Edexcel IAL Geography

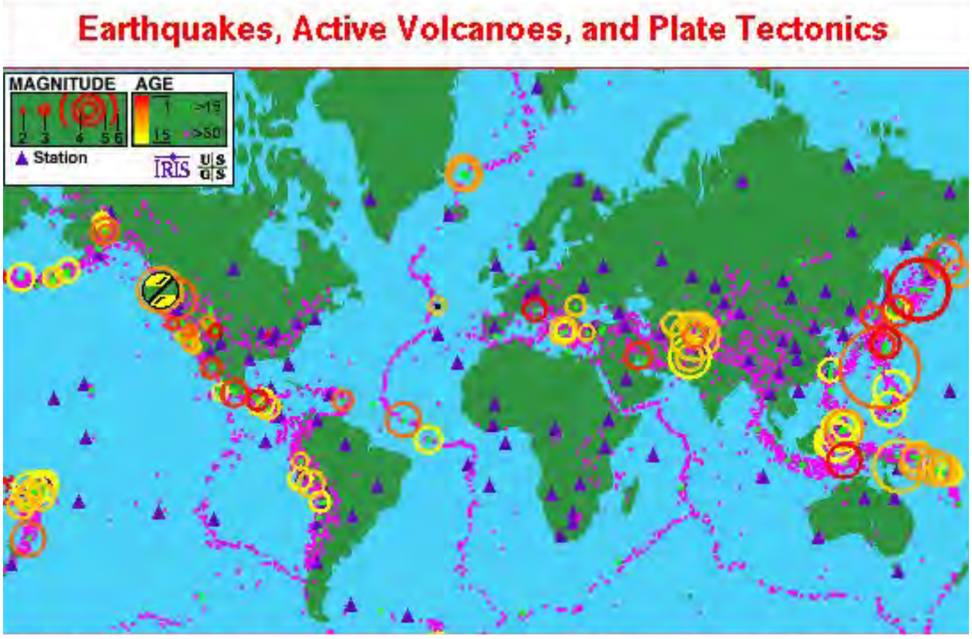
World at Risk

Detailed Notes

The Global Distribution of Hazards

- A **hazard** is a potential threat to human life and property.
- A natural hazard can be either **hydro-meteorological** (caused by climatic processes) or **geophysical** (caused by land processes).

Location of Geophysical Hazards



- Geophysical hazards occur **near plate boundaries**. These plates move at different speeds and directions which can cause collisions, earthquakes and volcanic activity as shown in the map above.

- Earthquakes can also occur near the middle of plates (called **intra-plate**). The causes of this are not fully understood but it is assumed that plates have **pre-existing weaknesses** which become reactivated, forming seismic waves. For example, an intraplate earthquake may occur if solid crust, which has weakened over time, cracks under pressure.

- **Volcanic hotspots** can also situated amongst the centre of pates. This is a **localised area of the lithosphere** (Earth's crust and upper mantle) which has an unusually high temperature due to the upwelling of hot molten material from the core. (First theorised by **Tuzo Wilson** in 1963)

- At hotspots, such as the Hawaii hotspot, **magma** rises as plume (hot rock). Usually, the most powerful earthquakes occur at **convergent or conservative** boundaries.

Location of Hydrometeorological Hazards

- Hydrometeorological hazards are **more common** than geophysical hazards. They can occur anywhere.
- **Hurricanes** tend to affect coastal settlements along **warm bodies of oceans** (Pacific Ocean, Atlantic Ocean near the Equator).
- **Flooding** will occur more often for retreating coastlines, rivers with rapid hydrographs and melting glaciers. **Droughts** tend to occur in Saharan or Semi-Arid climates, where water

availability is limited. Droughts can also be caused by long-period **anticyclones**, where high rates of evaporation will increase water stress.

➔ Occasionally, a geophysical hazard may cause a hydrometeorological hazards. For example, a volcano may superheat a local glacier, causing a **Jokulhlaup**.

Types of Hazards

Causes of Geophysical Hazards - Plate Movement

At plate boundaries, different plates can either move **towards each other** (**destructive** plate margin), **away from each other** (**constructive** plate margin), or **parallel** to each other (**conservative** plate margin). Different landforms are created in these different interactions. This spider diagram outlines what landforms and processes occur at the boundaries.

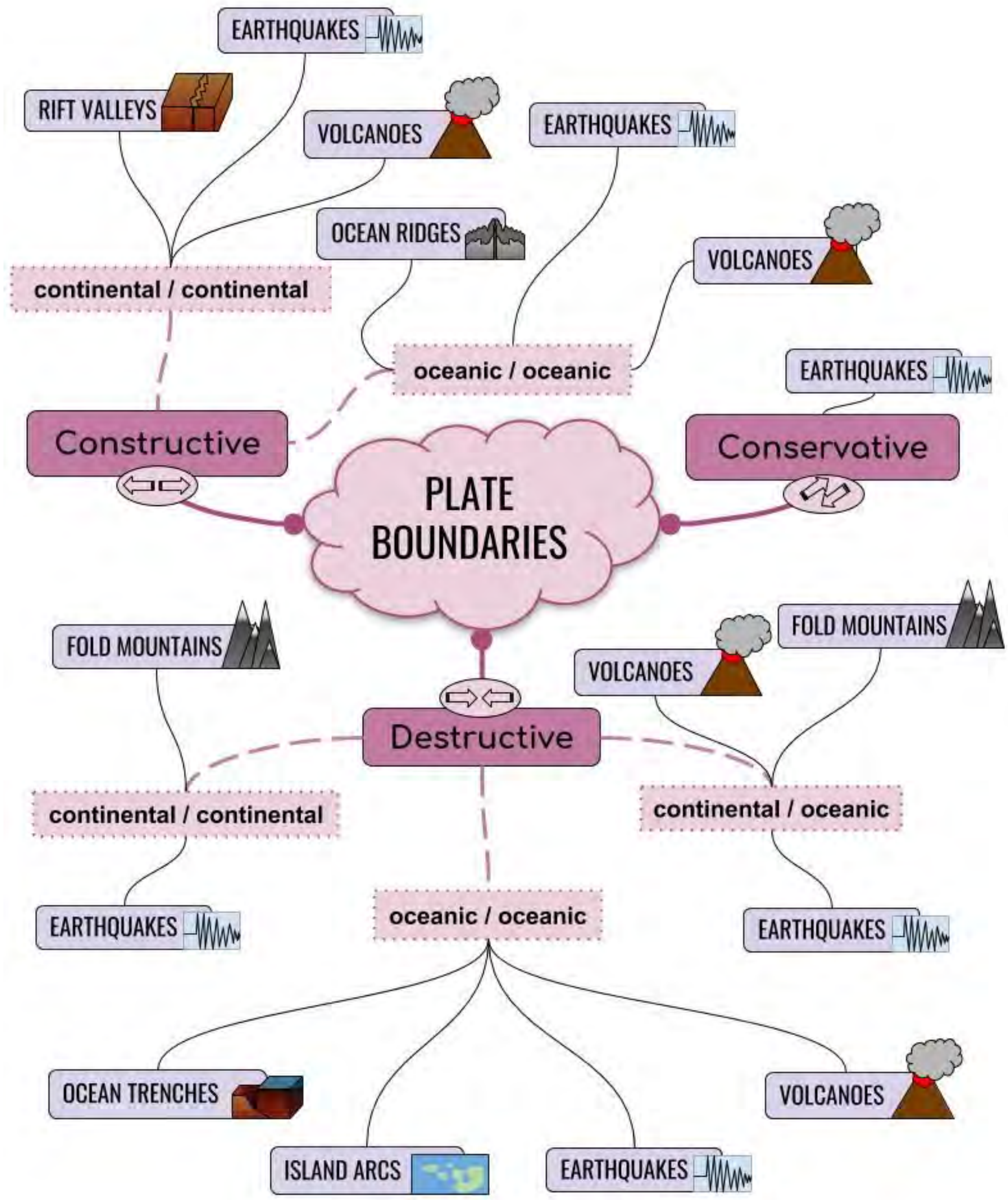


Plate Boundaries

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<tr><th colspan="2">Destructive plate boundaries</th></tr>
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Continental and oceanic:

- Denser oceanic plate **subducts** below the continental.
- The plate subducting leaves a deep **ocean trench**.
- The oceanic crust is melted as it subducts into the asthenosphere.
- The extra magma created causes **pressure** to build up.
- Pressurised magma forces through weak areas in the continental plate
- Explosive, high pressure volcanoes erupt through the continental plate, known as **composite volcanoes**.
- **Fold mountains** occur when sediment is pushed upwards during subduction.

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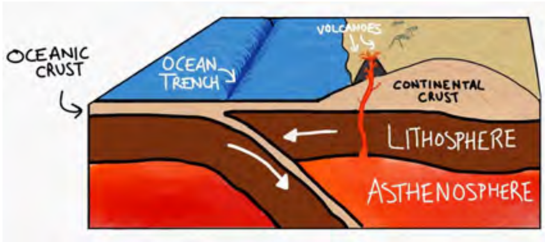

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Oceanic and oceanic:

- Heavier plate **subducts** leaving an ocean trench. Fold mountains will also occur.
- Built up pressure causes **underwater volcanoes** bursting through oceanic plate.
- Lava cools and creates new land called **island arcs**.

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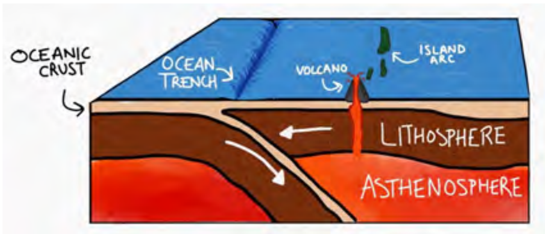

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Continental and continental:

- Both plates are not as dense as oceanic so lots of **pressure builds.**
- Ancient oceanic crust is subducted slightly, but there is **no subduction of continental crust.**
- **Pile up** of continental crust on top of lithosphere due to pressure between plates.
- **Fold mountains** formed from piles of continental crust.

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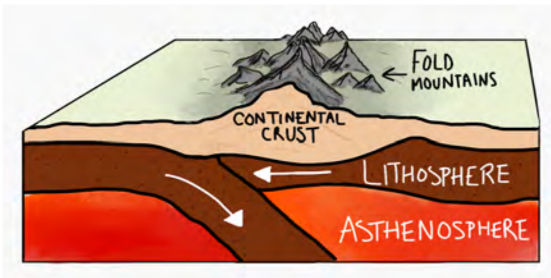

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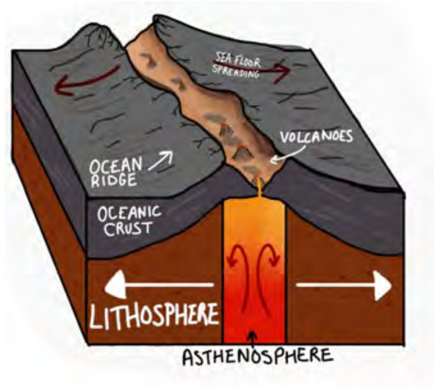
Constructive plate boundaries

Oceanic and oceanic:

- Magma rises in between the **gap left by the two plates separating**, forming new land when it cools.
- Less explosive underwater volcanoes formed as magma rises.
- **New land** forming on the ocean floor by lava filling the gaps is known as **sea floor spreading** (as the floor spreads and gets wider).

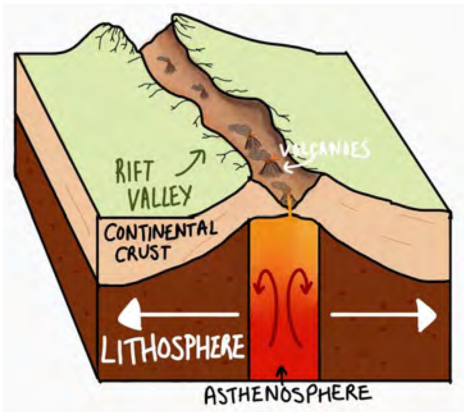


Evidence

There is sufficient evidence to prove plate movement, and **seafloor spreading** (theorised by **Harry Hess** in the 1940s) provides some of this proof. **Paleomagnetism** is the study of rocks that show the magnetic fields of the Earth. As new rock is formed and cools the magnetic grains within the rock align with the magnetic poles. Our poles (North and South) **switch** periodically. Each time these switch the new rocks being formed at plate boundaries **align in the opposite direction** to the older rock. On the ocean floor either side of constructive plate boundaries, Geologists observed that there are **symmetrical bands** of rock with **alternating bands of magnetic polarity**. This is evidence of seafloor spreading.

Continental to continental:

- Any land in the middle of the separation is forced apart, causing a **rift valley**.
- Volcanoes form where the magma rises.
- Eventually the gap will most likely fill with water and separate completely from the main island.
- The lifted areas of rocks are known as **horsts** whereas the valley itself is known as a **graben**.



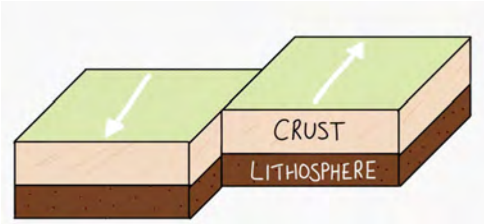
There are further forces influencing how convergent boundaries occur -

Ridge push:

The **slope** created when plates move apart has **gravity acting upon it** as it is at a **higher elevation**. Gravity pushes the plates further away, widening the gap (as this movement is influenced by gravity, it is known as **gravitational sliding**).

Slab pull:

When a plate **subducts**, the plate sinking into the mantle **pulls the rest of the plate** (slab) with it, causing further subduction.

Conservative plate boundary	
Between any crust, the **parallel plates** move in **different directions** or at **different speeds**. No plates are destroyed so no landforms are created. When these plates move, a lot of pressure is built up. On oceanic crust, this movement can displace a lot of water. On continental crust, **fault lines** can occur where the ground is cracked by the movement.	

Types of Geophysical Hazards

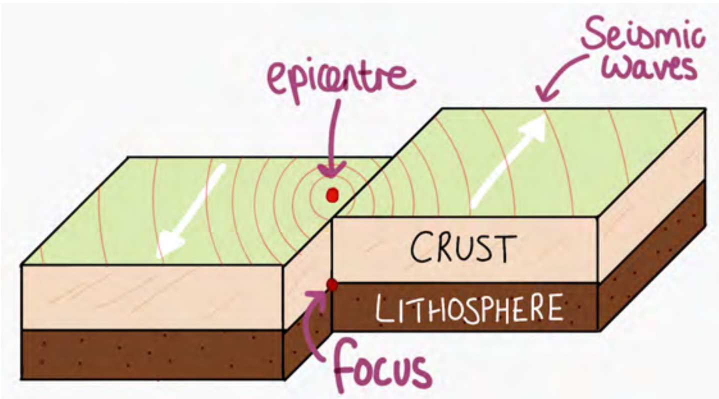
Earthquakes:

Plates do not perfectly fit into each other, meaning they do not move in **fluid** motions. At all boundaries, plates can become stuck due to the **friction between plates**.

You can try this by moving **one palm** of your hand **against the other**, and it is clear that at some points there is more friction between irregularities and bumps, causing the hands to become stuck slightly.

When the plates are stuck, the **convection currents** in the asthenosphere continue to push, which builds the pressure. It builds so much that it cannot be sustained and the plates eventually **give way**. All of this pressure is released in a sudden movement, causing a **jolting motion** in the plates. This jolt is responsible for **seismic** movement spreading throughout the ground in the form of **seismic waves** (or shock waves).

The **focus** (or hypocentre) is the point underground where the earthquake originates from. The **epicentre** is the area above ground that is **directly above** the focus.



Seismic Waves

Primary -Travels through solids -Compressional -Vibrates in the direction of travel - Travels at 4-8 km/s	**Secondary** -Vibrate at right angles to direction of travel -Travels only through solid rocks -Travels at 2.5 - 4 km/hr
Love -Near to ground surface -Rolling motion producing vertical ground movement -Travels at 2-6 km/hr	**Rayleigh** -Vertical and horizontal displacement -Travels at 1-5 km/hr -Compressional

Secondary and Love waves are the most destructive as they have **large amplitudes**. Due to their different speeds, these different waves will hit a location at different times. The **aftershocks** that survivors feel are these different types of waves arriving after each other.

Intensity of waves will **decrease further from the epicentre**, as waves lose energy as they travel. However, this does not mean that impacts felt or damage caused will always decrease further from the epicentre as other factors affect a location's **vulnerability:** geology, geographical location (whether the earthquake occurs near the sea or intraplate), education of locals, durability of buildings, mitigation.

Secondary Hazards of Earthquakes

Soil Liquefaction

- Affects poorly compacted sand and silt.
- Water moisture within the soil separates from the soil particles and rises to the surface.
- This can cause the soil to behave like a liquid, which can cause building subsidence or landslides.

Landslides

- The shaking caused by the earthquake can weaken or damage cliff faces, hills and snow material.
- Unconsolidated material or loose rocks can collapse.
- Landslides can travel several miles and accumulate material on the way.
- Risk varies with topography rainfall, soil and land use.

Volcanoes

Primary hazards, caused directly from the volcano, tend to have a **fast speed of onset**:

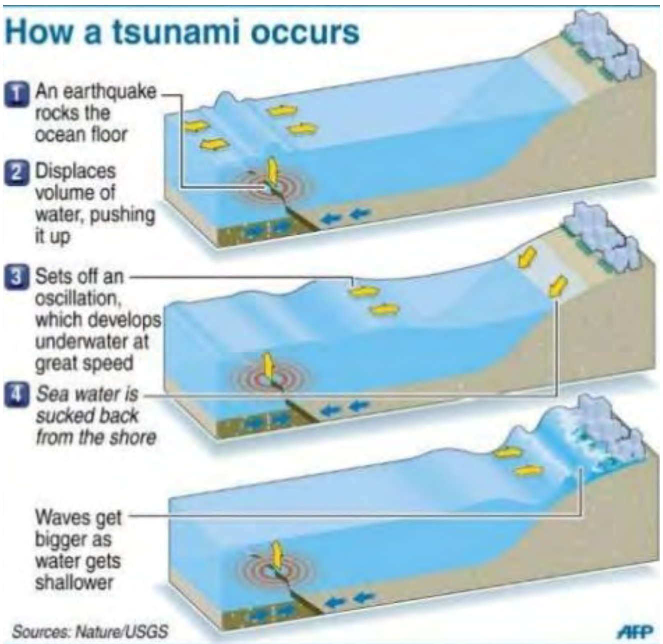
- **Lava flows** – Streams of lava that have erupted onto the Earth's surface. Fast flowing lava can be very dangerous which depends on the lava's **viscosity** (the explosivity and viscosity depends on **silicon dioxide** content)
- **Pyroclastic flows** – This is a mixture of hot dense rock, lava, ash and gases which move very quickly along the surface of the Earth. Due to their **high speeds**, pyroclastic flows are extremely dangerous and can cause **asphyxiation** for anyone unfortunately caught by the flow.
- **Tephra and ash flows** – When pieces of volcanic rock and ash are blasted into the air. This can cause serious **damage to buildings**, which can collapse under the weight of ash or tephra.
- **Volcanic gases** – Gases like **sulphur dioxide** and **carbon monoxide** are released into the atmosphere. Due to their potency, volcanic gases can travel long distances.

Secondary hazards occur as a result of the heat produced by the volcano:

- **Lahars** – Combination of **rock, mud and water** which travel quickly down the sides of volcanoes. These can occur when the heat of the eruption causes snow and ice to melt or alternatively when an eruption coincides with heavy rainfall.
- **Jokulhlaup** – Snow and ice in glaciers melt after an eruption which causes **sudden floods** that are very dangerous .
- **Acid rain** - caused when gases such as **sulfur dioxide** are released into the atmosphere.

Tsunamis:

- When an oceanic crust is jolted during an earthquake, all of the water above this plate is **displaced**, normally upwards
- This water is then pulled back down due to gravity. The energy is transferred into the water and travels through it like a wave.
- The water travels fast but with a low **amplitude** (height).
- As it gets closer to the coast, the sea level decreases so there is friction between the sea bed and the waves.
- This causes the waves to slow down and gain height, creating a wall of water that is on average 10 feet high, but can reach 100 feet.

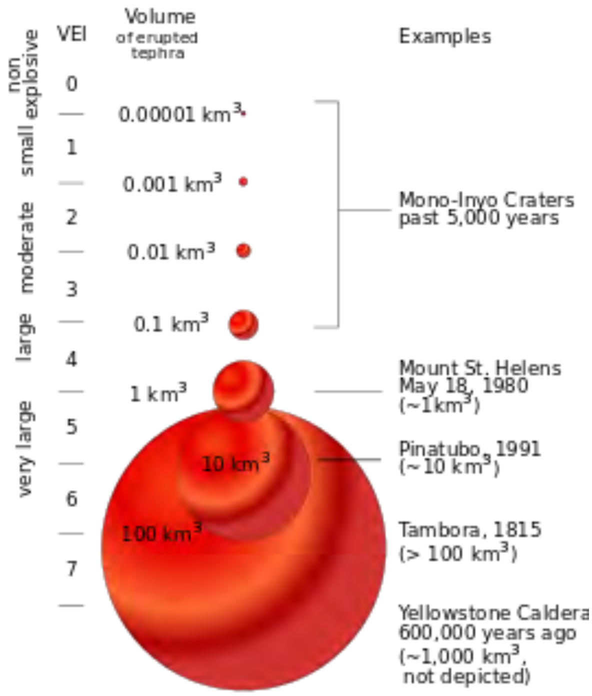


Tsunamis are generated generally in **subduction zones** at convergent plate margins. Most tsunamis are found along the Pacific ring of fire, hence the most vulnerable countries are often located in Asia or Oceania.

Measuring Geophysical Hazards:

Volcanic Explosivity Index (VEI)

- Measures the **relative explosiveness** of a volcanic eruption.
- Based on the **height** of ejected material and **duration** of eruption.
- Scale goes from 0-8 and is **logarithmic** (increase of 1 on the scale indicated a 10 times more powerful eruption).



Moment Magnitude Scale

- Measures the amount of **energy** released in an earthquake.
- Scale from 0-9.
- It's a **simple** measure, so environmental or social impacts must be inferred.

Factors affecting Geophysical Hazards

The severity of a geophysical hazard can be affected by **human and physical causes**: the built and natural environment, mitigation strategies, population resilience.

Human Factors	Physical Factors
• **Mitigation** - Hard or soft engineering will dissipate a hazard's effects differently, with different effects. For example, tsunami walls are effective in protecting assets from waves, but may increase coastal erosion. • **Population Density** - The higher the density of people living within an area, the longer evacuation may take, it's easier for disease to spread between households (a common secondary impact) and the more people displaced if buildings or infrastructure are destroyed. • **Level of Development** - MEDCs have wealth and technology to reduce the lives lost during a hazard: evacuation systems, education and training. • **Architecture** - Unstable buildings will collapse, causing the death of anyone unable to evacuate. Aseismic designs will reduce the risk of collapse during an earthquake, whereas buildings with supported roofs to avoid collapse due to ash during a volcano.	• **Morphology of the Coastline** - low lying bays will funnel and amplify tsunami waves. The gradient of the continental shelf will affect the height of tsunami waves. • **Geology** - softer sediments be more prone to liquefaction, which can cause subsidence and building collapse. • **Natural Characteristics of Hazard** - the magnitude, proximity to settlements, the time of the hazard (at night, fewer people can respond) all affect the scale of a disaster. • **Characteristics of Magma** - The higher the viscosity, the more resistance magma will feel whilst moving, therefore the more pressure that will build up during an eruption. Also, the silicon dioxide content of the magma will affect the explosivity of an eruption. • **Climate** - If a hazard occurs in cold environments (e.g. tundra), secondary hazards such as avalanches and jokulhlaups are more likely to occur.

Types of Hydro-Meteorological Hazards

Flooding:

Flooding tends to occurs at two common locations: on the **banks of a river** and at the coast during **storm surges**. There are several causes of flooding:

1. During a **low-pressure weather system** (tropical cyclone, depression), low pressure can displace a volume of seawater upwards. This will cause **storm surges** - repeated waves that increase in height on the approach to the shoreline and can travel far inland.
2. A **large volume of rainfall** over a prolonged amount of time will cause the ground to become **saturated**, meaning further rainfall is more likely to flow as **surface runoff**. Surface runoff is the fastest transfer of water into a river, so the river can rapidly increase in volume.

If the river is **narrow** or becoming filled (therefore **reducing channel capacity**), flooding is likely to occur in the plains surrounding.

3. In climates prone to snow (e.g. Tundra), sudden **snowmelt** will cause flooding. This may be due to glaciers melting due to a volcano (**jokulhlaup**) or naturally melting, but meltwater becomes trapped behind a thin barrier that will break under pressure (**Glacial Outburst Floods**).

Factors Affecting Flooding:

- **Impermeable rocks** like granite which encourage rapid surface runoff.
- **Relief** can reduce the time taken for water to travel to the river channel. High and steep slopes → More runoff
- Intense **storm precipitation** or **rapid snowmelt** can create an influx of water, which exceeds the infiltration capacity of soil.
- Low density **vegetation**, therefore less interception and plant uptake, so more rapid movement of water
- **Human activities** can increase the risk of flooding:
  - **Urbanisation** - More concrete surfaces and impermeable materials built with, so less water can infiltrate the ground.
  - **Deforestation** - Reduced vegetation and trees, therefore reduced uptake through plants' photosynthesis and so more water runs directly into the river causing flash flooding.

Droughts:

An **imbalance** in inputs and outputs of water can have serious implications for the hydrological cycle. A **deficit** (more commonly known as a **drought**) refers to when input is less than output. This deficit can be caused by natural and/or human factors.

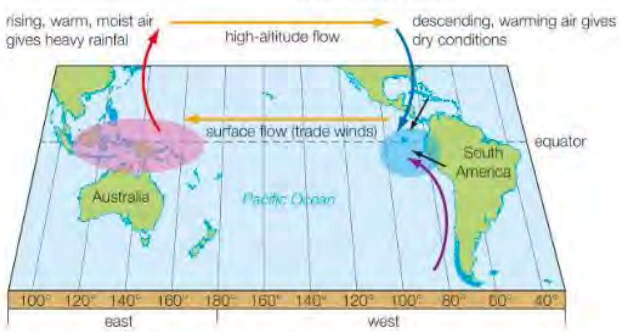
Types of droughts and their characteristics		
Features		Impacts
Meteorological Drought	**Rainfall deficit** Low precipitation High temperatures Strong winds Increased solar radiation Reduced snow cover	Loss of soil moisture Irrigation supply drops Reduction in water available for consumption.
Hydrological Drought	**Stream flow deficit** Reduced infiltration Low soil moisture Little percolation and groundwater recharge	Reduced storage in lakes and reservoirs Less water for urban supply Poorer water quality Threats to wetlands and habitats

Agricultural Drought	**Soil moisture deficit** Low evapotranspiration Reduced biomass Fall in groundwater level	Poor yields from rainfed crops Failing irrigation systems Livestock productivity falls Rural industries affected Government aid may be required
Socio-Economic Drought	**Food deficit** Loss of vegetation Increased risk of wildfires Soil erosion Desertification	Widespread failure of agricultural systems Food shortages Rural economy collapses Rural to urban migration International aid required Humanitarian crisis

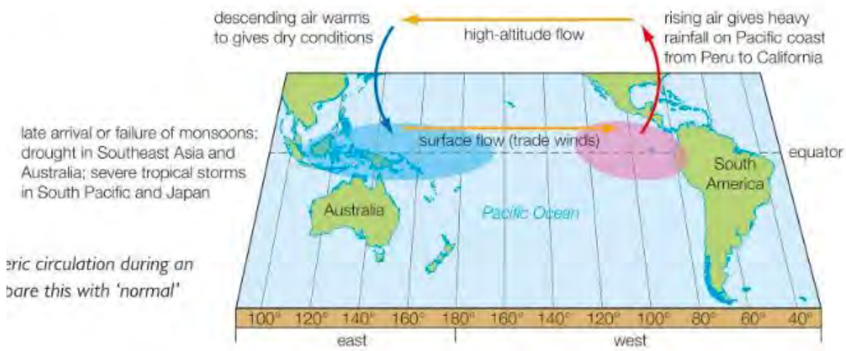
ENSO Cycles:

El Nino Southern Oscillations are the **change** in water body patterns within the Southern hemisphere, leading to unusual weather conditions. The causes of El Nino aren't fully understood.

- Normally cool water is found along the Peruvian coast, and warm waters are found around Australia.
- ENSO causes this to switch (Peru gets warm waters, whereas Australia get cold water) and usually occurs every 3 to 7 years, generally lasting for 18 months.
- Peruvians can determine ENSOs occurrence based on their **anchovy** harvest - anchovies prefer cold waters, therefore as the water warms up (due to El Nino) the anchovies will migrate away, causing a reduction in Peruvian harvest.
  - ENSO can also trigger **extremely dry conditions** in areas South and South-East Asia, Eastern Australia and North-East Brazil. In South Asia, ENSO can **weaken the annual monsoon**.



The conditions before and during El Nino



Measuring Hydrometeorological Hazards

Flood Discharge:

- The **volume of water** that passes a particular area per second.
- Often measured in cubic metres per second (m^3s^{-1})
- Discharge can indicate changes to **patterns in precipitation** or changes to the **river's channel capacity**, as well as measuring the **severity of a flood**.

Saffir-Simpson

- Measures the severity of a **tropical cyclone**
- Scale 1-5, where 1 is a weak hurricane and 5 is a major hurricane.
- The **wind speed** is the factor to measure. Low wind speeds tend to be low energetic cyclones, so little damage is caused.

Other Hazards - Landslides and Avalanches

Landslides and avalanches are **uncontrollable** slumps of rock, sediment and snow down a hill. They are **complex processes** and hard to describe. However, they are commonly caused by geophysical and hydrometeorological hazards:

Geophysical: **Seismic activity** and tremors can trigger the fall of unstable material. The vibrations of loose sediment can also cause **liquefaction**, which can also promote landslides. **Stratovolcanoes** typically cause landslides in the surrounding areas.

Hydrometeorological: **Intense rainfall** will saturate the ground and reduce friction between rocks. **Chemical weathering** (i.e. acid rain) will weaken boulders, and without the support of roots to bind the soil together, landslides will occur.

Avalanches specifically occur in tundra or glacial climates, and are the same principles of a landslide.

Landslides and avalanches can be very **destructive**:

- Loss of **infrastructure** and damage to buildings in their path.
- **Loss of Life** - If individuals become caught in the snow or debris, they may suffocate and die.
- **Reduces the value of the land**, due to the risk to life and debris will reduce its ability for agriculture or industrial use.
- If a landslide occurs near a river, the **natural flow** may become blocked by debris. This can cause flooding or starve wildlife further down the river as water becomes displaced.

Factors Influencing Hydrometeorological Hazards

Physical Factors	Human Factors
• **Location of Hazard** - if there are many islands in the path of a tropical cyclone, the system will lose energy and so be less destructive. • **Weather Conditions** - If a hazard occurs after previous rainfall, the ground is likely to be saturated and so flooding is more likely to occur and storm surges will travel further inland. • **Drainage Basin** - The permeability of the soil and rock, the size and relief of the basin and the number of tributaries (small streams that will merge into a river) all affect the speed of water passing through groundwater stores and the risk of flooding for the river.	• **Mitigation** - Storm surge barriers, hurricane shelters, growing drought-resilient crops, smart irrigation will all reduce the severity of a hydrometeorological hazard. • **Development** - The wealth of a country or community will determine whether they can afford mitigation strategies or insurance to avoid economic and physical loss. • **Deforestation** - The loss of trees and vegetation will reduce the lag time between precipitation and reaching the river, which can increase the risk of flooding. • **Monitoring of Hazards** - Tropical cyclone tracking and accurate precipitation predictions will allow for efficient preparations. However, only countries that are technologically advanced will monitor hazards.

Disaster, Risk and Severity of Natural Hazards

Disaster – A serious disruption of the functioning of a community or society involving human, material, economic and environmental losses which exceed the ability of the affected community or society to cope using its own resources.

The **risk** a community faces from a natural hazard can be calculated from the equation below.

$$\text{Risk (R)} = \frac{\text{Hazard (H)} \times \text{Vulnerability (V)}}{\text{Capacity to cope (C)}}$$

How **developed** a country is significantly affects how **resilient** its population is and their **capacity to cope** with a hazard.

A place may be at high risk if:

- Their **capacity to cope** is low - limited warning, infrastructure or mitigation are available to protect people at risk.
- They are quite **vulnerable** - whether they have little training or knowledge of the hazard, or live in an environmentally vulnerable location.

- The **hazard** itself is severe - high magnitude, large aerial extent, fast speed of onset, long duration.

Measuring the Severity of a Disaster:

There are many ways to measure a disaster, using simple measures or indices:

➔ **Fatalities** - The number of people killed by a hazard or the secondary hazards immediately affected.
➔ **Economic Loss** - The value of assets and property destroyed, the loss of economic productivity in the days following and during evacuation, the value of insurance claims to be made.

To compare disasters, many use **hazard profiling** to compare similar characteristics, including:

- Speed of Onset
- Economic Loss
- Magnitude
- Frequency
- Fatalities
- Aerial Extent
- Spatial Predictability
- Duration

The impacts of a natural hazard have changed over time. Nowadays, countries have **fewer fatalities** (due to improved technology and knowledge), **larger populations affected** (as more people live in hazardous locations) and **increased economic loss** (due to more people buying insurance).

Tectonic Mega-Disasters

- Large scale disaster affecting a **large spatial areas** or **large population.**
- They pose problems in effective management to minimise the impacts.
- The scale of the impact may require **international support and aid.**
- Mega Disasters are **low probability** (rare).

The globalisation of production and supply chains has allowed **international businesses** to reduce costs and become more efficient. However, mega-disasters significantly damage globalised businesses.

There are many different examples of business disruption by mega-disasters:

- **2011 Tohoku earthquake and tsunami** - There was a knock on effect for TNCs such as Toyota and BMW which operate and source products from Japan. This lost potential revenue for those TNCs and caused general economic uncertainty.
- **2011 Eyjafjallajökull eruption** - The significant ash cloud closed European air space, which lead to the halt of goods and trade into the EU by air. This resulted in Kenyan flowers (to be imported into the EU) couldn't be transported and wilted.
- **2005 Hurricane Katrina** - Causing $108 billion damage and flooding the Gulf Coast and New Orleans, this category 4 hurricane has been the most destructive in US history. Many

political initiatives have been made since, to try to reduce the impact of future storms such as improving evacuation plans for non-English speaking or disabled residents.

Multiple Hazard Zones

There are certain countries that are at risk from multiple geophysical and hydro-meteorological hazards, which are called **Multiple Hazard Zones**.

Due to the sheer number of hazards present, a multiple hazard zone may have **limited development**:

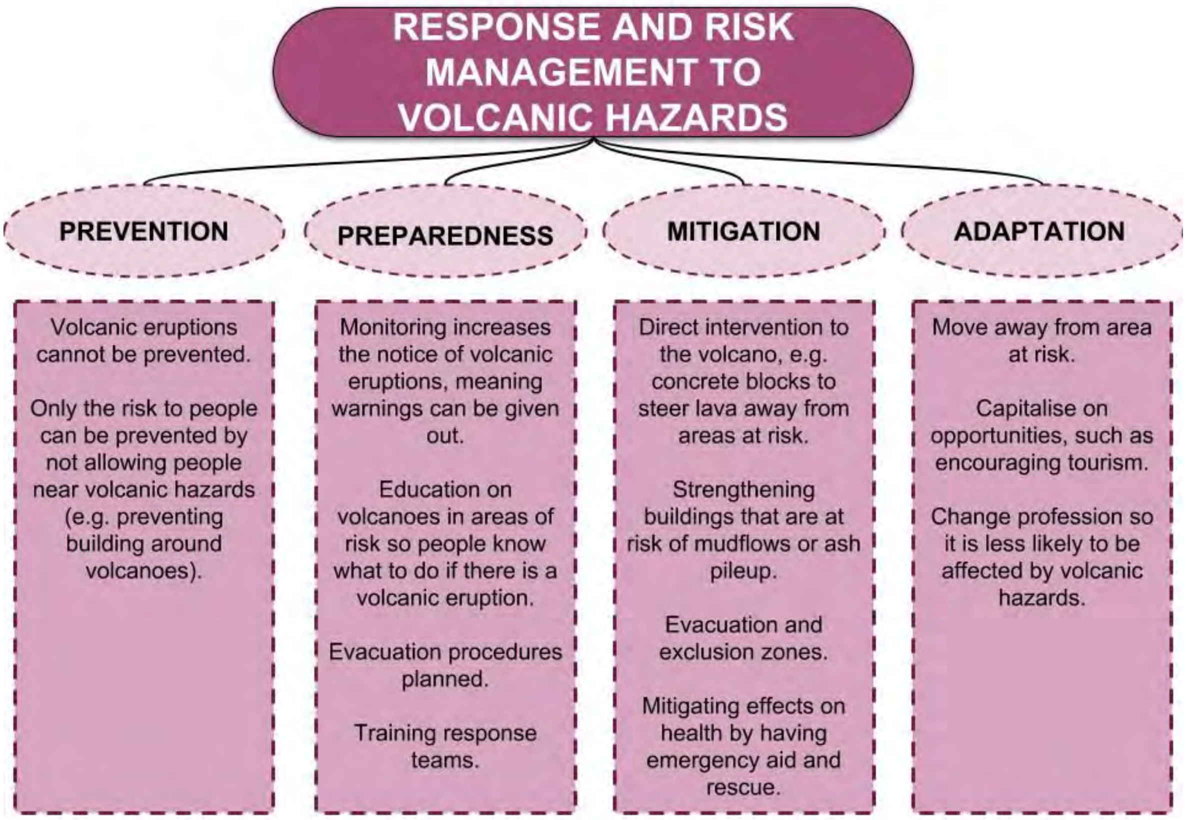
- ➔ **Weak infrastructure** as it is vulnerable to damage and can be expensive to constantly replace.
- ➔ Economic **pressure on health** services, as repeated hazards may cause repeated injuries or multiple disease outbreaks (in the aftermath).
- ➔ **Population migration** away to avoid risk to life.

However, some multiple hazard zones may thrive due to increased **tourist and geological interest**. The revenue created by tourism can fund mitigation and education, and so the local population becomes less vulnerable.

Multiple Hazard Zones include: The Philippines, Haiti, New Zealand.

Managing Hazards

Hazards can be responded to by **preventing** them directly, being **prepared** for the next hazard, **mitigating** the effects, or completely **adapting** your lifestyle to limit the hazard's effects. This is shown below in the **Response and Risk Assessment** of volcanic eruptions:



Monitoring and Prediction:

It is not possible for us to **predict accurately** when an earthquake will happen; instead, the risk of an earthquake can be **forecast** based on a statistical likelihood. Forecasts can be based on data and evidence gathered through **global seismic monitoring** networks and also from **historical records**.

Scientists can sometimes predict volcanic eruptions with some degree of **accuracy**. Scientists can use special equipment to monitor volcanoes and detect signs of imminent eruption:

- Small earthquakes - called **tremors**
- Changes to the **top surface** of the volcano as it swells when magma builds up
- Changes to the **tilt** as the slope angle changes when magma builds up

Mitigation:
Mitigation identifies the **characteristics** of the potential hazard and what can be done to reduce **their impact** on people, such as:

- Land use zoning
- Building codes and regulations.
- Protective defences (tsunami wall)

Preparedness:
Preparedness involves minimising loss of life and property

- Developing preparation plans
- Developing warning systems
- Stockpiling medicines, food, water etc.
- Education, training, drill

Response:
Coping with a disaster, the main aims would be to rescue people and reduce economic losses:

- Search and rescue efforts
- Evacuating people
- Restoring vital infrastructure like water and electricity
- Restoring vital services like law enforcement and health care

Management Approaches

There are **three** different approaches to managing a tectonic hazard and reducing their impact: **Modify the Event, Modify the Vulnerability, Modify the Loss**.

Modify the Event

We cannot control seismic activity. However, we can control the **design of buildings** (said to be the biggest **killer** during a natural disaster) through civil engineering using micro and macro methods.
Micro → Strengthening individual buildings and structures
Macro → Large scale support and protective measures designed to protect whole communities

Type of modification	Advantages	Disadvantages
Land use zoning Preventing building on low lying areas and areas of high risk	Low cost Reduces vulnerability	Stops economic development on some high value land Strict enforcement required
Resistant buildings Buildings with deep foundations, sloped roofs so that ash doesn't build and create pressure	Can help prevent collapsing Protects people and property	High cost for larger buildings Low income families cannot afford this
Tsunami/Storm Surge defences Sea walls which stop waves travelling inland	Reduces damage Provides security	Very high cost Doesn't look nice Can be overtopped
Lava diversion Barriers and water cooling to divert and slow down lava flow	Diverts lava away Low cost	Only works for low VEI lava

Modify the Vulnerability

Type of modification	Advantages	Disadvantages
Hi Tech Scientific Monitoring Monitors volcano behaviour and predict eruptions	Predicting eruption is possible in some cases Warning and evacuation can help save lives	Costly, in LDCs, volcanoes aren't usually monitored Doesn't prevent property damage
Community Preparedness and Education	Low cost and often implemented by NGOs Can save lives through small actions	Doesn't prevent property damage Harder to implement in isolated rural areas
Adaptation Moving out of harm's way and relocation	Helps save lives and property	High population densities prevent it Disrupts people's traditional home and traditions

Modify the Loss

Modification + Example	Advantages	Disadvantages
Short term aid Search and rescue and also food, water, aid and shelter	Can help reduce death toll by saving lives and keeping people alive until long term aid is provided	High costs and technical difficulties in isolated areas Emergency services are limited and are poorly equipped in LDC
Long term aid Reconstructions plant to rebuild an area and improve resilience	Reconstruction can help improve resilience through land use planning and better construction methods	Very high costs Needs are quickly forgotten by the media shortly are the disaster
Insurance Compensation to replace losses	Allows people to recover economically for paying reconstruction	Doesn't help save lives Not many in LDCs have insurance

Global Climate and Temperatures

The earth has experienced many periods in which temperatures were **much colder** than they are currently. Aside from an ice age around 300 million years ago, the most recent major **ice age** occurred in the **Pleistocene era**. The period spanned from around 2.5 million years ago to 11,700 years ago.

During this ice age, there were many **fluctuations** in global temperatures:

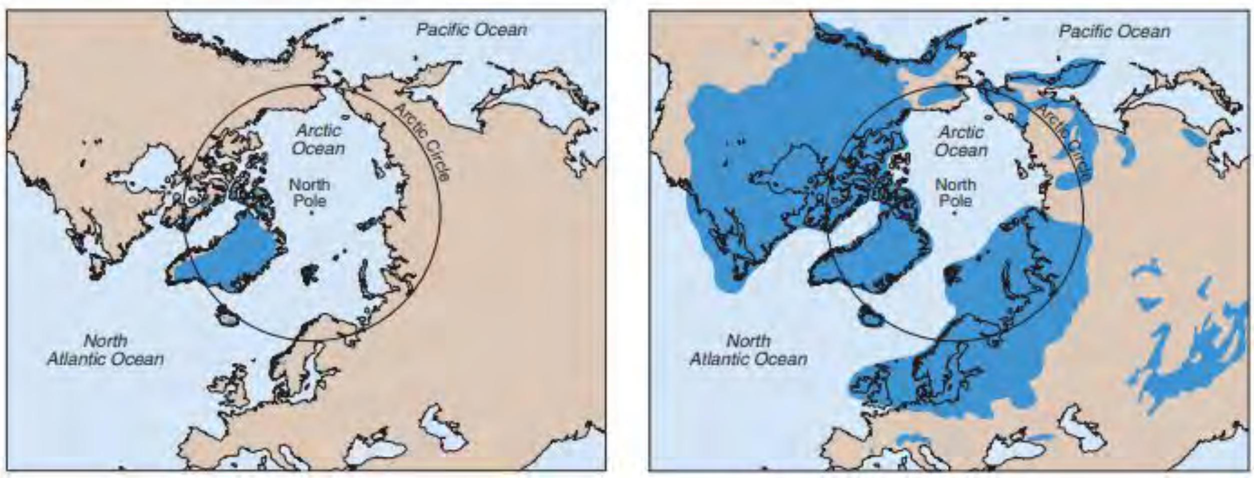
- **Glacial** period: **colder** temperatures, causing glacial **advances** and sea levels to fall.
- **Interglacial** period: **warmer** temperatures, causing glacial **retreats** and sea levels to rise.

The most recent period of glacial advance (**Last Glacial Maximum**) was around **21,000 years ago**, and the present distribution of cold environments is much more isolated in comparison to this period.

This interactive timeline outlines global temperature trends since the last **glacial maximum**.
(https://www.iflscience.com/environment/this-temperature-timeline-of-earth-shows-exactly-how-nonsensical-climatechange-deniers-really-are/)

A much larger area of the northern hemisphere was completely covered by ice, including the majority of the UK.

Present distribution of ice sheets. Last glacial maximum distribution of ice sheets.



Source: http://www.open.edu/openlearn/ocw/pluginfile.php/614637/mod_resource/content/1/e500_11_sci_sk1_05t.pdf

Evidence for Changing Climates:

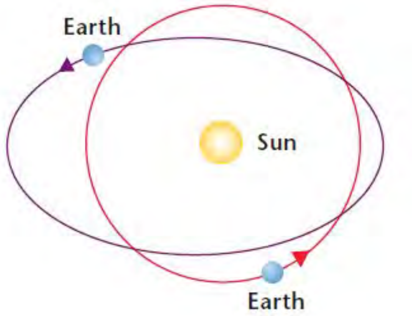
There is evidence for the change between glacial and interglacial climates across history:

1. **Tree Rings** - A tree's rings are determined by the climate it grows in; if a tree grows in fertile soils during a warm period of time, then its ring for the year will be wider. By taking a segment of an old tree, scientists can determine the climate conditions for each year.

2. **Ice Cores** - As glaciers build in the Arctic and Antarctic, air pockets may form, trapping the atmosphere conditions of that time. Scientists can determine the composition of greenhouse gases in the atmosphere in the past, and so determine the climate of the Earth at that time.
3. **Pollen** - The distribution of pollen across the plant indicates past distributions of plant growth. Since different plants can only grow in particular climates, pollen can be used to determine previous climates for a particular region.

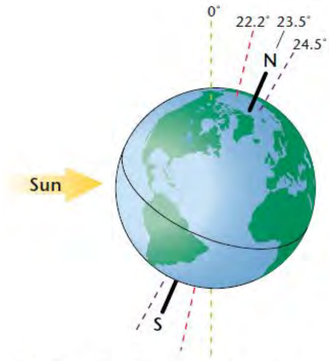
Long Term Causes of Glacial Periods

One piece of evidence to explain **long term climate change** is the Earth's **Milankovitch Cycles**. Milankovitch's theory of **astronomical climate forcing** states that when **global energy alters**, the consequent **variations in the earth's orbit** force **global changes**. These changes involve:



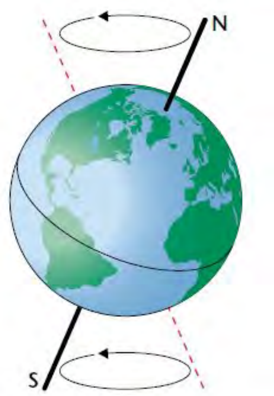
Eccentricity Earth encounters more variation in the energy that it receives from the sun when Earth's orbit is elongated than it does when Earth's orbit is more circular.

a) **Stretch/Eccentricity**: The earth's orbit changes from **circular to eclipse** every 96000 years, which changes the distance between the earth and the sun. Therefore, the Earth will be closer to/ further away from the sun at certain points during different orbital shapes, affecting the **climate** (e.g. if the Earth is closer to the sun, the Earth will receive more solar radiation and therefore be warmer).

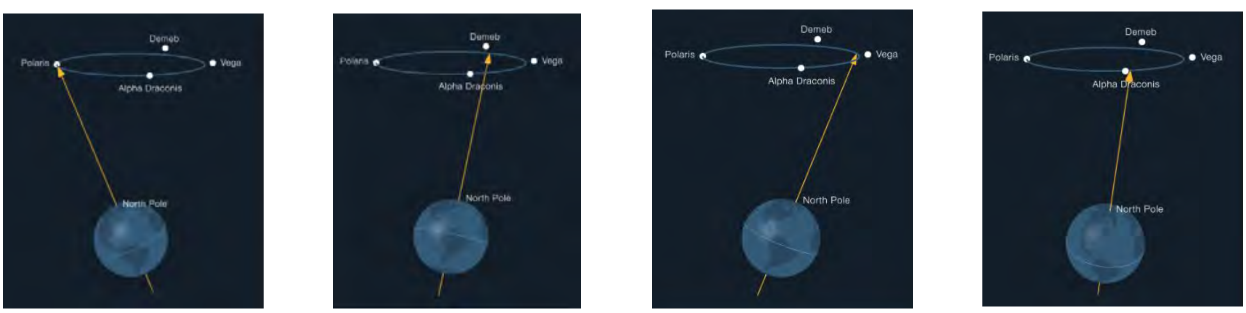


b) **Tilt**: The Earth's **tilt** changes between 21.8 degrees and 24.4 degrees every 41000 years. If the tilt is greater, tropics receive more energy and thus become larger.

Tilt The tilt of Earth's axis varies between 22.2° and 24.5°. The greater the tilt angle is, the more solar energy the poles receive.



c) **Wobble/Axial Precession**: Over time, the **direction in which the axis tilts** changes (in the same way that a spinning top moves). In 22000 years, the axial tilt spins one whole time around. This does not affect how much sun the Earth receives overall, only where the solar radiation is distributed (i.e. which hemisphere).



(Source: grahamhancock.com; https://i.stack.imgur.com/D93Lk.gif)

Short Term Causes of Glacial Periods

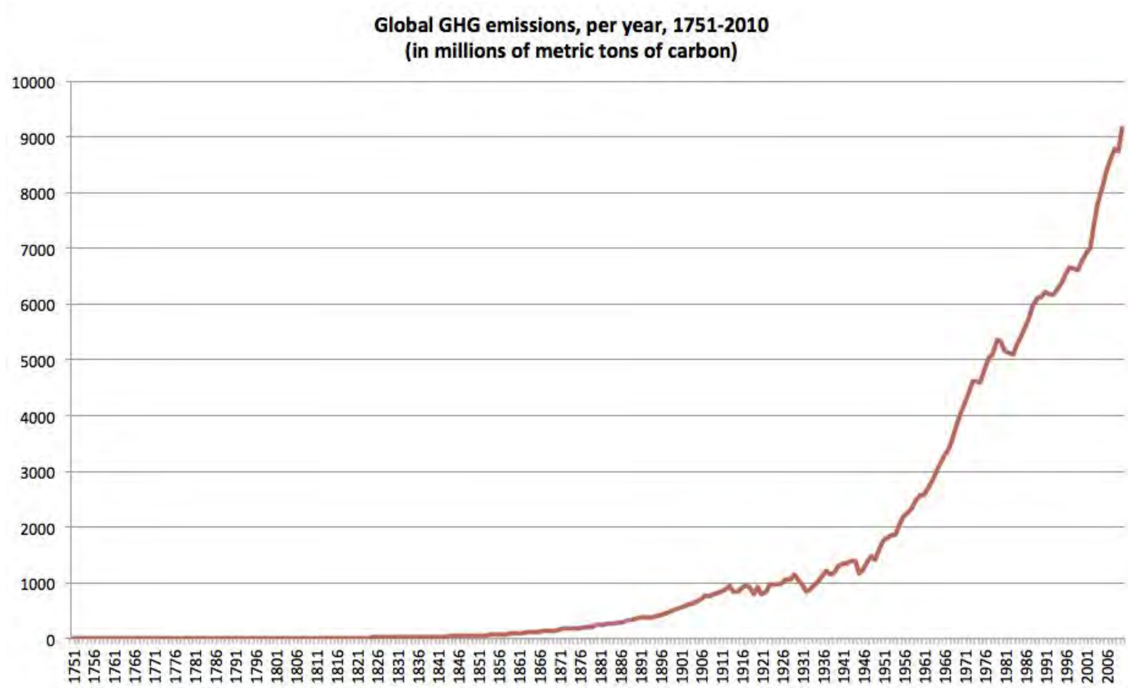
Short Term causes of Climate Change involve:

- **Variations in Solar Output**: **Energy output of the sun** is not constant. **Sunspots** occur by magnetic storms, forming dark areas on the sun which increase solar output. The number of sunspots increase/decrease in an 11 year cycle. Sunspots aren't regular and can vary; during the Medieval warming period, there were high numbers of sunspots but during the Maunder Minimum, there were few sunspots.
- **Volcanic Eruptions**: For instance, Mount Tambora in Indonesia erupted in 1815 and lowered global temperature by 0.5 degrees Celsius. Initially, scientists thought that the ash produced would block some solar radiation, hence cooling the Earth. However, it is actually sulfur dioxide, a potent greenhouse gas, which is released during an eruption and reflects radiation for several years.

Past climate trends have been argued, as well as how the climate will change in the future (naturally or due to anthropogenic influence).

Global Warming

Since the 1750s (when industrialisation began in the UK), global concentrations of **greenhouse gases** like CO_2 and CH_4 have increased by more than **25%.** Since the 1980s, **75%** of carbon emissions have come from **burning fossil fuels**.



Source: www.easterbrook.ca

Human activities have led to more carbon being released into the atmosphere and less being absorbed:

- **Land Use Change:** Accounts for a **tenth of carbon release annually** and impacts on **short-term stores** in the carbon cycle, such as the soil and atmosphere. For example:

- **Farming Practices:** In the Amazon, around **70% of deforestation is for cattle ranching**. Cattle produce significant amounts of **methane**, further contributing to global warming. Scientists are considering whether feeding cows different foods would help to reduce their methane emissions.

- **Fertilisers** are a significant source of greenhouse gases as well as **rice padi fields**, from which methane emissions have increased as a result of **increased productivity** due to higher CO_2 levels. More sustainable grains and seeds like **quinoa** are being considered as substitutes, which require **less water to grow**.
- **Deforestation:** In total, **deforestation accounts for about 20% of all global greenhouse emissions**. The main impact is when the cycle is interrupted and the land is used for other purposes, which then reduces carbon sequestration and land becomes a **carbon source** rather than a **carbon sink**.
- **Urbanisation:** This is the process of **replacing the countryside with buildings and other similar infrastructure**. It affects the **local and global carbon cycles**, by replacing vegetation and covering soils. **Urban areas occupy 2% of the world's land mass**, but these areas **account for 97% of all human caused global CO_2 emissions**. Cement is an important building material, but releases carbon dioxide during production, contributing **7% to global carbon dioxide emissions each year**, so sustainable options for recycling concrete are being developed.
- **Combustion of Fossil Fuels**: This results in **CO_2, sulphur and particulates** being released into the atmosphere. If combustion occurs in a hot engine, **NO_2** will also be released (also a greenhouse gas) as nitrogen from the air fuses with oxygen.

The amount of carbon is measured in **gigatonnes** (Gt) or **petagrams** (Pt). It is estimated that burning fossil fuels has added more than **180 Gt** of carbon to the atmosphere.

Increasing levels of greenhouse gases can affect the **planet's climate**, which can have implications for the water cycle, biomes and wildlife living on Earth.

Implications of The Enhanced Greenhouse Effect

Thawing of Tundras and Glaciers

Warmer temperatures cause **melting**, which is clearly bad for all cold environments.

- Permafrost melts
- Glaciers retreat
- Alpine environments thaw for longer summers

This melting causes further issues:

- Local **floods** near glaciers
- Regional floods if rivers etc.carry water elsewhere
- Global floods if major ice sheets and glaciers melt, causing sea level rises
- Disruption to flora and fauna that are adapted to the environment
- **CO_2** is released into the atmosphere that is **stored** in ice sheets and permafrost

- **Albedo effect** is lessened due to less ice sheets (this is the idea that white surfaces - ice - reflect solar radiation back into the atmosphere, meaning more heat is absorbed into oceans)

Positive feedback loops caused by melting

↗ **Permafrost melts** ↘

Greenhouse effect ← **CO_2 released**

↗ **Ice sheets melt** ↘

Sea temperatures rise ← **Ocean absorbs more heat (lowered albedo effect)**

Higher regional temperatures affect cold environments in other ways

- **Invasive species** that are adapted to higher temperatures have grown and caused the colonisation of some cold environments
- **Migration patterns** of certain animals have been disrupted by the higher temperatures. For example, the strandings of polar bears migrating to lower latitudes in winter
  - **Food chains** are disrupted by migration changes and invasive species

Temperature

The amount of **solar energy** reaching the Earth varies depending on location, and is the main factor in determining climate temperatures. **Solar intensity** is more intense at the equator, and reduces as you travel towards the poles.
The **Albedo Effect** will also determine the temperature of a location. Snow **reflects** solar radiation whereas dark forests **absorb** the most solar radiation.

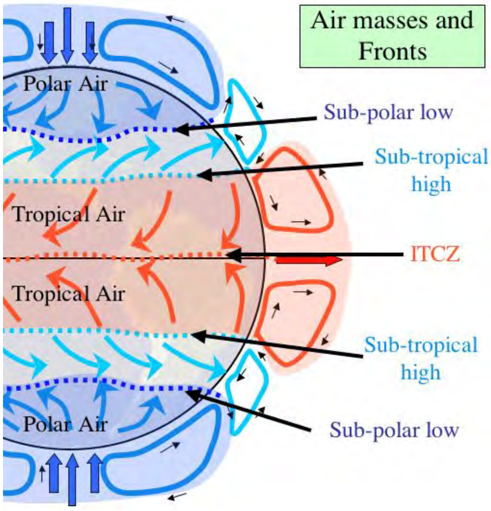
Climate and Weather

Rising levels of CO_2 in the atmosphere are believed to be the main contributor to an increase in **average global temperatures**.
However, increases may vary:

- In Europe, average temperatures are expected to increase more than the global average.
- The largest increases are expected in Eastern and Northern Europe during winter and Southern Europe during summer.
- Annual precipitation is expected to increase in Northern Europe but decrease in Southern Europe.

Extreme weather events and hydro-meteorological hazards are likely to increase in severity and frequency if temperatures rise due to Climate Change:

- If land and sea surface temperatures continue to rise, the **period between ENSO cycles** (currently every 2-3 years) could **decrease**. This would lead to more periodic unusual climates for both South America and Australia.
- Increasing average global temperatures would increase rates of evaporation, which could lead to potential **droughts** and **increasing water scarcity**.
- However, for some locations, a rise in average temperatures will lead to more convectional rainfall and **enhanced tropical cyclone or depression intensity**. This in turn will cause more intense and periodic flooding.



Precipitation

Solar radiation is the most intense along the equator, so **convectional rainfall** is common and rainfall is generally very high.

Where **convectional rainfall** is likely to occur can be understood using the **ITCZ Model**.

Rainfall occurs at **subtropical highs** (mid-latitude) and the **poles**.

Where air submerges and cools, water vapour condenses to form clouds and precipitation. Where air rises, the air heats up and moisture will evaporate. This creates dry weather conditions.

Source: montessorimuddle.org

Ecosystems

Ecosystems help to regulate the carbon and hydrological cycles. **Global Warming** could impact the functioning of ecosystems. The two **biomes** most at risk are **the Artic** and the **coral ecosystems.**

Species with low population numbers are already at **high risk**. There is already evidence showing that there will be change in species' population size, timing of reproduction and migration.

Marine organisms are also at risk. They are threatened with **low oxygen levels** and high rates of **acidification**. The impact on coastal ecosystems and low lying areas of **sea levels rising** could continue.

Uncertainty in Predictions:

Not all scientists agree that permafrost melting will release CO_2 and CH_4. Some studies show that when permafrost melts, the **carbon may remain** in the soil and warmer temperatures lead to **more decomposition** which uses CO_2

It is very **difficult to predict** future emission levels and so scientists use various scenarios to show projected greenhouse gas concentrations. There are several **uncertainties** in estimating future Climate Change, but they have identified several **tipping points and feedback mechanisms** that scientists believe would accelerate change. A climate tipping point is a **critical threshold**; when this threshold is reached, small changes in the global climate system can transform a stable system irreversibly.

- **Economic growth** – There is a correlation between economic growth and energy consumption. After the financial crisis in 2007, there was concern that CO_2 emissions would begin to rise as GDP growth picked up.

- **Population change** – Increasing affluence in emerging economies means that that by 2050 there could an additional 1 billion consumers which could lead to more emissions due to more energy consumption.

- **Technology and Globalisation** - Increased globalisation leads to more traveling and transportation of goods which could mean more emissions. However, technological advancements may compensate and decrease emissions created by the interconnected world.

- Peat is the **accumulation** of partly decayed vegetation, which stores a large amount of carbon. Warming causes peat to dry out and the rate of **decomposition increases**. An increase of 4 degrees causes a 40% loss of soil organic carbon from shallow peat and 86% from deep peat. Peatlands emit carbon in the form of **methane** which increases greenhouse gases and accelerates enhanced Greenhouse Effects through a **positive feedback loop**.

- When **permafrost melts**, trapped carbon is released into the atmosphere as CO_2 and methane which **increases greenhouse gas concentrations** in the atmosphere. This leads to higher temperatures and further melting of ice. The **Siberian permafrosts** are one of the largest stores of methane, which would vastly accelerate Global Warming if released.

- Rainfall in the Amazon is largely **recycled**. If there is a **drought** in the rainforest, trees may die. A tipping point could be reached when moisture can no longer be recycled (due to too few trees to intake moisture) which leads to more trees dying. In the **boreal forest ecosystem**, hot and dry summers lead to **water stress** which can result in a loss of trees. A tipping point could be reached when trees no longer absorb much CO_2 which in turn increases the concentration of greenhouse gases in the atmosphere, leading to further dry summers.

- Cold water in the North Atlantic forms part of the **thermohaline circulation**. To keep warm water heading from the tropics towards Britain, heavy water must sink in the North. The melting of the Northern ice sheets releases large amounts of **fresh water** into the ocean which is less dense and has low salinity. This will **disrupt the circulation** of water, affecting the temperature of the ocean reaching the ocean and in turn the weather of the UK. It is believed by some scientists that the thermohaline circulation is slowing down. If it stops then the world will go into another ice age.

Impacts of Climate Change:

It is thought that climate change will affect industrial sectors and economic productivity, especially for agriculture.

Farming is most susceptible to changes in weather and climate, as the growth of crops depends on the conditions they are grown in. Since climates will change differently for different regions, there are several different possible impacts on agriculture:

- For semi-arid climates, Climate Change is likely to increase average temperatures and so increase the rate of evaporation of water moisture. This will reduce the amount of moisture in the soil, and so reducing plant growth. A reduction in soil moisture will increase the soil's vulnerability to erosion, which will further limit crop growth.
- Some regions of the world will experience more precipitation, so plant productivity may increase in certain regions such as some current tundra climates; as temperatures increase at northern latitudes, permafrost may thaw making it possible to plow the lands for farming.

Farmers' techniques will need to adapt to the changing climates. Some farmers may lose their ability to farm, if the soils and environment become unfavourable: hot, dry, arid. However, some farmers may continue to farm with improved irrigation and strategic crop planning.

Governing Climate Change:

National and international efforts to combat and adapt to Climate Change have varying levels of success.

National efforts may not be possible depending on the cost of engineering schemes, technology and knowledge, level of development. However, national efforts tend to have a small impact on emissions. International efforts can have a larger impact on global emissions, and cooperation between countries tend to motivate and hold accountable countries who don't participate. However, very large scale collaborations are hard to organise.

UN Climate Change Conferences

Finally, the UN also aims to encourage the protection of the environment and the reduction of greenhouse gas emissions. The changing attitude of many state governments has been caused by several important conferences:

- **Montreal Protocol** - Finalised in 1987. Aimed to stop the use of CFCs and Halons, both highly damaging to the ozone layer.
- **The Kyoto Protocol** - Held in 1997. Aimed to generally reduce greenhouse gas emissions
- **The Paris Agreement** - Held in 2015. Highest number of signatures/ states participating to date. However, key emitters such as the USA have withdrawn since.

Environmental Alliances

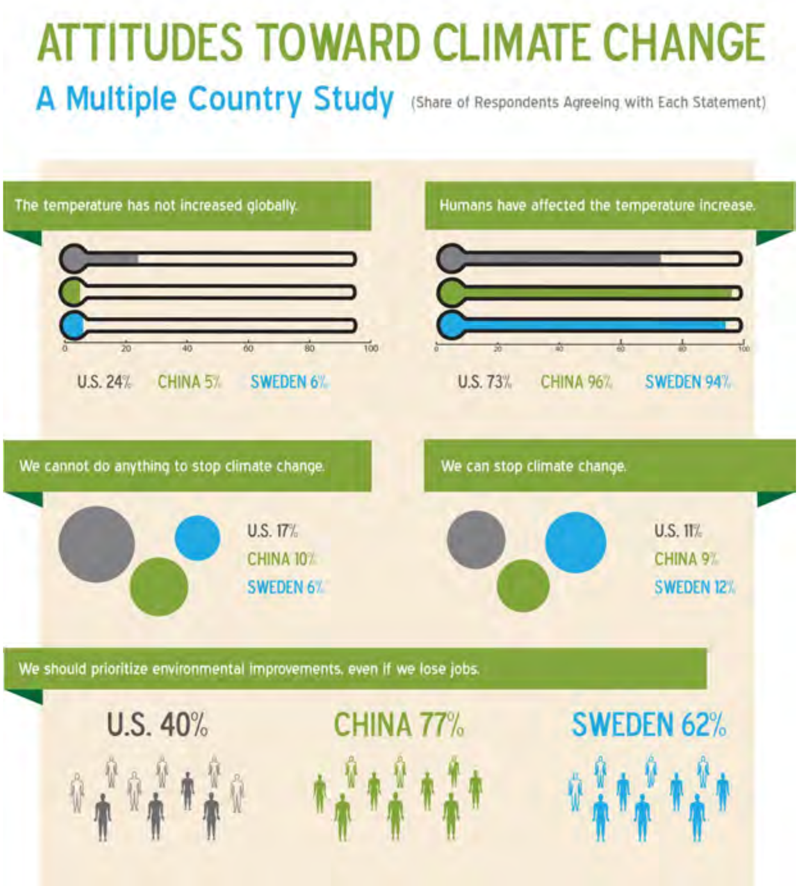
Intergovernmental Panel on Climate Change (IPCC) - This organisation was established by the UN in 1988. Its aims are to stabilise greenhouse gas emissions and reduce the harm humans are doing to the environment. Its success can be argued, since many governments still pollute and are not held accountable by the many policies and protocols they may have signed.

Varying Attitudes to Global Warming

Some countries have **different attitudes** to global warming and climate change.

Some don't believe that climate change is occurring, since they **dispute** whether greenhouse gas emissions are the cause of average temperature change.

Some countries **don't feel accountable** for their emissions, so won't reduce their emissions or adapt their farming practices.



It is often small countries that are impacted most severely by Climate Change - small islands threatened by sea level rise, for example. However, they may not be the main culprit of anthropogenic greenhouse emissions, but don't have the **voice** to hold larger countries (USA, EU, China) accountable.

Source: peakresources.blogspot.com