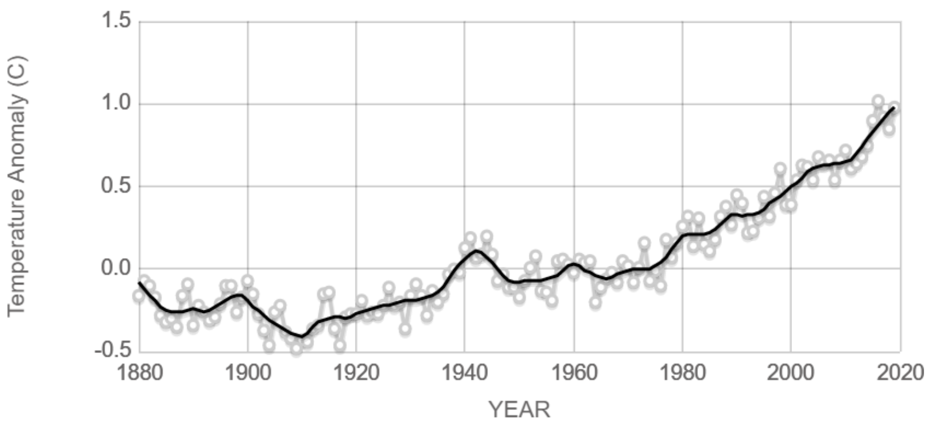
Greenhouse Gas Levels and Climate Change

Emissions of greenhouse gases due to human activities is thought to be a **bigger influence** on **current global warming** than **natural causes of climate change**.

Average global **temperatures** are projected to increase by as much as **4°C** by the end of the century (projected between 1.8°-4°C) due to human activities.

Below is a graph of the amount of **atmospheric CO_2** recorded since **1958**, and a graph of **average temperature difference** (anomaly) since **1880**. Notice how the global temperatures are rising in a similar pattern to the levels of CO_2 in the atmosphere.





Evidence for Human Induced Climate Change

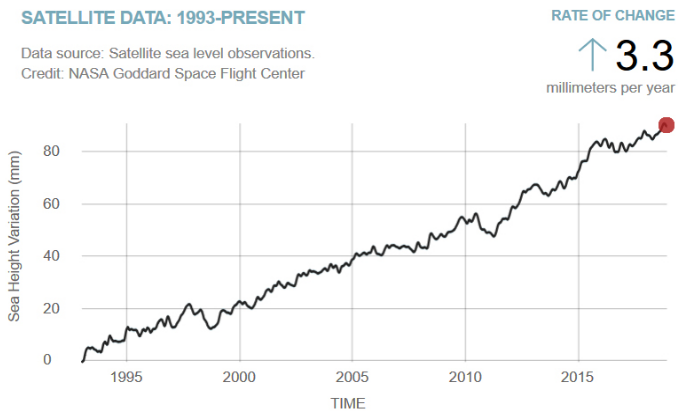
We know that our climate **has been warming** in recent years due to our temperature records, but we can also see **more evidence** of our changing climate in different parts of the world.

Sea Level Rise

The average **global sea level** has risen by **21-24cm** since the 1800s, and **a third** of this rise has occurred within the **last 25 years**.

Sea level rise has been occurring because **higher temperatures** have caused glaciers and ice sheets to melt, and this **freshwater** then flows into the sea.

Furthermore, water **expands** when it gets warmer (known as **thermal expansion**) so as the Earth warms, the whole sea is expanding and **rising**.



Decay of glaciers and ice

Glaciers and ice sheets are **melting** all around the world, which is evidence that **the climate is warming**. Some glaciers are projected to **completely melt** by 2035. The majority of glaciers are shrinking and thinning.

Sea ice is also **thinning** and not **extending as far**, especially in the Arctic Ocean. Sea ice has thinned by up to 65% since 1975 in the Arctic Ocean.

(Source: www.flickr.com/photos/wasifmalik)

Increased extreme weather

There has been an increase in **extreme weather events,** which is evidence that the climate is changing.

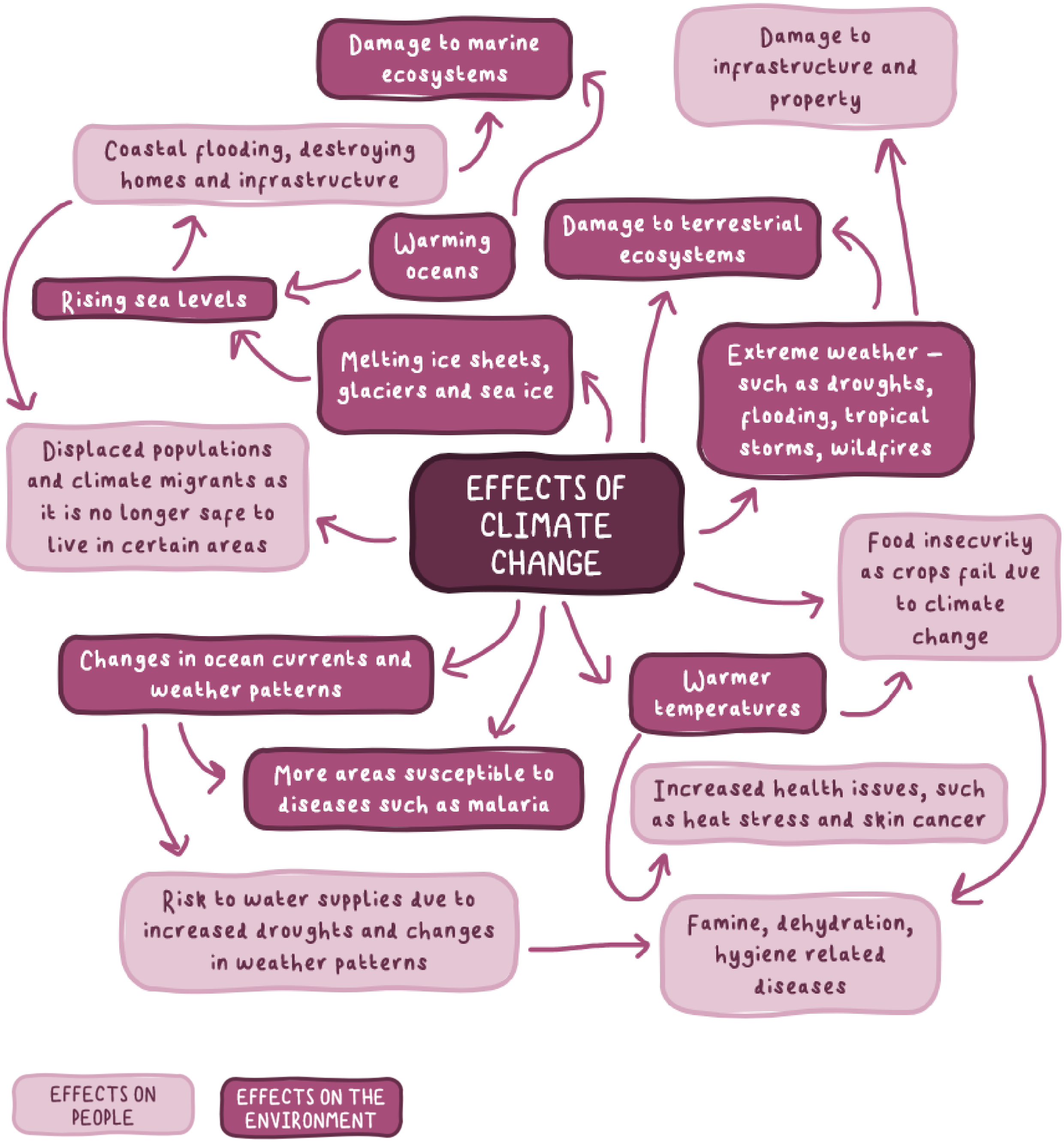
Nine out of ten of the warmest years on record have occurred in the 21st century. Prolonged periods of **hot, dry weather** are becoming more common in parts of the world. **Precipitation** is also becoming **more intense**, increasing **flooding risk**.

Tropical storms are becoming more **intense**, and **forest fires** are happening more frequently, which is thought to be because of the changing climate.

Effects of Climate Change

There are many potential **consequences** of climate change on the **population**, including issues with **food**, **water**, and **land availability**.

Below are some examples of these effects. Many are **interlinked** and **related** to each other, and many **environmental effects** can cause **human effects**.



The UK's Climate

The UK has a **temperate, oceanic** climate:

- A **temperate** climate has seasons (summer, winter, autumn) where the weather patterns and temperatures vary.
- Since the UK is surrounded by bodies of water - The North Sea, for example - can affect daily temperature changes and weather patterns. This is an **oceanic** climate.

Even though the UK's weather changes daily, the climate follows a similar pattern each year.

- High levels of **rainfall**
- Warm temperatures during the **summer,** colder temperatures during the **winter**
- Many **depressions** each year, bringing heavy rainfall, flooding and sometimes snow.
- Very rare to experience **extreme weather hazards** (hurricanes, droughts, tornados, etc)

Source: Manchester Evening News

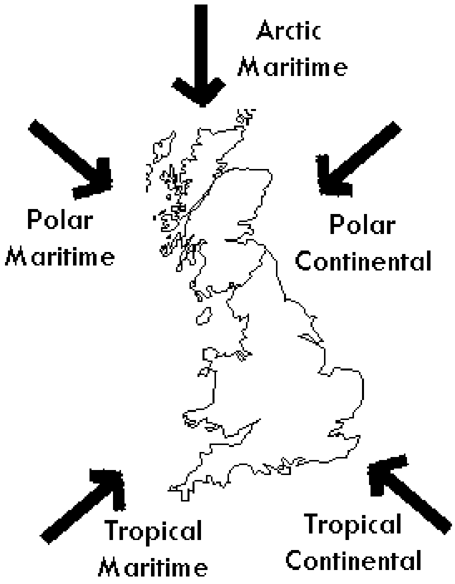
Due to the UK's **latitude** - the height above the equator - the country's weather is affected by **air masses** from different regions:

→ **Maritime** - Being next to an ocean stops a country from changing temperature really quickly, since you can't heat up a vast volume of water quickly. This means the UK has mild temperatures and a small range of temperatures.

→ **Polar & Arctic** - This air mass brings cold temperatures and low levels of rainfall.

→ **Tropical** - Warm temperatures can bring summery weather and limited cloud cover.

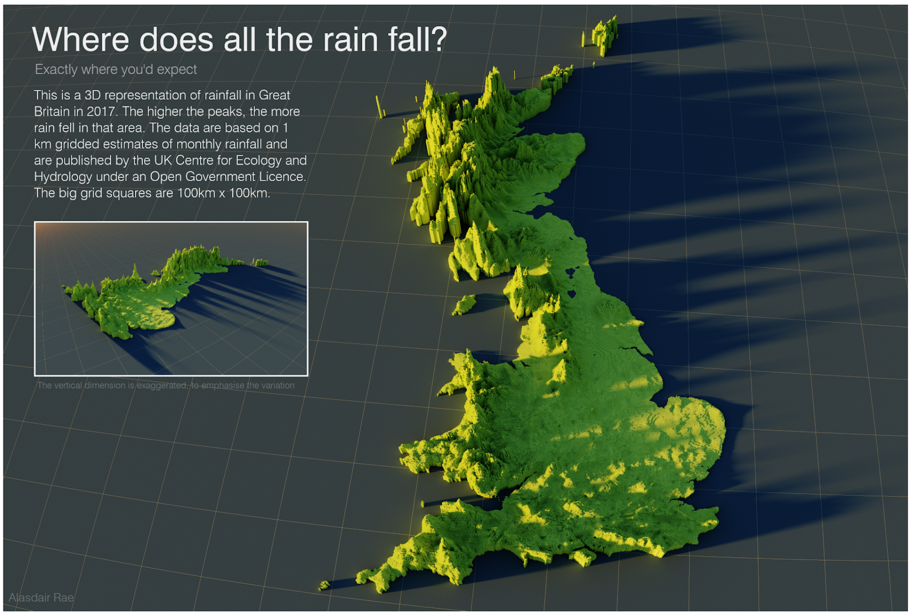
The **boundary** between warm and cold air masses will cause rainy weather, which is called a **depression**. This weather can change in the space of days.



Source: Blogspot

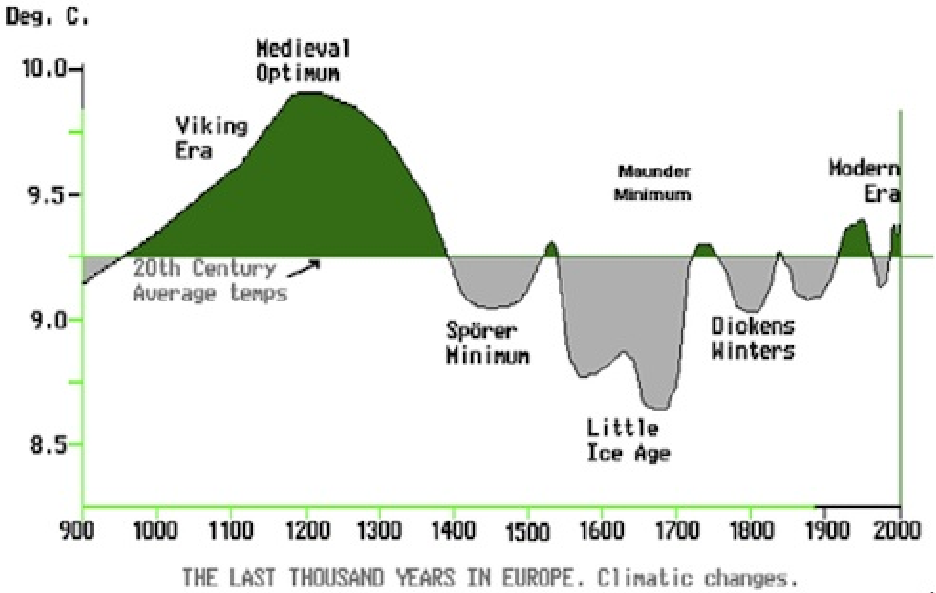
An **anticyclone** brings settled weather conditions - constant temperatures, little cloud cover and limited rainfall - whether that's cold or warm! These weather conditions can last weeks!

The map below shows **average rainfall levels in Britain**. The areas with **high peaks** are areas that receive more rainfall. Notice high rainfall in the **uplands**, such as the Scottish Highlands, the Lake District, the Pennines, and parts of Wales (Cambrian Mountains), and low rainfall in the lowlands.



(Source: http://www.statsmapsnpix.com/2020/08/rain-shadow-maps.html)

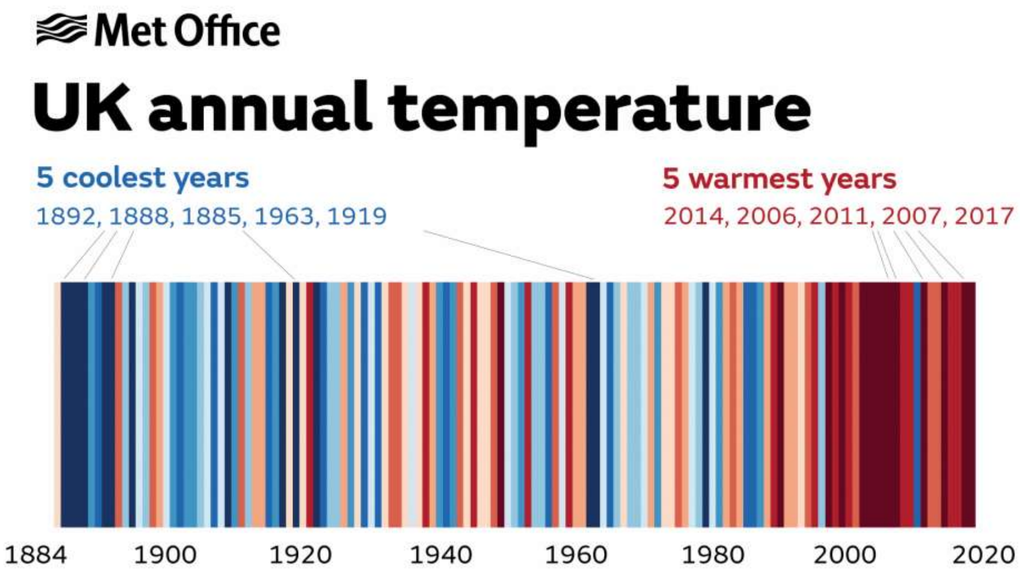
Over the last 1,000 years (a decade) the UK's climate has varied:



Source: The Register

In the last decade, the average temperature has risen and dipped many times. The average temperature increased during the **Medieval Optimum**, which will have impacted vegetation growth. This change in climate will have been noticed by farmers as the **warmer average temperatures** may have resulted in larger **crop yields** & longer **growing seasons**.

More recently, the temperatures appear to have dipped during the **Maunder Minimum** & **Little Ice Age**. The Maunder Minimum may have been a drop in average temperatures due to **low Sun activity**, which would have reduced the amount of radiation received by the land. Scientists were able to record past temperature trends - such as the Little Ice Age - using **ice cores** and **tree rings**.



Within the last 100 years, the UK's average temperatures have been **increasing**. This is likely due to the **Enhanced Greenhouse Effect**. In the future, we can expect to see:

- **Hotter** summers & more frequent anticyclone droughts
- **Milder and wetter** winters - more rain, less snow!
- More **frequent** meteorological hazards (depressions are now being named because we receive so many each year).


Source: The Standard, Dawn

Tropical Storms

What is a Tropical Storm?

A tropical storm is a **very large**, spinning storm that forms in the **tropics**.

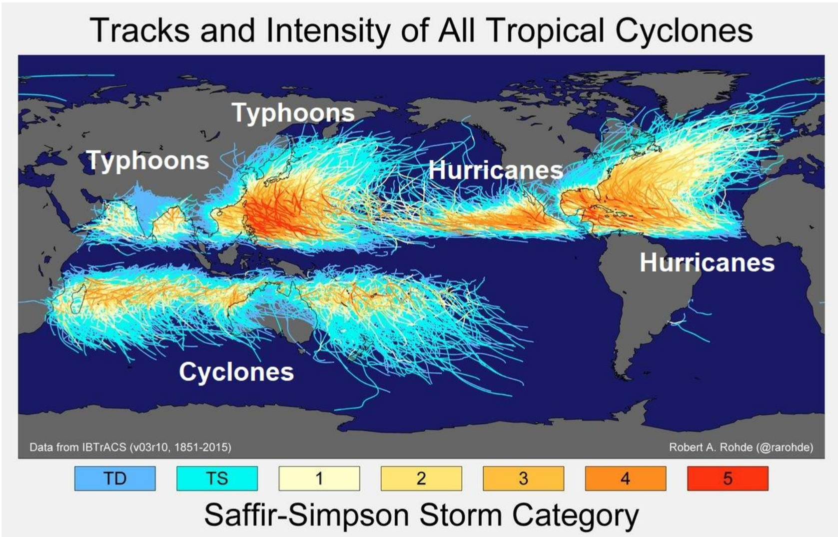
Tropical storms have **high winds** and **torrential rain**, and usually affect **small islands** and **coastal regions**.

Hurricane Florence (2018) from the International Space Station.

Global Distribution of Tropical Storms

Tropical storms are called different things in different regions:

- **Hurricane:** In the **USA** and **Latin America/The Caribbean**
- **Cyclone: Australia (Oceania)** and **Madagascar**
- **Typhoon: India**, **Japan** and **the Philippines**



Causes of Tropical Storms

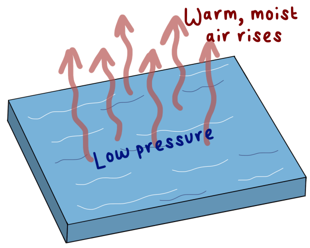
Tropical storms need **very specific conditions** to form, meaning they will only form in **certain areas.** Tropical storms form between **5-15° north or south of the equator**, in warm oceans.

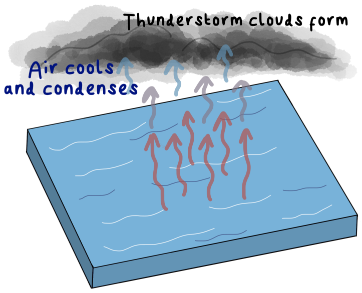
- **Temperature:** Ocean temperatures must be around **26 - 27°C** and at least 50 metres deep. Warm water provides the storm with **energy**. This is why storms form during late summer, when the ocean has had time to heat up.
- **Air pressure:** Must be in areas of **unstable air pressure** - usually where areas of **high pressure** and **low pressure** meet - so that warm air rises more readily and clouds can form (this air must also be humid for cloud formation). Warm air rises because it is **less dense** than cold air.
- **Wind shear:** Winds must be present for the **swirling motion** to form, but not too strong or the storm system will be **ripped apart** in the early stages.
- **Rotation:** Tropical storms only form around the equator, between 5-15° either side of the equator, but tropical storms **will not form on the equator**. The **Coriolis Effect** is the effect of the **Earth's rotation** on weather events. The storm spins because the Earth is spinning; but there is **no Coriolis Effect at the equator**, hence why these storms will only form a certain distance away from it.

Tropical Storm Formation

1

Warm, moist air rises, leaving an area of **low pressure below**. This causes warm air from the surroundings to **move into this low pressure area** and rise too. Overall, **warm air is constantly rising** and accumulating in the atmosphere.



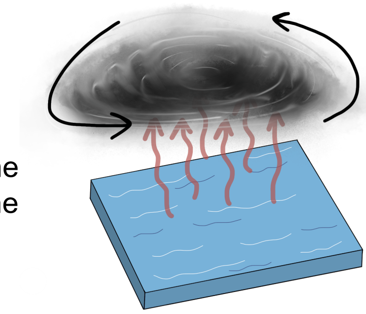


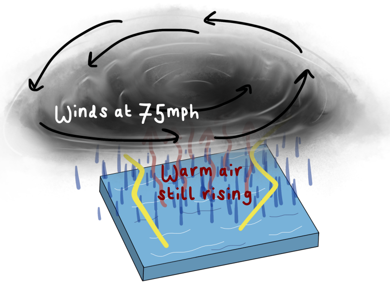
2

When the warm air rises, it eventually **cools**. This moist air will then **condense** and form large **thunderstorm clouds**.

3

The whole system is spinning due to the **Coriolis effect**. In the **southern** hemisphere, the storms spin **clockwise**; in the **northern**, **anticlockwise**.





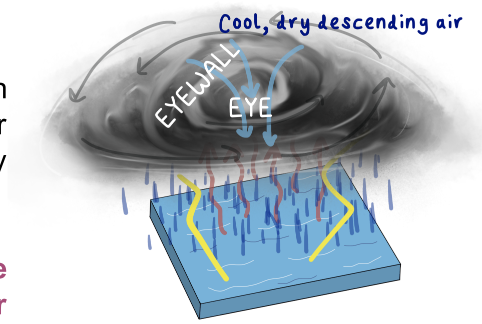
4

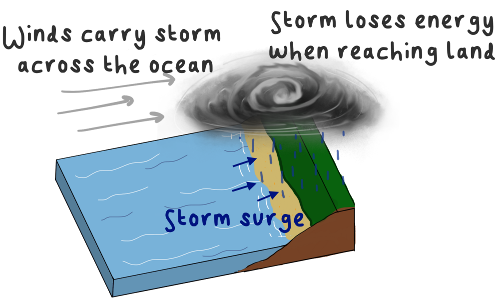
The **constant additions of energy** from the warm air causes the storm to spin faster and generate higher wind speeds. At **75 mph** the storm can be classed as a category 1 **tropical storm**.

5

The storm develops an **eye** in the centre. This is an area of **extremely low pressure** where cool, dry air descends. The weather within the eye is relatively **calm and cloud free**.

Surrounding the eye is the **eyewall**, the most **intense and powerful** area of the storm. **Warm, moist air rapidly rises** here, with extremely **high winds and torrential rain**.



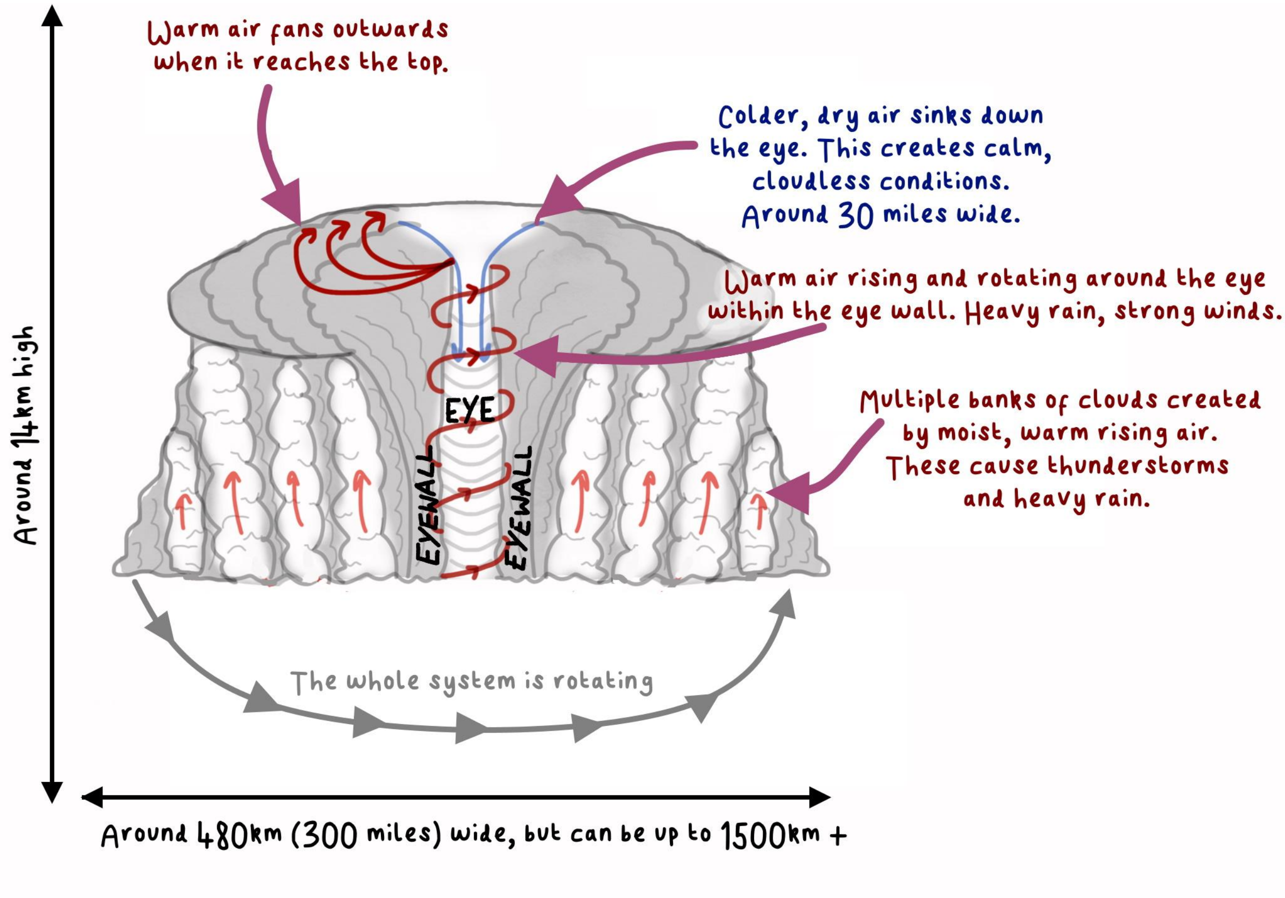


When the tropical storm reaches a coast, the **low pressure and high winds** will cause a large amount of sea water to be pushed onto the coast, which is called a **storm surge**.

When the storm reaches **land**, it no longer has a **supply of energy** (warm, moist air from the sea) and the eye eventually **collapses** and the storm **dissipates**. Heavy rain can persist for days.

Tropical Storm Structure

There are **complicated processes** going on **inside a tropical storm**. Below is a **cross-section of a tropical storm** (imagine if you cut a tropical storm in half and looked in the middle).



There is a huge contrast between **weather conditions** in the **eye** and in the **eyewall:**

- The eye: the eye is characterised by very **calm and cloudless conditions**. Inside the eye there is **extremely low pressure** (can be 15% lower pressure than areas outside of the storm).
- The eyewall: within the eyewall are the **strongest winds, thunder and lightning, and torrential rain**. In very intense storms, **sustained winds** can reach **240km/hour** (150mph), and **gusts** can exceed **320km/hour** (200mph).

The Effects of Climate Change on Tropical Storms

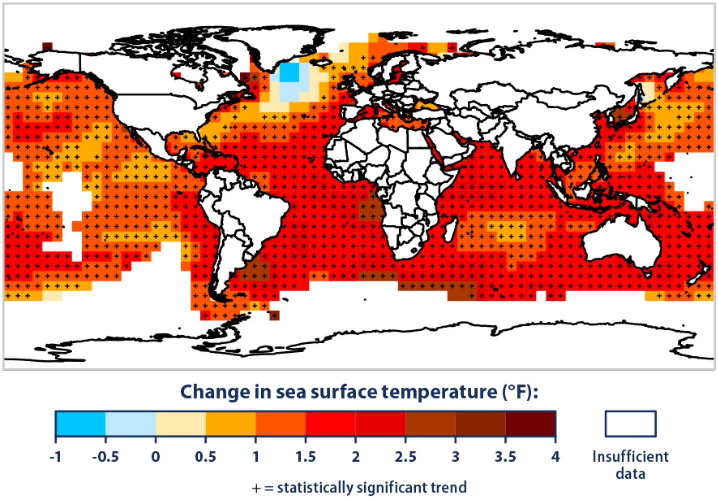
Tropical storms rely on **heat from the ocean** to develop. With **global sea surface temperatures rising**, scientists are researching how the **patterns** of **tropical storms** may be affected.

Distribution

Distribution refers to **where the tropical storms are formed**, and where they **move to**.

As **sea surface temperatures are rising** in areas where tropical storms **are not usually active**, tropical storms could potentially form **in these areas** in the future. The sea may be **warm enough** to provide **enough energy to form a tropical storm**.

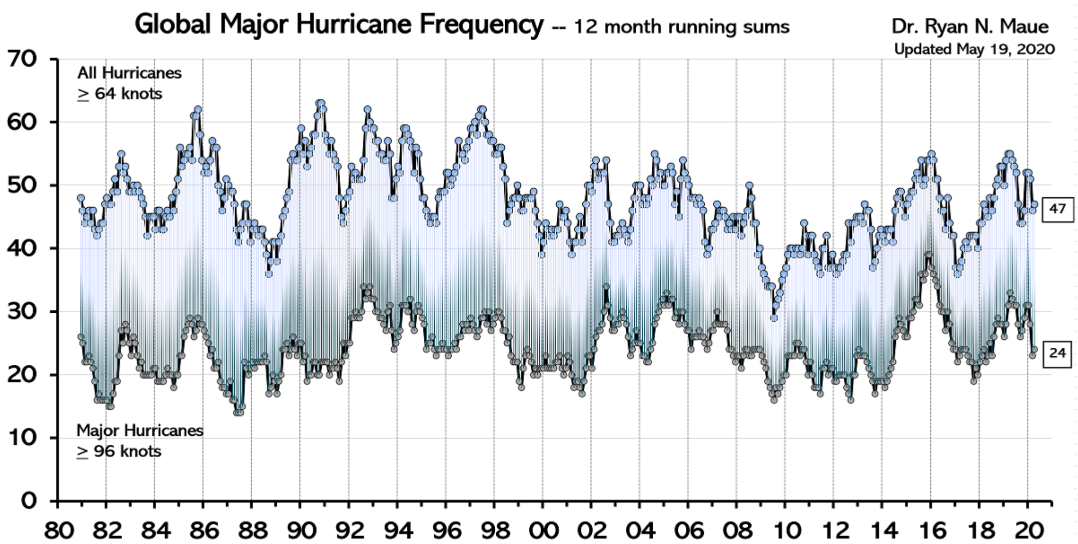
For example, in 2004, **Hurricane Catarina** hit the south-east coast of **Brazil**, which had never been struck by a tropical storm before. Sea surface temperatures were **higher than average** that year, meaning this tropical storm was able to form in the South Atlantic. With sea surface temperatures rising in the majority of places, the locations that tropical storms **typically develop** may **expand** to other regions.



(Source: https://www.epa.gov/climate-indicators/climate-change-indicators-sea-surface-temperature)

Frequency

Frequency refers to the **number of tropical storms**.



(Source: http://climatlas.com/tropical/)

Studies have shown that climate change has **not** increased the **frequency of tropical storms**. In all regions that experience tropical storms, there has been **no significant increase** in recent decades. Some studies indicate there may even be a **decrease** in the frequency of tropical storms.

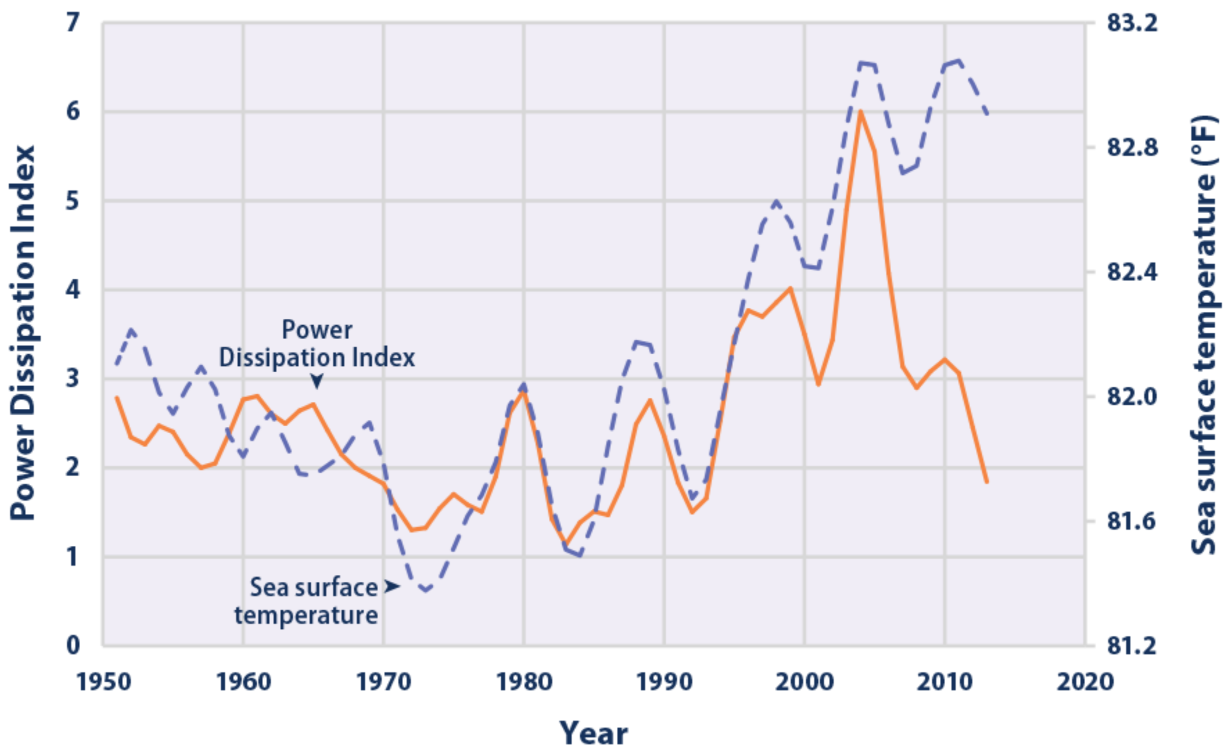
Intensity

The **intensity** of a tropical storm is how **much power** the tropical storm has (e.g. its wind speed) which is measured using a scale of 1-5. Category 1 is the lowest intensity, Category 5 is the highest intensity.

There is significant evidence to suggest that **the intensity of tropical storms** has been increasing in recent years due to **climate change**.

Below is a graph showing the relationship between the average **Power Dissipation Index** of tropical storms compared with **sea surface temperatures**. It appears that as sea surface temperatures rise, the intensity of tropical storms are rising also.

An increase in the number of Category 4 and Category 5 hurricanes is **likely in the future**, and wind speeds of the average tropical storms are projected to increase by **up to 10%** in the future.



(Source: www.epa.gov/climate-indicators/climate-change-indicators-tropical-cyclone-activity)

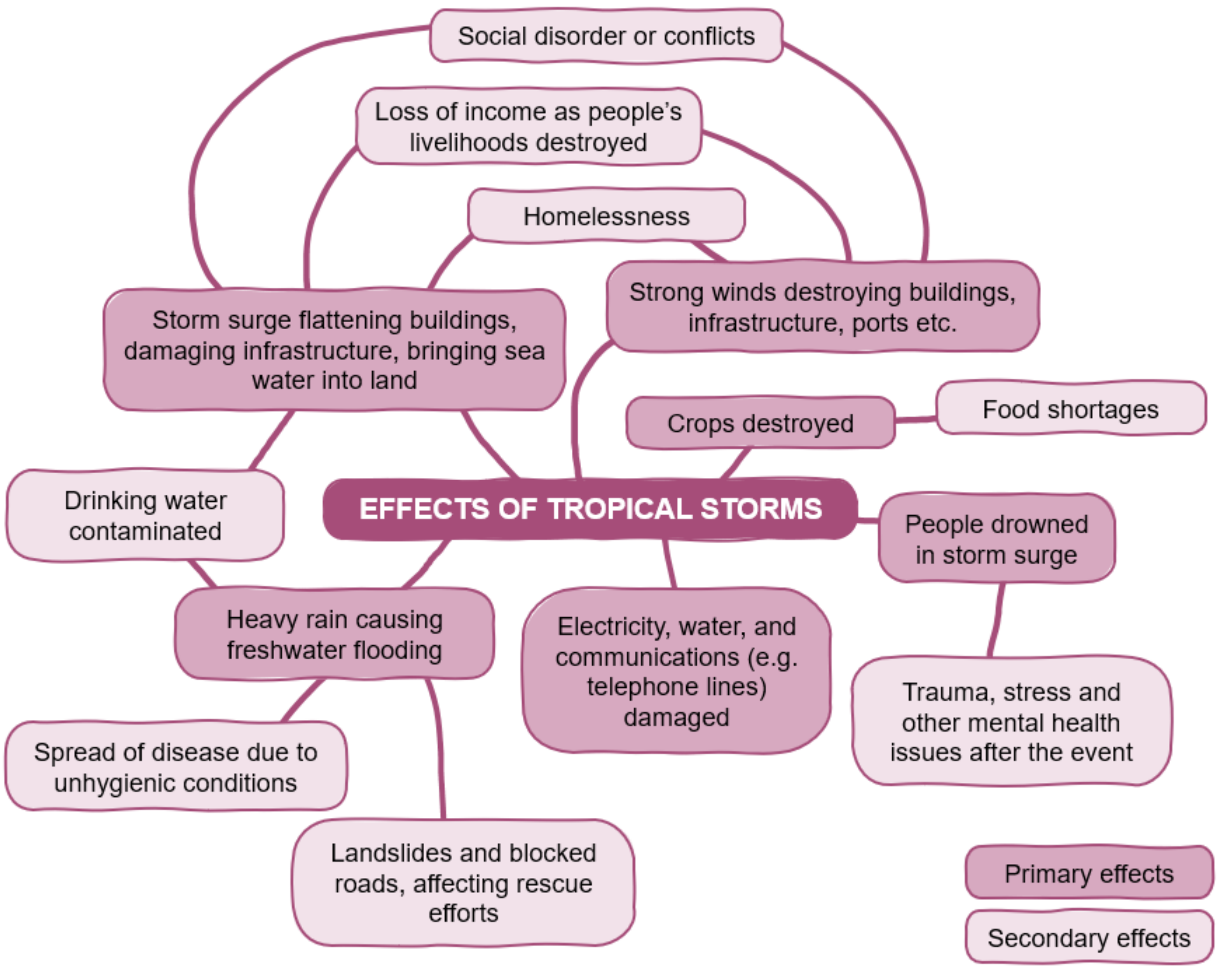
Power Dissipation Index (PDI): A measure of a tropical storm's **intensity**. PDI accounts for a tropical storm's **strength**, **duration** and **frequency**. The points on the graph are a **five year average**.

Effects of Tropical Storms

Tropical storms can be very damaging to **people, the environment, and the economy**. Like with **tectonic hazards** (3.1.1.2) the effects of a tropical storm can be divided into **primary effects** and **secondary effects**.

Primary effects: The effects that are **directly caused by the tropical storm** itself. For example, strong winds knocking over power lines.

Secondary effects: The effects that are a **result of the primary effects**. For example, landslides caused by the flooding.



The devastation of **Typhoon Haiyan**, a Category 5 tropical storm that hit the **Philippines** in **2013**. Pictured is the city of **Tacloban**, on the Philippine island of Leyte, after the typhoon hit.

(Source: Tigeryan—iStock/Thinkstock)

Drought

Drought is a period of **low water availability**, caused for a number of reasons. The most common is a **meteorological drought**; a drought that has been caused by a **lack of precipitation** and high temperatures, leading to **increased evaporation**. However, drought can be caused by human activities which decrease the volume of clean freshwater available:

- **Agriculture** - The demand for freshwater for farming is too high, causing the levels of water moisture in the soil to decrease. This may be due to **over-extraction** for **irrigation** or planting **water-intensive crops** (such as rice, soya or cotton).

- **Pollution** - By polluting clean water storages (lakes, reservoirs, etc) with **litter, sewage or chemicals**, the amount of clean water for domestic use will decrease. This may lead to families drinking dirty water or walking further to find clean water stores.

Polluted Water (Source: The Statesmen)

- **Affordability** - In some countries, there is limited fresh water available. The government may look to increase the amount of water available to residents, but that may increase the **price** of water. **Low economic groups** may not be able to afford clean water, leading to inequality in who can afford water and therefore who has better health.

- **Hydrological Drought** - Having **impermeable surfaces** (such as concrete and tarmac) will reduce the rate of **infiltration** of rainfall into the soil. The soil is a store of water and will lengthen time taken for rainfall to reach the river. Usually, the slower the rainfall takes, the more reliable the source of water is and the less likely it is for flash flooding to occur. Tarmac surfaces will increase the risk of **flash flooding** and speed up the time taken for water to run out of an area.

A dam. (Source: ND Daily)

Other reasons for a drought include:

- **Building a dam** along a river, which will reduce the water available to villages and towns in the lower course of the river.

- **Deforestation** is the reduction of trees and vegetation from an area. The fewer the number of trees, the less water can become trapped in leaves or taken up by roots, and so the quicker the rainfall will leave the area.

Some **environments** are more prone to drought than others, and some environments have adapted to a low availability of water. Drought in different countries will be different, so make sure to compare each country to its **normal conditions**. For example, a drought in the UK may last for **weeks** and lead to dying grass; whereas a drought in Kenya only occurs when **farm crops die** out and fail causing **famine**, and this type of drought can last for years.

Characteristics of Arid Environment	Characteristics of a Drought
 Source: Water World	 *Source: Sky News*
Low **vegetation**, but plants and animals have **adapted** to a lack of water. **Seasonal fluctuations** in the drought season and rainy season. Sometimes rivers may flow for certain months of a year.	A **random deficit** in rainfall and a drop in rivers and lakes that doesn't follow a regular pattern. Vegetation won't be adapted to the dry conditions and so may **wither or die** during this drought.

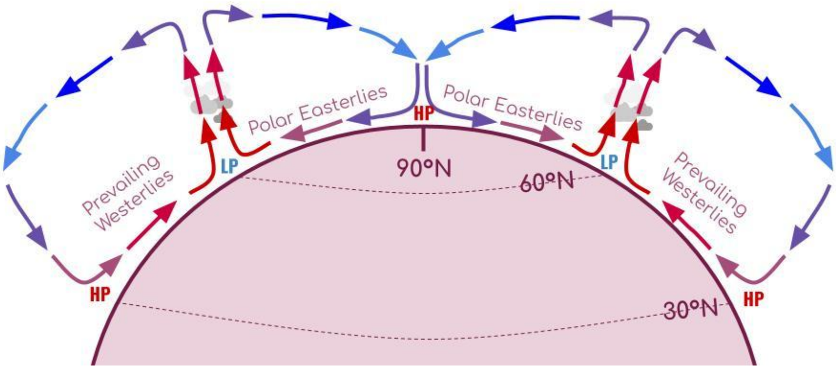
Why might some countries suffer from droughts more than others?

A country's **location** can have a large effect on the frequency of droughts. This is due to the **global circulation patterns**. Sometimes, circulation patterns can change and the location of flows of air shift. This can cause **unusual changes** to a region's climate.

Low Rainfall (arid) areas.

If a region is described as **arid**, it means that area receives **very little rain**, causing it to be **dry**.

Dry air sinks at the subtropics (around 30°), meaning it forms an area of **high pressure**. **Clouds do not form here** because the air isn't rising, so it is very **dry**. This is where we find many of the world's **deserts**.



Dangerous Droughts

Droughts can be **hazardous** to communities and species who live in these **environments**. The range of risks can vary in how dangerous they are and how long a drought needs to be before causing this impact. Below is a scale showing the **severity** of these impacts:

Banned Activities

In developed countries, short-term drought may be managed by banning certain ***domestic activities*** *such as using hosepipes, filling swimming pools and washing cars.*

This may be annoying but this will conserve reservoir water for drinking and essential use

Conflict

Disagreements over water supplies can lead to conflict. Conflict can include ***arguments*** *between local governments but this can escalate to* ***physical conflict****.*

Water may be the cause of many conflicts between countries that share a river or water source in the future.

Water Borne Diseases

If the amount of clean water available decreases, the risk of water-borne infection increases. Water-borne diseases are illnesses caused by ***bacteria*** *multiplying in the water supply.*

When drunk, this contaminated water may cause diarrhea, cholera or fever.

This can be fatal for children and young children.

Wildfires

As vegetation dies and the soil becomes increasingly dry, the risk of ***wildfires*** *will increase. A wildfire is a fire that can burn vegetation and the ground underneath, leading to migration away.*

Wildfires can destroy fragile habitats and property, which you may not be able to replace.

Agriculture Failures

With decreased levels of water moisture in the soil, farmers may be worried that their crops don't have enough water to grow or that their livestock is at a risk of ***heatstroke****.*

Smaller harvests may mean the price of food increases

Drought longer than a few months can lead to long-term food shortages, which will reduce life expectancy for a country