Chapter One – The Challenge of Natural Hazards

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CHAPTER 1 – THE CHALLENGE OF NATURAL HAZARDS

1.01 Types of Natural hazard.

This unit is all about Natural hazards. AQA define natural hazards as;

"A natural event (for example earthquake, volcanic eruption, tropical storm, flood) that threatens people or has the potential to cause damage, destruction and death."

The key part of the definition is the threat to human populations and their properties. There are many natural events around the globe that do not occur in close proximity to people so do not pose a hazard. When natural events occur close to large or vulnerable populations we have a natural hazard on our hands.

There are different types of natural hazards that can affect people around the globe, including;

Key Words

- **Earthquake** - a sudden or violent movement within the Earth's crust followed by a series of shocks.
- Hazard risk - the probability or chance that a natural hazard may take place.
- Volcano - an opening in the Earth's crust from which lava, ash and gases erupt.

- **Atmospheric hazards** - Created in the atmosphere, by the movement of air and water
- **Terrestrial/Geological hazards** - Created by the movement of the Earth's tectonic plates or surface rock and soils
- **Water based hazards** - Created by rivers, sea or oceans
- **Biological Hazards -** Any biological substance that poses a threat to the health of people

Nine deadliest natural disasters since 1900

Rank	**Death toll (estimate)**	**Event**	**Location**	**Date**
1.	1,000,000–	1931 China floods	China	July 1931
2.	450,000 (242,000–	1976 Tangshan earthquake	China	July 1976
3.	375,000 (250,000–	1970 Bhola cyclone	East	November
4.	280,000	2004 Indian Ocean	Indian Ocean	December 26,
5.	273,400	1920 Haiyuan earthquake	China	December
6.	229,000	Typhoon Nina—contributed	China	August 7, 1975
7.	160,000	2010 Haiti earthquake	Haiti	January 12,
8.	145,000	1935 Yangtze river flood	China	1935
9.	142,000	1923 Great Kanto earthquake	Japan	September

(source - http://en.wikipedia.org/wiki/List_of_natural_disasters_by_death_toll)

1.02 Factors affecting hazard risk.

The risk posed by a hazard is affected by many things. Not all earthquakes have the same impact the world over for example, and not all tropical storms are deadly. Why is it that earthquakes of the same magnitude have different death tolls? Why is it that hurricanes of the same magnitude create different amounts of economic damage? Some places are **more VULNERABLE** to natural hazards and some places have a **lower CAPACITY TO COPE** as they have weaker infrastructure, poor government organisations and agencies (such as the army, or police) or low quality equipment.

The major things affecting all natural hazards are;

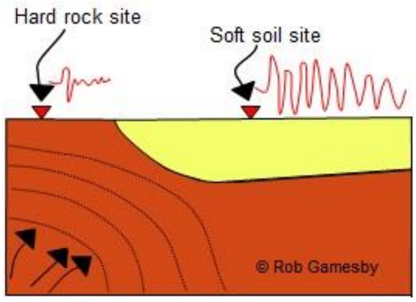


Figure 1 Earthquakes in different sediment types

1. **Natural factors** - things like rock type (geology) in an earthquake, the shape of a coastline in a tsunami, the height of the land hit by a tsunami can influence the effects. For example, a gently sloping coastline will often suffer more damage than a steep coastline in a hurricane's storm surge. It is known that generally earthquake shaking in soft sediments is larger and longer than when compared with the shaking experienced at a "hard rock" site. Softer sediments are more likely to liquefy too, which can contribute to building collapse.

2. **Magnitude -** the size of the event massively affects the impact it has. A hurricane of magnitude 5 on the Saffir Simpson scale will have more impact than that which has a magnitude 3, whilst every step up the Earthquake Richter scale represents a 10 fold increase in damage and a 30 fold increase in energy released.

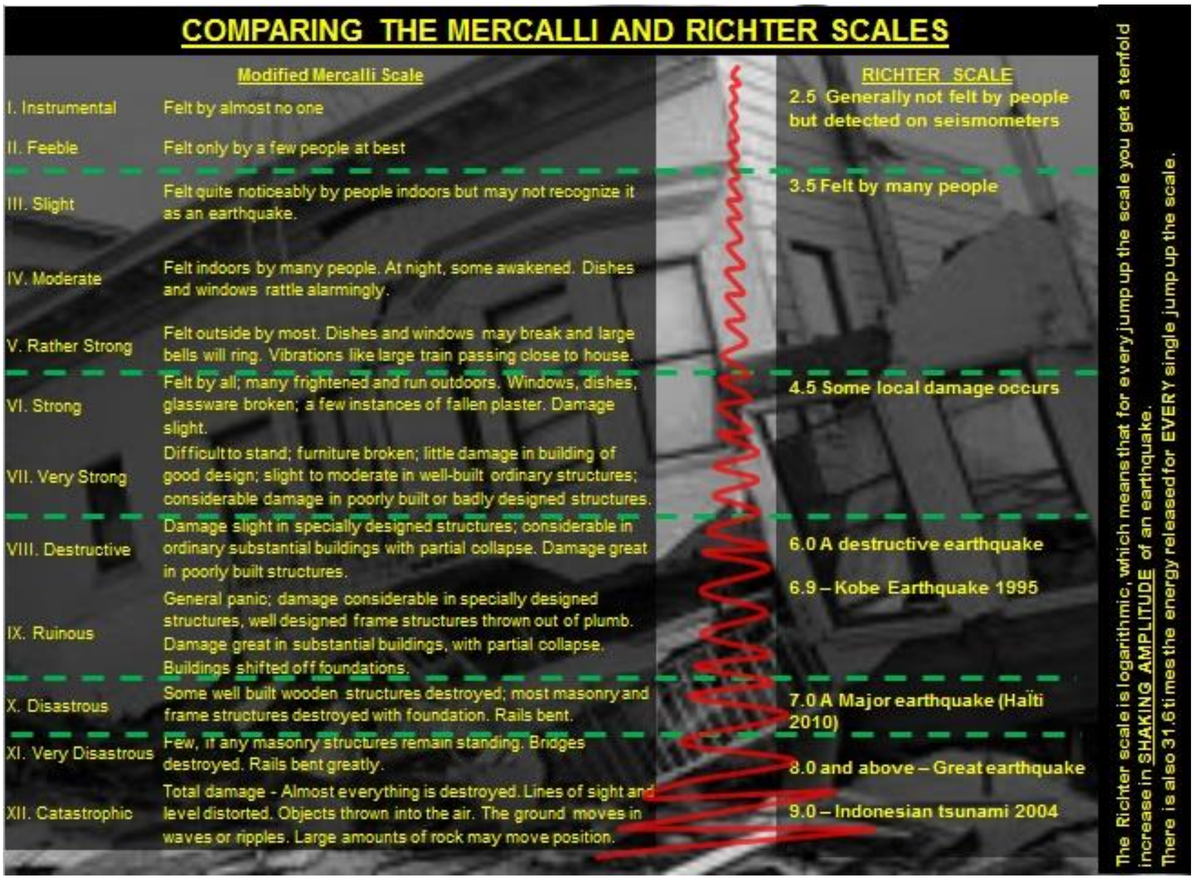


Figure 2 The Richter and Mercalli Scales

3. **Frequency** – this is how often the hazard occurs. The more often a hazard occurs generally the more prepared people are, and the more used to coping they are. Large earthquakes and volcanic eruptions

are generally very rare events in terms of a human lifespan so when they occur they can surprise. Floods are often regular events, large parts of Bangladesh flood every year for example. In this event people can adjust their buildings and lives to cope with the risk associated.

4. **Population density and distribution –** this is the **number of people** in an area and where they are. Generally, the greater the number of people in an area, the greater the potential for disaster. Therefore, an earthquake in Alaska will have less impact than one which hits a more densely populated area such as San Francisco. The Pacific Ring of fire covers a 40,000km horseshoe shape and has around 90% of the world's earthquakes and 452 volcanoes. Hundreds of millions of people live in this zone, including over 20 million people close to Popocatépetl volcano in Mexico.
5. **Level of development of the place -** this determines how much money is available to PREPARE for the event in advance in terms of predicting the hazard and PREPARING people to cope with it, and also determines how the country RESPONDS after the event, wealthy places tend to respond quicker. **High Income Countries (HIC)** are generally much better at preparing and responding to natural hazards because;

- **Governments** – their governments are often stable and democratic and have lots of agencies that can help during an emergency. Being democratic means that the public can put pressure on the government to have life safe buildings that survive natural disasters, or makes then want to respond quickly as it will help get the politicians votes.
- **Technology** – HICs can afford the technology to help them predict events, the USA has the United States Geological Survey to collect earthquake data from seismometers for example. They also have the technology to help buildings survive various natural hazards
- **Planning laws** – many HICs have laws that prevent building in hazardous locations, along a low coastline at risk from storm surges in a hurricane for example.
- **Agencies** – many HICs have agencies that can act quickly to help people after a disaster, such as a well-equipped army or fire service and experts to coordinate a response in both the short and long term.

6. **Management – the 3Ps (Predict, Prepare and Prevent)**

Predict – some natural hazards are easier to predict than others, hurricanes can be identified by satellites and then tracked. This allows governments to evacuate if needed.

Preparations - if a place is well prepared regardless of its level of development this can limit the impact of a hazardous event. In India, despite its low level of economic development, rounded wooden houses have been designed to be earthquake proof, thus limiting the impact of these hazards.

Prevent – this could be preventing damage to buildings etc. through strict building rules.

Figure 3 Drop Cover and Hold on
https://www.fema.gov/media-library/assets/images/72486

7. **Education** – regardless of level of development people can be educated to survive natural hazards. Education about the risks of contaminated flood water or Earthquake drills (like the ones Japan has on the 1st September to commemorate the 1923 Tokyo Earthquake) can save many lives.

8. **Time** - the amount of time since the last hazardous event can influence the impact, if a long time goes by people can be unprepared. Also, if the hazard occurs when lots of people are asleep they can also be unprepared. The Christchurch Earthquake of 2011 happened during the day when lots of people were at work, this contributed to the death toll as many got trapped in collapsed office buildings.

1.03 Global distribution (where they are) of earthquakes and volcanic eruptions

Plate Tectonics and the structure of the Earth

Plate Tectonics is a theory that tries to explain how the Earth is structured and what it is made up of.

To the right is an idealised diagram of the Earth's interior (middle bit). The Earth formed approximately 4.5 billion years ago following a huge explosion of a star. The materials that make up our earth slowly gathered together due to gravity, to create a ball of hot molten material. This material has slowly cooled over geological time, forming a crust at the Earth's surface of rocks. These rocks are fractured into huge segments called Tectonic plates.

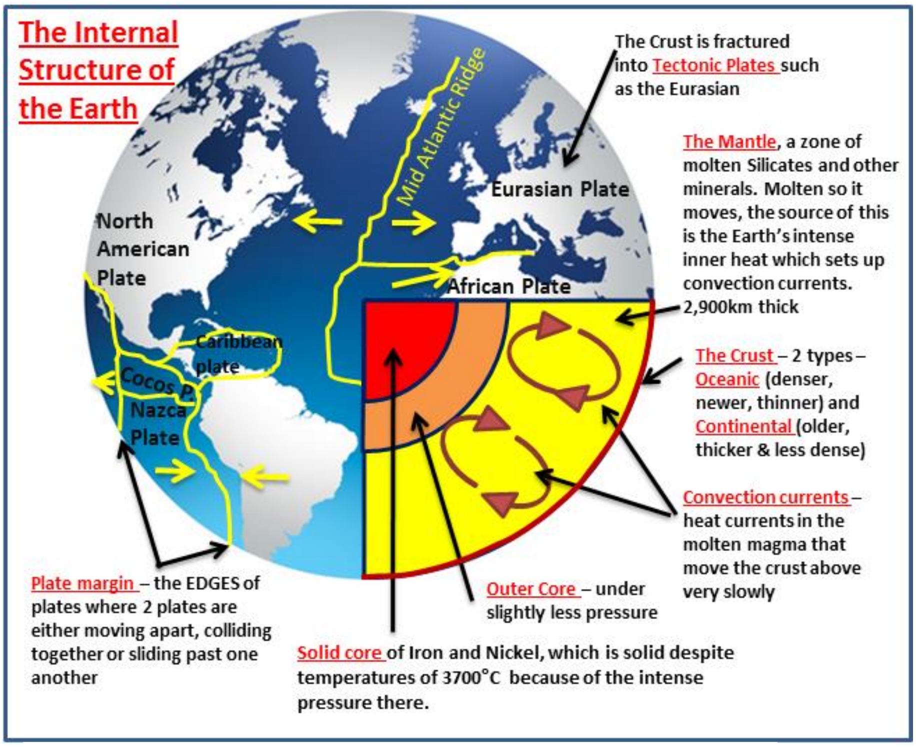


Figure 4 The Earth's internal structure

These tectonic plates are moving about very slowly, pushed and shoved around from underneath by currents within the mantle called **convection currents**.

Beneath the crust temperatures start to rise as you descend into the second of the Earth's zones, the Mantle, a zone of molten Silicates and other minerals. The Earth does have a solid core of Iron and Nickel, which is solid despite temperature of 3700°C because of the intense pressure there.

Key Words

- **Plate boundary** - the boundary or margin between two tectonic plates.
- **Tectonic hazard** - a natural hazard caused by movement of tectonic plates (including volcanoes and earthquakes).
- **Tectonic plate** - a rigid segment of the Earth's crust which can 'float' across the heavier, semi-molten rock below. Continental plates are less dense, but thicker than oceanic plates.

The plates and plate margins

The tectonic plates are made up of different materials, and there are 2 broad types;

Continental crust is thicker, older and lighter, and is composed mainly of Granite. It is 22 mi (35 km) thick on average and less dense than oceanic crust. Continental crust is more complex than oceanic crust in its structure and origin and is formed primarily at subduction zones at

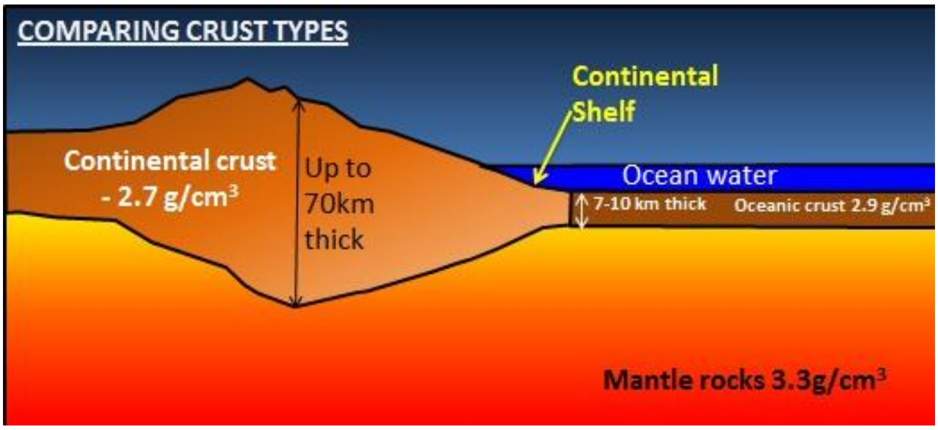


Figure 5 Contrasts between Oceanic and continental crust

destructive plate margins.

Oceanic crust is younger and heavier, and is mainly composed of basalt and Gabbro. It is mainly formed at constructive margins or spreading mid ocean ridges.

The Tectonic Plates vary in size and the Earth's surface can be likened to that of a boiled egg which has been cracked. The major plates include the Pacific, Eurasian, African, Antarctic, North American and South American, and the Indo-Australian. There are other smaller plates however, such as the Philippines and Cocos plates. The tectonic plates join at zones called **plate margins**, where most of the world's volcanic and earthquake activity occurs. Remember that this is a theory proposed by Alfred Wegener as **CONTINENTAL DRIFT** in 1912, and is now supported by lots of evidence since.

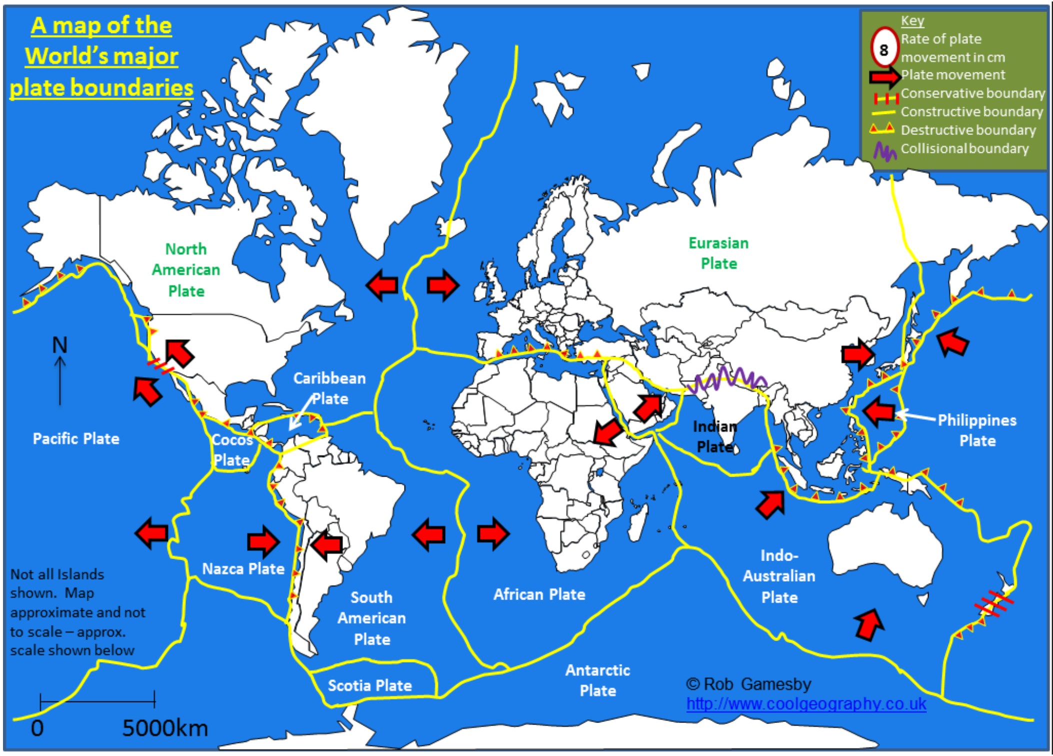


Figure 6 A map of the World's major plate margins

ACTIVITIES – 1.03

1. Draw a simple copy of figure 4 then add one fact about each zone of the Earth's Structure
2. Define the terms;

a) Tectonic Plate

b) Plate margin

3. Contrast the characteristics of continental and oceanic crust

1.04 Types of plate margin

Volcanoes and earthquakes mainly occur along **plate boundaries** where magma can escape from the Earth's mantle or where stresses build up between 2 plates rubbing together. An exception to this includes Hawaii, which is found in the middle of the Pacific plate over **a hot spot**.

Constructive or Divergent Margins

At this type of plate margin two plates are **moving apart** (DIVERGE) from each other in opposite directions. Convection currents moving in opposite directions (caused by the intense heat of the Earth's interior) in the mantle move two plates apart. As these plates move apart this leaves cracks and fissures (**lines of weakness**), that allows magma from the mantle to escape from the highly pressurised interior of the planet. This magma fills the gap and eventually erupts onto the surface and cools as new land. This can create **huge ridges** of undersea mountains and volcanoes, and where these mountains poke above the level of the sea, islands are created. Both earthquakes and volcanoes can result at these margins, the earthquakes caused by the movement of magma through the crust. A really good example of this is the **Mid-Atlantic Ridge**, where the Eurasian plate moves away from the North American plate at a rate of around 4cm per year. Iceland owes its existence to this ridge.

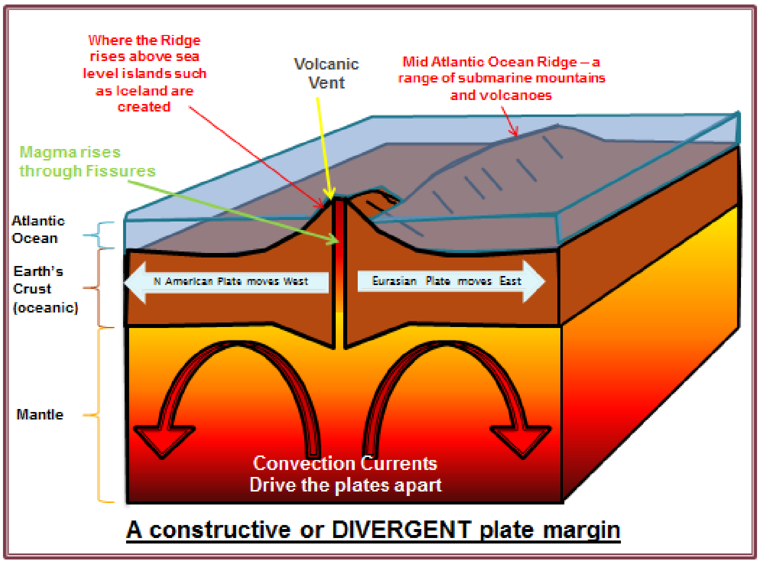


Figure 7 A constructive plate margin

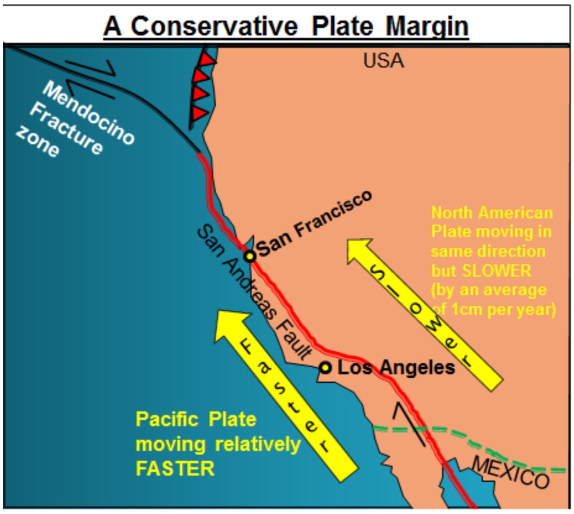


Figure 8 A conservative plate margin

Conservative margins

At conservative margins mountains are not made, volcanic eruptions do not happen and crust is not destroyed. Instead, 2 plates either slide past each other in opposite directions, or 2 plates slide past each other at different speeds. As they move past each other stress energy builds as the plates snag and grind on one another. When this stress energy is eventually released it sends shock waves through the earth's crust. We know these shock waves as earthquakes, and a good example of this is the San Andreas Fault in California, where the Pacific plate is moving NW at a faster rate than the North American plate.

Key Words

- **Conservative plate boundary** - Tectonic plate margin where two tectonic plates slide past each other.
- **Constructive plate boundary** -Tectonic plate margin where rising magma adds new material to plates that are diverging or moving apart.
- **Destructive plate boundary** - Tectonic plate margin where two plates are converging or coming together and oceanic plate is subducted. It can be associated with violent earthquakes and explosive volcanoes.

Destructive or Convergent Margins

A Destructive (CONVERGENT) Plate Margin – The Andes Mountains in South America

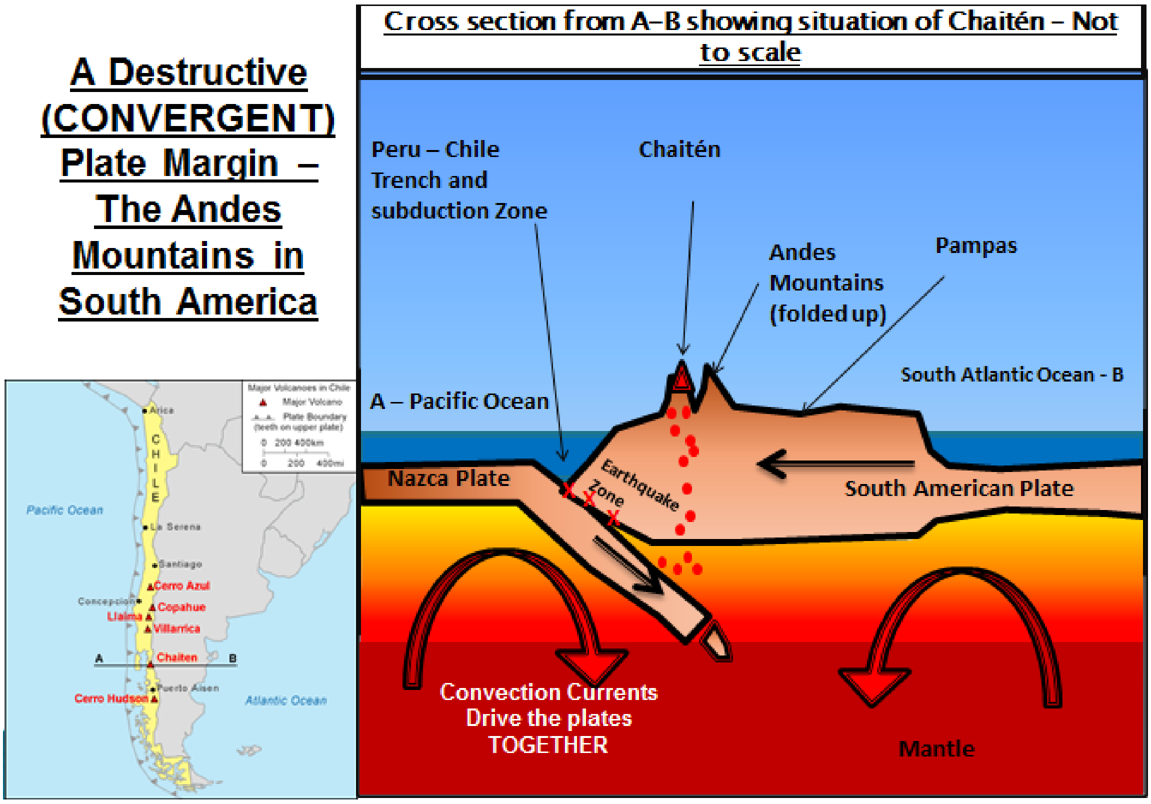


Figure 9 A destructive plate margin

At these margins 2 plates move or **CONVERGE together** and the destruction of some of the Earth's crust results. An **oceanic plate (denser)** is pushed towards a **continental plate (less dense)** by convection currents deep within the Earth's interior. The oceanic plate is **subducted** (pushed under) the continental plate at what is called a subduction zone, creating a deep ocean trench. It is the Oceanic crust which sinks down into the mantle because it is denser (heavier). As it descends friction, increasing pressure and heat from the mantle **melt the plate**. Some of this molten material can work its way up through the continental crust through fissures and cracks in the crust to collect in magma chambers. This is often some distance from the margin where magma can eventually re-emerge at the surface to create a **range of mountains**. The movement of the plates grinding past one another can create **earthquakes**, when one plate eventually slips past the other releasing seismic energy. There are several really good examples of destructive plate margins, including along the West coast of the Americas and Japan, where the Philippines sea plate is pushed under the Eurasian plate.

ACTIVITIES 1.04

1. Complete the flow chart below to explain exactly what happens at **Destructive** plate margins. Mention subduction, oceanic crust, continental crust, earthquakes and volcanoes in your flow chart.

   1
   2
   3
   4
   5
   6

2. Explain why we get earthquakes but not volcanoes at **CONSERVATIVE** plate margin

Volcanoes

Volcanoes are basically mountains that can explode with violent consequences**. Volcanoes** are a geological landform **created by the intrusion of magma into the earth's crust and by the eruption of that magma onto the Earth's surface through a vent**. There are many different types of volcano, and they are classified in different ways according to their type of eruption, the material ejected and their activity.

Figure 10 - Redoubt volcanic eruption
https://commons.wikimedia.org/wiki/File:MtRedoubtedit1.jpg

Volcanic activity

According to the activity of volcanoes, there are extinct, active, and dormant categories. Easily recognized volcanoes are active volcanoes, but dormant and extinct volcanoes are difficult and dangerous sometimes. The people living near known extinct and dormant volcanoes must always be on the lookout. Volcanoes can erupt at any time without warnings.

The constantly erupting volcanoes are active. The eruption is usually quiet but can sometimes be violent. Stromboli, which lies on an island near Italy, is a famous active volcano.

Intermittent volcanoes erupt at fairly regular time periods. Mount Asama and Mount Etna are some intermittent volcanoes.

Inactive volcanoes that have not erupted for an amount of time but can’t be called extinct are dormant volcanoes. They can be called “sleeping” volcanoes.

Inactive volcanoes which have not erupted since the beginning of recorded history are extinct volcanoes. They will never erupt again unless they are still dormant and have been mistaken for extinct volcanoes.

Types of volcano

Shield volcanoes

Hawaii is an example of a place where volcanoes extrude **huge quantities of basaltic lava that gradually build a wide mountain with a shield-like profile**. Their lava flows are generally very hot and very fluid, contributing to long flows. The largest lava shield on Earth, Mauna Loa, rises over 9,000 m from the ocean floor, is 120 km in diameter and forms part of the Big Island of Hawaii.

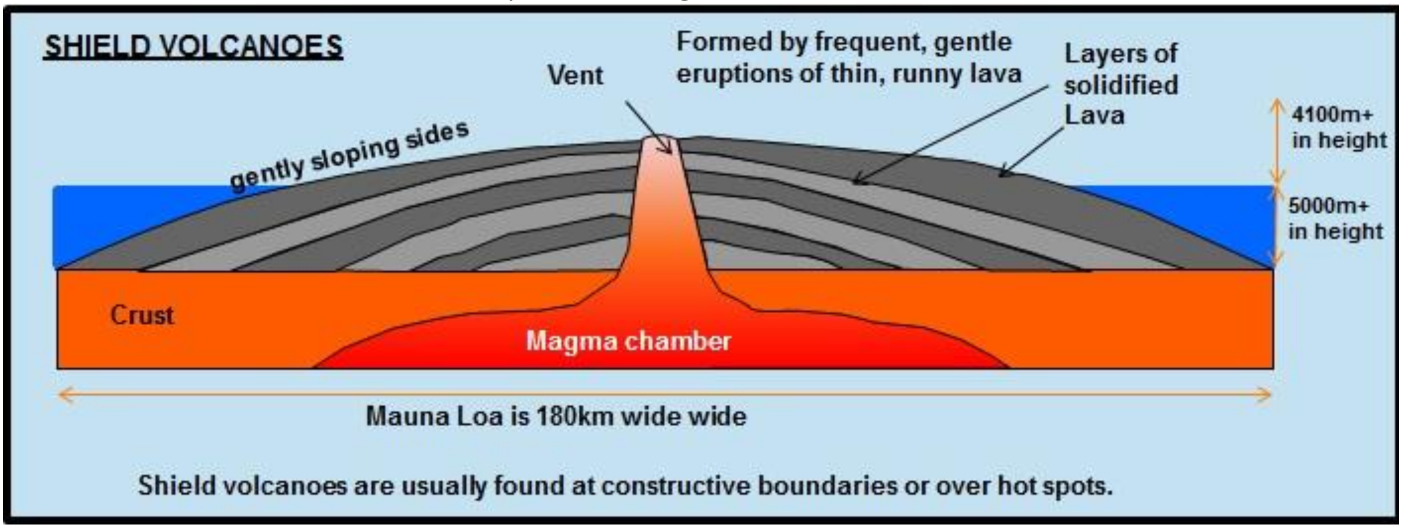


Figure 11 - Typical shield volcano

Strato volcanoes

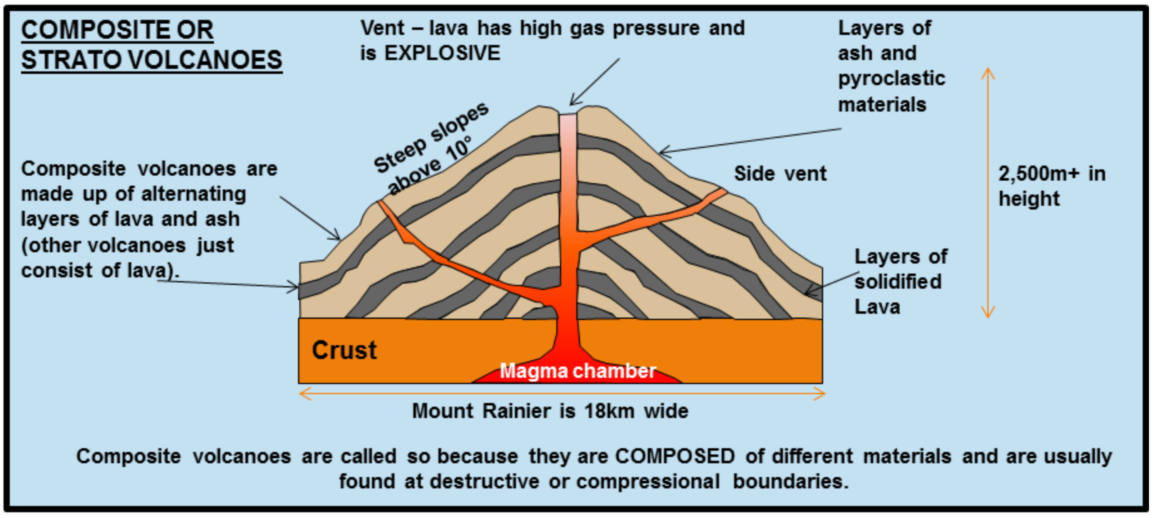


Figure 12 - Strato volcanoes

These are tall steep sided conical mountains composed of lava flows and other material in layers, these layers (strata) give rise to the name. Strato volcanoes are also known as composite volcanoes. Classic examples include Mt. Fuji in Japan, Mount Mayon in the Philippines, and Mount Vesuvius and Stromboli in Italy.

Volcano structure

Volcanoes are often made up of several layers of **dust, ash, pyroclastic (blast) material and lava**. The amount of each material depends upon the eruption history of the volcano. You can see a cross section of a volcano above, as you can see there is also a complex system of vents and faults along which volcanic material can travel. A vent is simply an opening through which eruptive material escapes, and volcanoes often have a central magma chamber.

ACTIVITIES 1.04b

1. Compare and contrast the shapes of shield and composite (strato) volcanoes shown on figures 11 and 12
2. Explain why strato and shield volcanoes differ
3. List and describe a range of hazards associated with volcanoes

Earthquakes

Earthquakes are vibrations in the Earth's crust that create shaking at the surface. They are highly unpredictable and often occur suddenly without warning, mainly on the plate margins. We do know where most earthquakes will occur, and they tend to coincide with destructive, conservative, collisional and constructive plate margins.

Figure 13 Earthquake damage in Haiti, 2010
By UN Photo/Logan Abassi United Nations Development Programme (originally posted to Flickr as Haiti Earthquake)

Reasons for Earthquakes happening

1. Earthquakes occur because **stresses build up** between the plates as one plate passes another.
2. As the plates move past one another they don't do so smoothly, rather, they **snag and grind**, allowing energy to build up.
3. When the plates eventually move again this **energy is released** as shock or **seismic waves** through the Earth's crust.
4. The point at which this slippage occurs is called the **FOCUS**, whilst the point on the ground surface above the earthquake FOCUS is called the **EPICENTRE**.
5. Seismic shock waves will go **radially outwards** from these points and their energy will reduce with distance.

Earthquakes can also occur at constructive plate margins. Here, the earthquake is the result of magma forcing its way between the plates, causing the earth to tremble. Collisional margins, where continental crust meets continental crust, can also have earthquakes as a result of the pressures generated by collision.

Earthquake waves

The **first waves** in an earthquake will shake the ground **UP then Down** in a longitudinal movement. These waves are called P or **PRIMARY waves**. They travel fastest, and can also cause back and forth movement. These waves are relatively weak and cause the surface to move in a back and forth motion. The next waves to arrive are **S or Secondary waves, which travel slower through the crust. These waves cause the crust to move from side to side at right angles to the outward motion of the main wave.**

How Earthquakes are measured

Earthquakes can be measured using 2 scales -the Richter scale or the Mercalli scale (see figure 2). **The Mercalli scale measures the effects of the earthquake and runs from 1 to 12.** The higher up the scale the more damage is experienced by people and building structures. **The Richter scale is different in that it**

measures the energy of an earthquake. The scale is logarithmic, which means that for every jump up the scale you get a tenfold increase in power of an earthquake. Therefore a magnitude 6 is 10 times more powerful than a magnitude 5, and 100 times more powerful than a magnitude 4. The higher the magnitude of an earthquake the less frequent its occurrence. The largest ever recorded was in Valvidia in Chile in 1960 and recorded 9.5 on the scale.

Reasons why Earthquake damage varies

Population Density - the more densely populated an area the more potential there is for loss of life and damage to property. One of the reasons for the huge extent of the damage caused by the earthquake which hit Kobe was the fact that the area is very densely populated.

Earthquake depth - generally, the deeper the focus of the earthquake in the Earth's crust the less damage that is caused. This is because the waves lose energy as they travel through the crust, so by the time they reach the surface the damage can be minimised.

Earthquake strength - the stronger the earthquake the more damage would be caused. This is explained in how we measure earthquakes above.

Geology - the rock type of the area in which the earthquake occurs. If the area is solid rock there is generally less damage than on sands and clays. On clays, liquefaction can occur, where water penetrates between the clay particles creating a quick-sand like substance into which buildings can sink.

ACTIVITIES 1.04c

1. Explain how the following factors affect the level of earthquake damage

Earthquake strength	
Geology	
Earthquake depth	
Population density	
Building design	

2. JUSTIFY which of the 5 factors above you think has the most influence on damage during an earthquake

1.05 Contrasting tectonic hazard case studies

The Kobe Earthquake – an earthquake in an HIC (High Income Country)

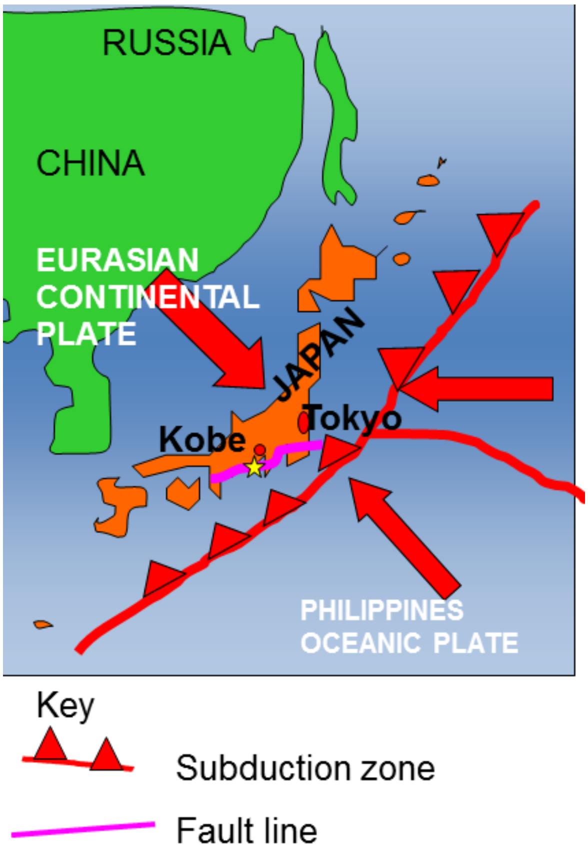


Figure 14 The location of the Kobe Earthquake

Kobe is located in the south east of Japan, near a destructive plate margin. It is a megacity and has one of the largest container ports in the World. Although further from a plate margin than most of the cities in Japan, Kobe is still found on a fault line.

The earthquake that hit Kobe during the winter of 1995 measured **6.9 on the Richter scale**. At this plate margin, the Pacific plate is being pushed under the Eurasian plate, stresses build up and when they are released the Earth shakes. This is known as an earthquake happening along a subduction zone. The focus was only 16km below the crust and this happened on the 17th Jan 1995 at 5.46am. 10 million people live in this area.

Effects

The effects of this earthquake were catastrophic for an HIC. Despite some buildings having been made earthquake proof during recent years many of the older buildings simply toppled over or collapsed. A lot of the traditional wooden buildings survived the earthquake but burnt down in fires caused by broken gas and electricity lines. Other effects included;

Figure 15 - damage during Kobe Earthquake
By 松岡明芳 [GFDL (http://www.gnu.org/copyleft/fdl.html)]

- More than **5000 died** in the quake
- **300,000** were made **homeless**
- More than **102,000 buildings** were destroyed in Kobe, especially the older wooden buildings.
- Estimated cost to rebuild the basics = £100 billion.
- The worst affected area was in the central part of Kobe including the main docks and port area. This area is built on soft and easily moved rocks, especially the port itself which is built on reclaimed ground. Here the ground actually liquefied and acted like thick soup, allowing buildings to topple sideways.
- Emergency aid for the city needed to use damaged roads but many of them were destroyed during the earthquake.
- **Raised motorways collapsed** during the shaking. Other roads were affected, limiting rescue attempts.
- Many small roads were closed by fallen debris from buildings, or cracks and bumps caused by the ground moving.
- The earthquake occurred in the morning when people were cooking breakfast, causing over 300 fires, which took over 2 days to put out.

Responses to the quake

Figure 16 - Collapsed buildings during the earthquake
By 松岡明芳 [GFDL (http://www.gnu.org/copyleft/fdl.html)

Water, electricity, gas, telephone services were fully working by July 1995 and the railways were back in service by August 1995

A year after the earthquake, 80% of the port was working but the Hanshin Expressway was still closed.

By January 1999, 134,000 housing units had been constructed but some people still had to live in temporary accommodation.

New laws were passed to make buildings and transport structures even more earthquake proof.

More instruments were installed in the area to monitor earthquake movements.

Most new buildings and roads have, in the last 20 years, been designed to be earthquake proof, schools and factories have regular earthquake drills, etc. Despite this, many older buildings still collapsed or caught fire. This led to many blocked roads and massive problems of homelessness.

Electricity and water supplies were badly damaged over large areas. This meant no power for heating, lights, cooking, etc. Clean, fresh water was in short supply until April 1995. The government and city authorities were criticised for being slow to rescue people and for refusing offers of help from other countries.

Solutions;

Preparation – A lot of the buildings in Kobe and Japan made after the 1960s are earthquake proof (necessary by law) with counterweights on the roofs and cross steel frames. Many of the damaged buildings in Kobe were built before this period and were made of wood, which caught fire. People are educated on earthquake preparation in Japan.

Prediction – Japan has the world's most comprehensive prediction programme with thousands of seismometers and monitoring stations in Japan designed to give warning. Kobe hadn't had an earthquake in 400years and had less prediction equipment than other areas of Japan.

Aid – The Japanese rejected international offers of aid and dealt with the earthquake itself. All of the homeless people were dealt with reasonably quickly and the city recovered thanks to government money.

ACTIVITIES 1.05

Draw then complete the case study table to summarise the ESSENTIAL information about this earthquake;

Background (where, when, size)		
Causes		
Effects	Short term	
	Long term	
Responses	Individuals	
	Agencies	
	Governments	

1.05 Contrasting tectonic hazard case studies

Haiti Earthquake, Caribbean (LIC)

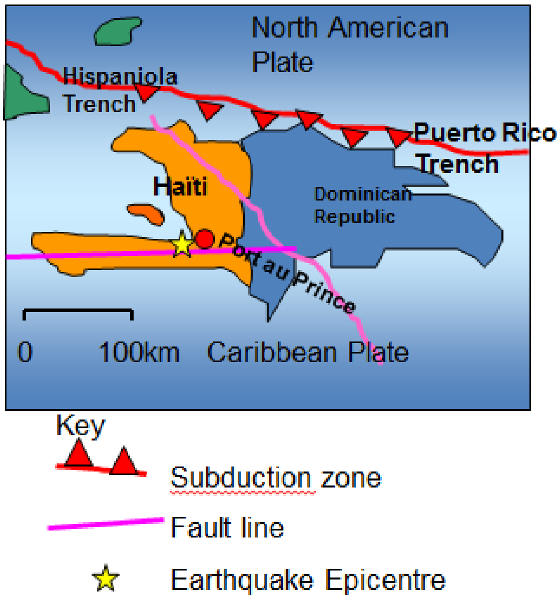


Figure 17 A map of the Haiti Earthquake

Haiti is the **poorest country in the Western Hemisphere**, its GDP is only $1,200 per person, 207th in the world, and its HDI is incredibly low at 0.404, 145th in the world and 80 % of its 9.7 Million people live below the poverty line.

Port Au Prince, the capital, is on a fault line running off the **Puerto Rico Trench**, where the North American Plate is sliding under the Caribbean plate. There were many aftershocks after the main event. The earthquake occurred on January 12th 2010, the epicentre was centred just 10 miles southwest of the capital city, Port au Prince and the quake was shallow—only about 10-15 kilometres below the land's surface. The event measured **7.0 on the Richter Magnitude scale.**

There were many impacts including;

•**316,000 people died** and more than **a million people were made homeless**, even in 2011 people remained in make shift temporary homes. Large parts of this impoverished nation were damaged, most importantly the capital Port Au Prince, where shanty towns and even the presidential palace crumbled to dust. 3 million people in total were affected. Few of the Buildings in Haiti were built with earthquakes in mind, contributing to their collapse

•The government of Haiti also estimated that **250,000 residences and 30,000 commercial buildings had collapsed** or were severely damaged. The port, other major roads and communication links were damaged beyond repair and needed replacing. The clothing industry, which accounts for two-thirds of Haiti's exports, reported structural damage at manufacturing facilities. It is estimated the **1 in 5 jobs were lost** as a result of the quake

Figure 18 - building damage during the Haiti Earthquake By Photo Marco Dormino/ The United Nations United Nations Development Programme

•Rubble from collapsed buildings blocked roads and rail links.

• The port was destroyed

• Sea levels in local areas changed, with some parts of the land sinking below the sea

• The roads were littered with cracks and fault lines

Short term responses

Many countries responded to appeals for aid, pledging funds and dispatching rescue and medical teams, engineers and support personnel.

Communication systems, air, land, and sea transport facilities, hospitals, and electrical networks had been damaged by the earthquake, which slowed rescue and aid efforts.

There was much confusion over who was in charge, air traffic congestion, and problems with prioritisation of flights further complicated early relief work.

Port-au-Prince's morgues were quickly overwhelmed with many tens of thousands of bodies having to be buried in mass graves.

As rescues tailed off, supplies, medical care and sanitation became priorities.

Delays in aid distribution led to angry appeals from aid workers and survivors, and looting and sporadic violence were observed.

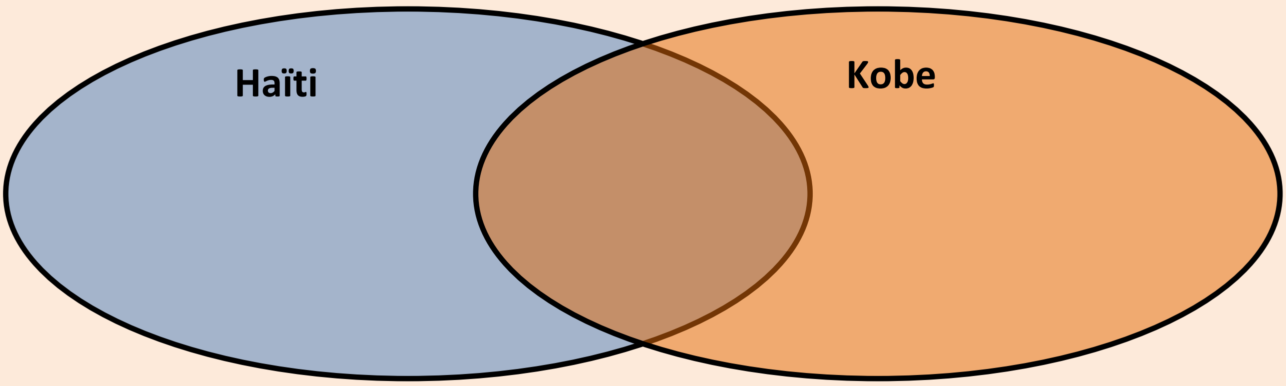
Long term recovery:

Figure 19 Recovery efforts after the Haiti Earthquake
By Daniel Barker, U.S. Navy

- **The EU gave $330 million** and the World Bank waived the countries debt repayments for 5 years.
- The Senegalese offered land in Senegal to any Haitians who wanted it!
- **6 months** after the quake, **98% of the rubble remained uncleared**, some still blocking vital access roads.
- The number of people in relief camps of tents and tarps since the quake was 1.6 million, and almost no transitional housing had been built. Most of the camps had no electricity, running water, or sewage disposal, and the tents were beginning to fall apart.
- Between 23 major charities, $1.1 billion had been collected for Haiti for relief efforts, but only two percent of the money had been released
- One year after the earthquake 1 million people remained displaced
- The Dominican Republic which neighbours Haiti offered support and accepted some refugees.
- Medicines San Frontiers, a charity, tried to help casualties whilst the USA took charge of trying to coordinate Aid distribution.

ACTIVITIES 1.05b

1. Describe the location of the Haïti earthquake using the map on the previous page
2. Draw then complete the Venn diagram below to compare the similarities and differences between the Haïti and Kobe earthquakes



1.06 Reasons why people continue to live in areas at risk from tectonic hazards.

Around **500 million** (in 2000) **people live on or close to volcanoes**. By 2025 it is estimated that 600 Million people will be living in tectonically active areas. For example, 961,000 people live in Naples, Italy, despite being at the foot of the dangerous Mount Vesuvius. Popocatapetl (pronounced poh-poh-kah-teh-peh-til) is a volcanic mountain less than 50 miles from Mexico City (one of the largest megacities in the world) in Mexico.

Often people live in these zones because they decide that the advantages of the place outweigh the risks. Most volcanoes and earthquake zones are safe for long periods in between eruptions or earthquake events. Frequently tectonic events can be adjusted to and are considered by the residents as being predictable.

Reasons for living close to volcanoes;

1. Some settlements have grown into enormous cities and would be **hard to move** anywhere else	2. Some places are **well prepared** for hazards so people feel safe	3. A **good job and way of life** may keep you in a danger zone
4. Sulphur can be **mined**, Ljen volcano has a crater lake, which is the site of a sulphur mining operation, because of the high sulphur levels on the lake floor	5. **Volcanic soils are fertile** as the weathering of volcanic rock releases potassium into the soil, which is essential for plant growth e.g. Naples, Italy has olives, vines, nuts and fruit (mainly oranges and lemons) growing area to Mount Vesuvius.	6. **Tourism is a popular activity in these areas. Mount Etna**, attracts thousands of **tourists,** who travel in cable cars and 4 wheel drives to the crater, providing a range of jobs for local people. The Blue Lagoon in Iceland is heated by geothermal heat and 1.2 million people visited the Lagoon in 2010
7. Magma contains a large amount of minerals, such as, copper, gold, silver, lead and zinc. After an eruption this magma cools and these minerals can **be mined. E**.g. Yanacocha gold mine in Peru	**8.** Large settlements in seismic zones offer **job opportunities**, such as San Francisco in the USA. San Francisco is in the Bay area, which has a GDP of $535 billion, & ranks 19th in the world when compared to national economies.	9. People in Mount Merapi, Indonesia, **worship ancient spirits** believing they will warn them of an eruption, on a full moon they throw items into the volcano crater to calm the volcano's spirits.
10. The World's best **coffee** is grown on volcanic soil in Columbia.	11. People believe the chances of the **volcano erupting** are very slim	12. In **Iceland** volcanoes provide **cheap geothermal power**, 28 % of all its energy. This is even used to **heat pavements** in winter in Reykjavik.
13. Poor people, especially in LICs **cannot afford to live away from volcanoes** as they provide jobs and their families and friends live there.	**14.** Basalt is found in volcanic areas and can be used in **construction and to build roads.**	15. **Engineering** can make people feel safe in these areas in richer parts of the world. Buildings can be made to be earthquake proof like the Bird's Nest stadium in Beijing.
16. Many **volcanic and earthquake events are INFREQUENT** – so people don't think they will get caught up in a disaster.		

1.07 How monitoring, prediction, protection and planning can reduce the risks from a tectonic hazard.

The human race is still not capable of predicting exactly when and where volcanoes and earthquakes will occur. Large scale monitoring of tectonic activity does allow us to narrow down the locations and time frames however, and we monitor volcanoes and earthquakes in many ways. The most widely used method is studying the geographical area of the volcano.

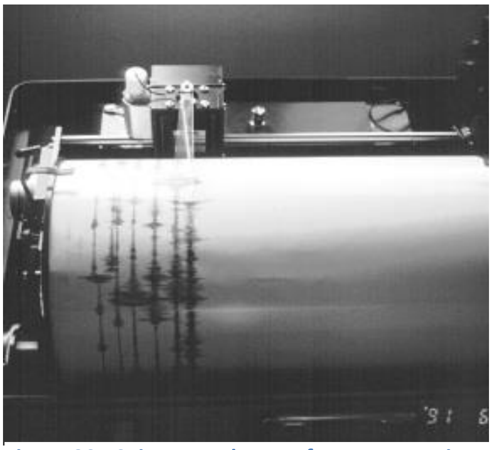


Figure 20 - Seismograph trace from Mount Pinatubo

VOLCANOES

Seismic waves

Scientists can use seismic or earthquake waves to show if a volcano is getting ready to erupt. Many volcanoes experience an increasing intensity in frequency and size of earthquakes as they prepare to erupt. We can monitor these using seismometers which produce seismographs. This technique was used in Nevado Del Ruiz in 1985 and for Mount Pinatubo in 1991.

Monitoring gas emissions

As Magma rises into magma chambers gases escape. One of the main gases is Sulphur Dioxide, and if its quantity in escaping volcanic gas increases this can signal the start of a major eruptive sequence. In the Mount Pinatubo Volcanic event the amount of Sulphur Dioxide increased by 10 times in 2 weeks.

Ground deformation

The movement of magma within the crust can deform the ground above. This has been witnessed at Yellowstone beneath Yellowstone Lake. This swelling of the volcano signals that magma has collected near the surface. Scientists monitoring an active volcano will often measure the tilt of the slope and track changes in the rate of swelling. Mount St Helens showed this prior to its eruption in 1980.

Satellite Images and Remote Sensing

Remote sensing is the use of satellites to detect things about the Earth's surface. This is useful for monitoring any changes in volcanoes at the surface. Using satellites we can monitor the heat or thermal activity of the volcano to check for upwelling magma, we can check for escaping Sulphur dioxide using gas sensing and we can look to see if the ground is deforming by checking before and after images of the ground.

Key words

- Management strategies - Techniques of controlling, responding to, or dealing with an event.
- Monitoring - Recording physical changes, such as earthquake tremors around a volcano or tracking a tropical storm by satellite, to help forecast when and where a natural hazard might strike.
- Planning - Actions taken to enable communities to respond to, and recover from, natural disasters, through measures such as emergency evacuation plans, information management, communications and warning systems.
- Prediction - Attempts to forecast when and where a natural hazard will strike, based on current knowledge. This can be done, to some extent for volcanic eruptions and tropical storms, but less reliably for earthquakes.
- Protection - Actions taken before a hazard strikes to reduce its impact, such as educating people or improving building design.

EARTHQUAKES

Seismometers

For earthquakes the equipment above is used plus other equipment and measures, these include;
Using foreshocks by monitoring seismic waves– we often get small earthquakes before "the big one" that can give warnings. The Japan Tsunami (mag 9.0) was preceded by a massive magnitude 7.2 earthquake.

Animal Behaviour

Animal behavior has been suggested as a method, as many observations have shown that animals react to an earthquake before the event and well before human beings.
Tilt meters can show ground deformation, leading to an earthquake. These have been replaced in many cases by more modern and wider ranging satellite imagery.

Laser beams

Laser beams can be used to detect plate movement by directing the beam across the fault line.

Protection

The best way to protect people from tectonic hazards is to look at the way we construct buildings and roads. Buildings can be designed to withstand the shaking of the earth and to limit the loss of life and damage caused. The Transamerica pyramid has a shape that can withstand seismic waves and withstood the 1989 Loma Prieta earthquake which struck San Francisco. Other strategies include rolling weights on the roofs of buildings, shatterproof glass to prevent scattering glass during a quake, emergency shutters for glass, gas shut off valves and identification numbers on buildings.

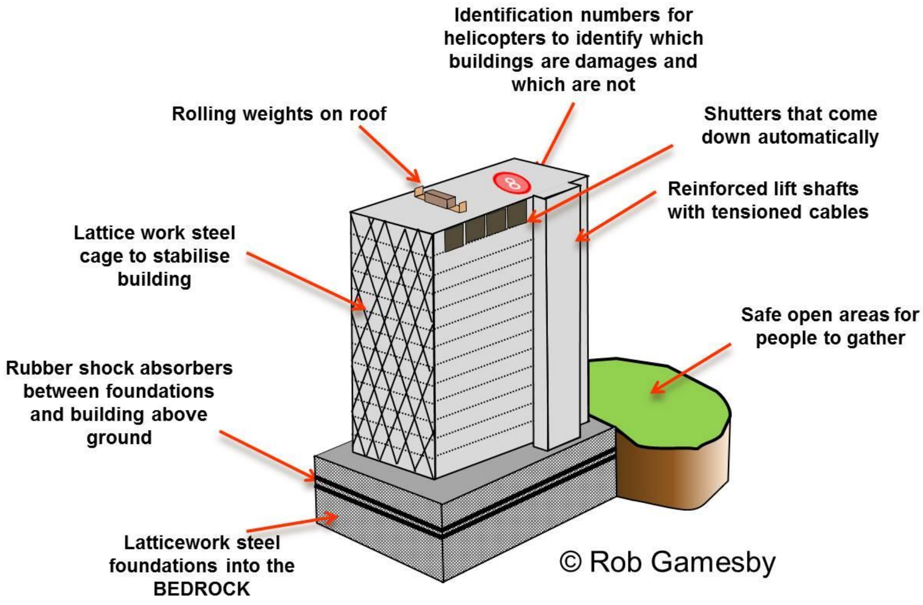


Figure 21 - Earthquake "proof" or life safe buildings

Planning

We can also plan for earthquake and volcanic activity. Prior to events we can plan where we will or will not allow building. Preventing building on softer sediments can protect people from the worst of the shaking and liquefaction during earthquakes for example. Plans should also be in place prior to events so that emergency services know what to do during a volcanic or earthquake event.

ACTIVITIES 1.07

1. Classify the reasons people live close to volcanoes into social, economic and environmental factors.
2. Is it sensible for people to continue to live in zones with earthquake risks. Fully justify your response using evidence from the previous 2 pages.

1.08 Global atmospheric circulation

The Earth's atmosphere is in constant motion and is **driven by the energy we receive from the sun**. The air moving around the globe does so because we get **more energy in tropical areas** and less at the poles. Air movements or winds help to balance this out. They do so according to the model below.

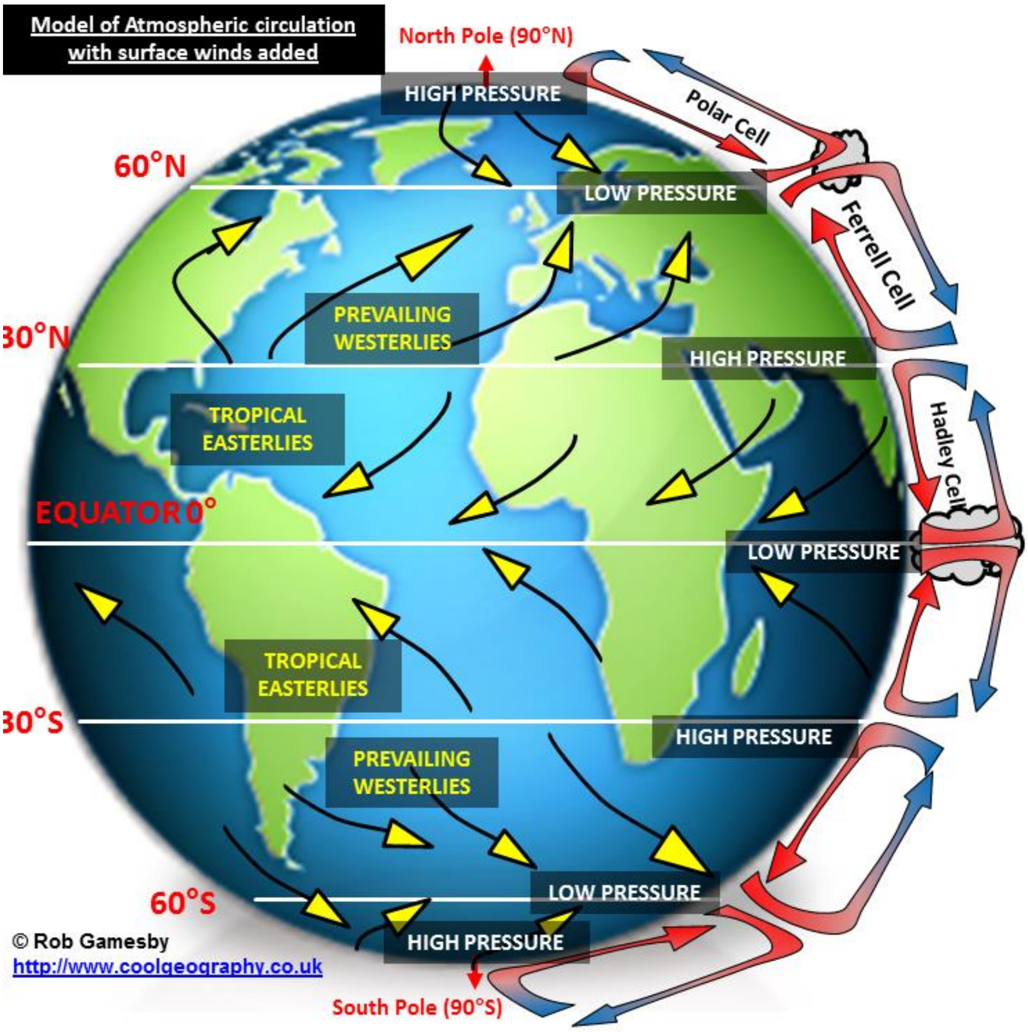


Figure 22 - A model of atmospheric circulation

Most insolation arrives between the 2 Tropics. This causes air to rise from the surface UP through the atmosphere in thermals at the Inter Tropical Convergence Zone (ITCZ). This creates huge cumulonimbus clouds as the air cools, Tropical storms with low pressure occur here. As the air heads North and South it cools and then sinks back down to the surface at approximately 30°N & S giving HIGH pressure. This goes back to the Equator as the TRADE winds or tropical easterlies. Two further cells exist further North and South. These cells are called the Hadley, Ferrel and Polar cells, giving 6 in total (3 in either hemisphere).

- Where air is sinking in the model this gives high pressure. These areas coincide with many of the earth's deserts and dry areas as the air is sinking so little condensation occurs as the air warms.
- Where air is rising in the model this gives low pressure. These areas coincide with wetter areas with lush vegetation as air cools as it rises, allowing water vapour to condense to droplets allowing more rain.
- **WINDS occur because air molecules move from areas of high pressure to areas of low pressure**.

The model is disrupted by mountain ranges and differences between the land and sea.

1.09 Tropical storms – what, where and why.

Tropical storms are an area of **low pressure** with winds moving in a spiral around the calm central point called the **eye of the storm**. Winds are powerful and rainfall is heavy. They can last for days to weeks within the Tropical regions of our planet.

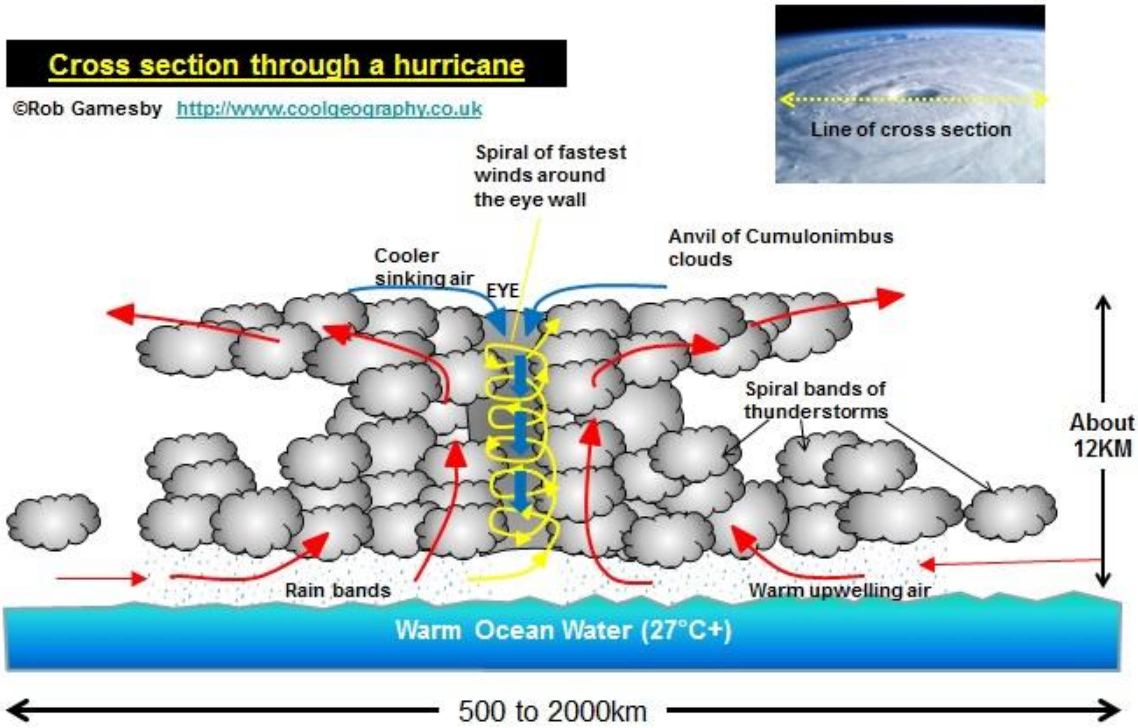
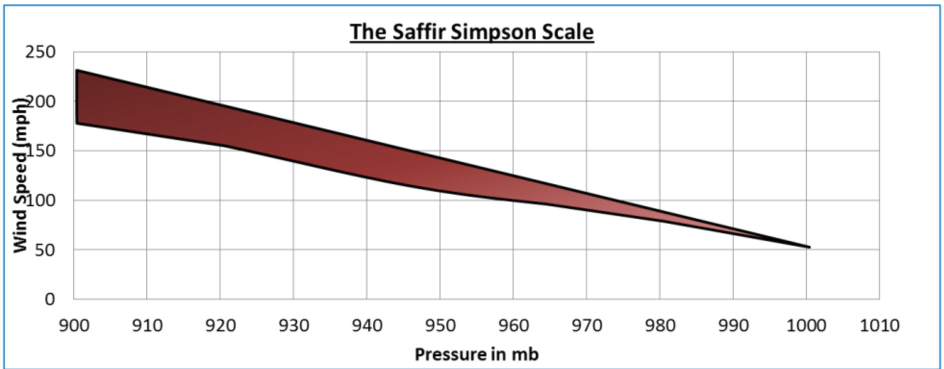


Figure 23 - a cross section through a tropical storm

Hurricanes occur when these tropical storms develop wind speeds of over 74mph (miles per hour). They are known by many names, including hurricanes (North America), cyclones (India) and typhoons (Japan and East Asia). Tropical storms are defined by their wind speeds and the potential damage they can cause, using what is known as the Saffir Simpson scale, shown below. Many tropical storms form between the tropics, some develop into tropical depressions but not many actually develop into full blown hurricanes/cyclones/typhoons.

Wind speeds are used to decide what category of storm a tropical storm is, over 120Kph or 74 miles per hour is needed for a category 1 hurricane, over 250Kph or 155 miles per hour is the worst hurricane, a category 5 which would cause extreme damage. As can be seen on the map, these storms all start within the Tropics over warm ocean waters. Their paths then take them outside of the tropics and they die out over time once they have made landfall. The most tropical storms can be found in the Asian Pacific.



Category	Wind speed (mph)	Pressure	Size of storm surge
Tropical Storm	< 74		0-0.9m
1	74 – 95	>980	1.2 - 1.5m
2	96 – 110	965 – 979	1.8 – 2.4m
3	111 – 130	945 – 964	2.7 – 3.7m
4	131 – 155	920 – 944	4.0 – 5.5m
5	>155	<919	> 5.5m

Figure 24 - The Saffir Simpson scale

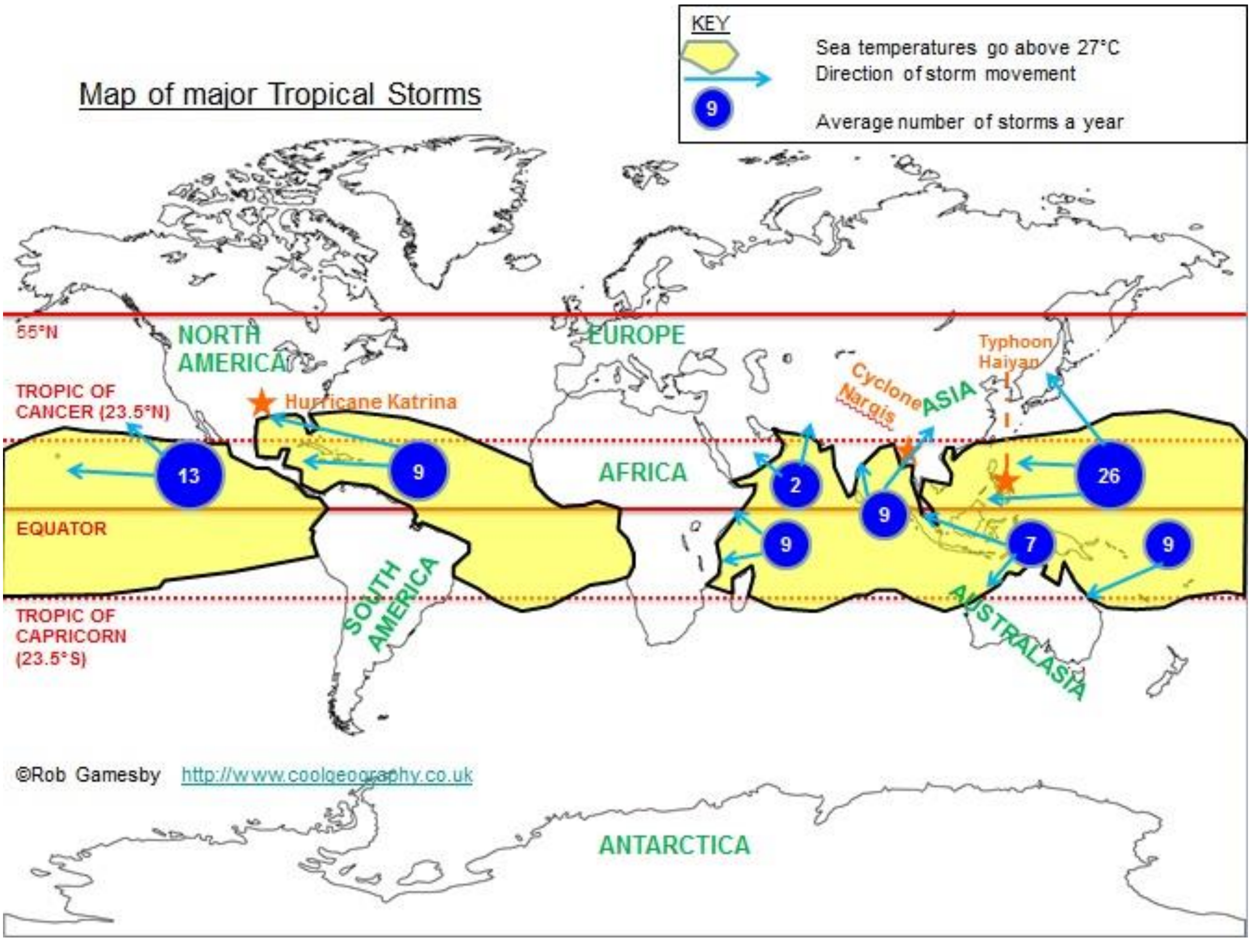


Figure 25 - the global location of tropical storms

How tropical storms form

- Step 1 — The sun sends incoming solar radiation to Earth which warms our oceans
- Step 2 — This warms the oceans to a critical 27°C
- Step 3 — This causes warm MOIST air to rise through the air in THERMALS. This gives LOW PRESSURE at the centre of the storm
- Step 4 — This air cools as it rises, at 1°C per 100m, this causes condensation to occur, clouds to form and rain to occur
- Step 5 — Some cooled air sinks back down helping to create the EYE
- Step 6 — Air rushes in from higher pressure areas outside of the storm to lower pressure areas at the centre of the storm creating winds
- Step 7 — The whole storm rotates because of the Earth's spin

ACTIVITIES 1.09

1. Produce a simple flow chart describing how air moves around the globe as shown on figure22.
2. Describe where tropical storms can be found using the map above.
3. Why don't we get tropical storms in the UK? Use the flow chart opposite to help your answer.

1.10 How climate change might affect the distribution, frequency and intensity of tropical storms.

Climate change is a long-term change in the earth's climate, especially a change due to an increase in the average atmospheric temperature. Recent warming of the climate means that there is more energy available in the atmosphere and ocean waters to fuel tropical storms. The graph showing the total number of storms in the North Atlantic shows that despite a warming of global temperatures this **HAS NOT** had a significant impact on the **FREQUENCY** number of moderate to long lived storms. We have, however, seen an increase in the number of short duration storms that are hurricane intensity for 2 days or less.

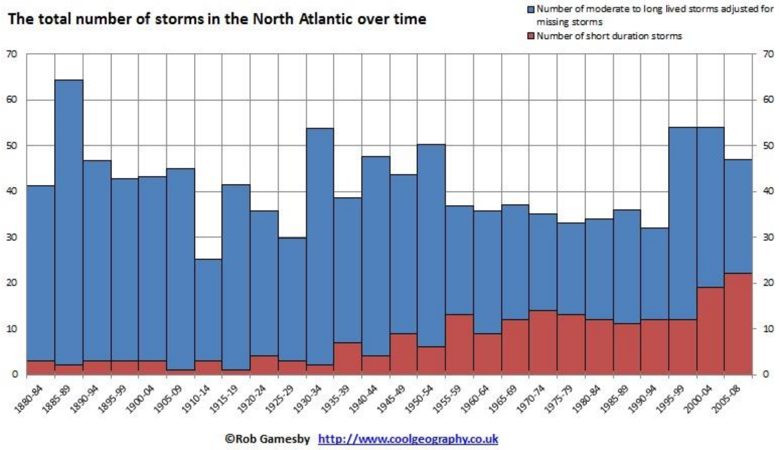


Figure 26 - Tropical storm totals

What has **increased** due to warmer temperatures has been the **INTENSITY** of the storms experienced. The trend line on the graph shows that accumulated storm energy is clearly going up over time. Stronger winds like this will result in greater damage to human property and unfortunately higher STORM SURGES, (huge waves of water pushed up onto the land) which kill the majority of people that die in tropical storm events.

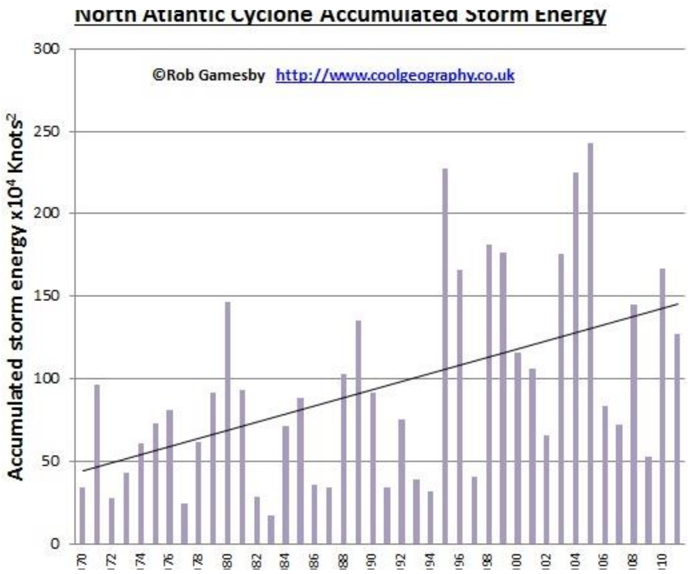


Figure 27 - Accumulated energy of North Atlantic storms

The **DISTRIBUTION** of tropical storms is also predicted to change. The map shows where we will experience changes in the Power Dissipation Index. Significant areas around the globe will experience stronger storms, and some of those areas are outside of the current areas were ocean temperatures go above 27°C. So in summary, although the number of storms has not gone up, the strength or intensity of the storms is going up and these storms are affecting more parts of the globe, thanks to warmer temperatures due to climate change.

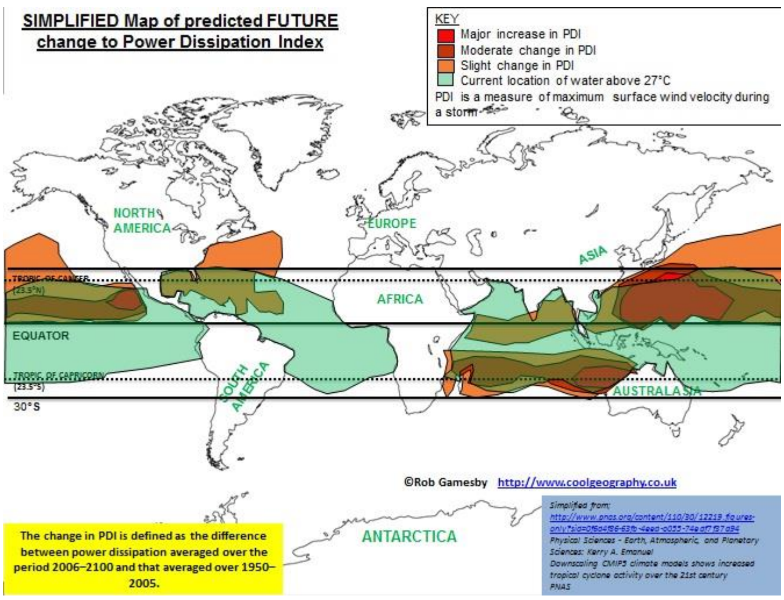


Figure 28 - Map of changes to storm intensity

1.11 A case study of a tropical storm Haiyan

The Philippines consists of a group of islands in the **South China Sea**. The country regularly suffers from large typhoons that move in from the south west every year during the tropical storm season. This case study is about **Typhoon Haiyan**, which is unofficially the fourth most intense tropical cyclone ever observed.

Facts about the Philippines & UK (from CIA Fact book 2014)

Indicator	Philippines	UK
Population	108 million	64 million
GDP per capita PPP	$4700	37,700
People Living in Poverty (less than $2 per day)	27% of the population	16.2%
Access to Clean Water	95.4% of the population	100%
Life Expectancy	72 years	80.4years
Literacy Rate	48.7%	99
People Per Doctor	1.15 doctors per 1000 people	2.81 doctors per 1000 people

Key words

Economic impact - The effect of an event on the wealth of an area or community.

Environmental impact - The effect of an event on the landscape and ecology of the surrounding area.

Primary effects - The initial impact of a natural event on people and property, caused directly by it, for instance the ground buildings collapsing following an earthquake.

Secondary effects - The after-effects that occur as indirect impacts of a natural event, sometimes on a longer timescale, for instance fires due to ruptured gas mains, resulting from the ground shaking.

Social impact - The effect of an event on the lives of people or community.

BACKGROUND CAUSES

The Philippines sits in an area of seasonally warm ocean water (sea temperatures over 27°C) and has enough Coriolis Force to create rotating winds over the ocean's surface.

Sea-level rise is happening globally but is particularly affecting the Philippines. It is caused by global warming and has gone up by about 20cm since 1900. These sea level rises create **larger storm surges**.

Use of groundwater has caused parts of the country to sink.

The worst affected city, Tacloban, is at the end of a bay that funnelled water from the storm surge.

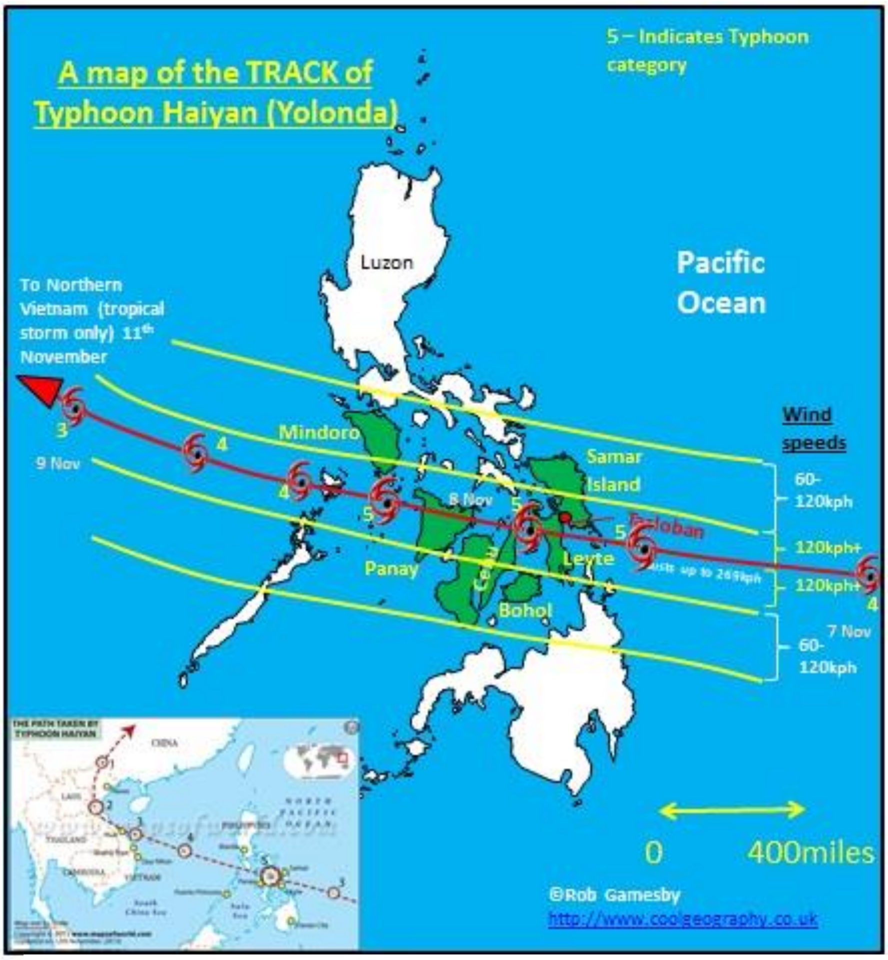


Figure 29 - Map of the track of Typhoon Haiyan

Timeline of development;

- 2nd November 2013 – Typhoon Haiyan starts as an area of low pressure several hundred kilometers east-southeast of Pohnpei in the Federated States of Micronesia.

- 3rd November – moves west and develops into a tropical depression
- 4th November - Haiyan becomes a tropical storm
- 5th November - the system began a period of rapid intensification that brought it to typhoon intensity.
- 7th November - Typhoon Haiyan made landfall in Guiuan, Eastern Samar
- 10th to 11th of November - Haiyan reaches Vietnam and weakens in intensity

Impacts

Quick facts according to the Disasters and Emergency Committee of the UK

- Typhoon Haiyan - known locally as Yolanda - hit eastern Samar Island at 8.40pm GMT on 7 November 2013 (4.40am 8th November local time).
- It caused a storm surge – a wall of water – that was 25 feet high in some areas, including in the town of Tacloban.
- Over 14 million people were affected across 46 provinces.
- The city of Tacloban, home to more than 220,000 people, suffered more loss of life than any other area of the Philippines.
- Five million people saw their homes severely damaged or destroyed (550,000 houses destroyed and an additional 580,000 houses were severely damaged).

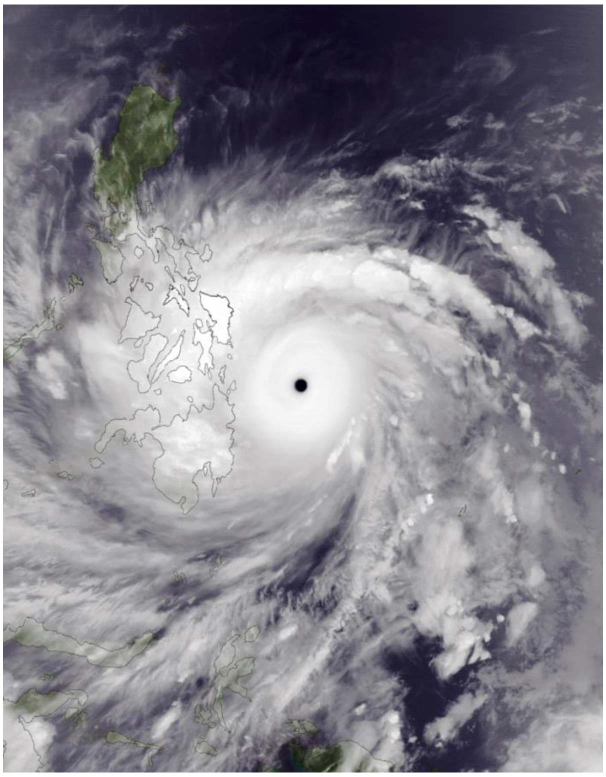


Figure 30 - NASA image of Typhoon Haiyan
By NASA, LAADS Web,

Typhoon Haiyan is one of the most devastating storms of recent history. It killed approximately **7400 people** (6,340 confirmed, 1,061 missing) and **affected 9 million people**. Immediately after the storm the Philippines faced a humanitarian crisis after the Visayas Islands in the central part of the country had 1.9 million homeless and more than 6,000,000 displaced.

Figure 31 - devastation in Tacloban
By Trocaire from Ireland (DSC_0749)

The economy was affected, with **estimated losses at $2.9billion** with much of this in agriculture. The major rice and sugar producing areas for the Philippines were destroyed. A total of 131,611 tons of rice was lost (Food and Agriculture Organisation (FAO)), together with much of the coconut crop which is nearly half the Philippines agricultural exports (the country is the world’s biggest producer of coconut oil). 5.9 million Workers lost income sources according to USAID. Tacloban airport terminal building was also completely destroyed by a 5m storm surge.

The United Nations feared the possibility of the spread of disease is high due to the lack of food, water, shelter, and medication. In addition, casualties were reported as a result of the lack of aid in affected areas. Socially people were affected; they became refugees in lass affected areas and migrated there. Also, fishing communities were affected with the storm destroying boats and associated equipment.

The natural environment was also affected, with loss of forests, trees and widespread flooding. Local ecosystems were also affected by sewage leaking from overwhelmed sewage systems and oil leaks. A lack of sanitation in days following the event also leads to a higher level of pollution.

Management & responses

The government was criticised for its slow response to this event. However, the Philippines formally declared "A State of National Calamity" and asked for international help; one day after the Haiyan hit the country. A week after the typhoon had struck President Benigno Aquino was under growing pressure to speed up the distribution of networks or food, water and medicine to desperate survivors and to get paralysed local governments functioning. However, the storm damaged infrastructure making response difficult. For example, the Tacloban city government was decimated, with just 70 workers in the immediate days after the disaster compared to 2,500 normally. Many were killed, injured, lost family or were simply too traumatised to work.

By December, water tanks had been installed by charities like Oxfam but not in all areas.

A water tank, filled with 10,000 litres of clean fresh water is installed in Maribi, Leyte (December 2013). Anne Wright/Oxfam

Figure 32 - Water aid after the Typhoon

6 Months later, many people still had limited access to shelter and water. NGOs like the International Red cross were trying to provide adequate settlements, fresh water access and access to jobs/livelihood.

The Philippines authorities have invested in disaster risk reduction (DRR) and climate change adaptation (CCA). They spent $624m on this in 2011 – two per cent of the national budget and 0.28 per cent of GDP – while at least five per cent of a local authority's revenue is set aside for its Local Disaster Risk Reduction Management Fund

ACTIVITIES 1.11

Draw then complete the case study table to summarise the ESSENTIAL information about this earthquake;

Background (where, when, size)		
Causes		
Effects	Short term	
	Long term	
Responses	Individuals	
	Agencies	
	Governments	

1.11 Types of weather hazard experienced in the UK – Depressions and Anticyclones

It is hard to believe at times but the British Isles are home to nearly every hazard on planet Earth. Despite being far from a plate margin, Britain gets small earthquakes from old fault lines that run through the country. Britain also has extinct volcanoes - Edinburgh castle is built on top of an ancient volcanic rock outcrop! Our most common hazards include floods, which seem to be increasing in intensity and frequency, cold weather - the winter of 2010-11 being a great example, and storms, brought to us by mid latitude depressions from the Atlantic.

We also get less obvious hazards, Britain gets over 30 Tornadoes a year, suffers from extreme coastal erosion, has had many heat waves and droughts (especially in the last 30 years).

These hazards have a DISTINCT GEOGRAPHIC PATTERN of distribution. The **storms or depressions** that bring windy and wet weather to Britain **occur mainly in the WEST and the North**, and the North West of Scotland gets these storms most often and at the greatest intensity. **Flooding** occurs in **low lying areas** around rives and at the coast, and more people than ever are living in flood risk areas. Extreme cold weather can affect all areas of the British Isles but is most likely in the North and at altitude, whereas heat waves are most likely in the South East. Tornadoes are most likely in the south in inland areas.

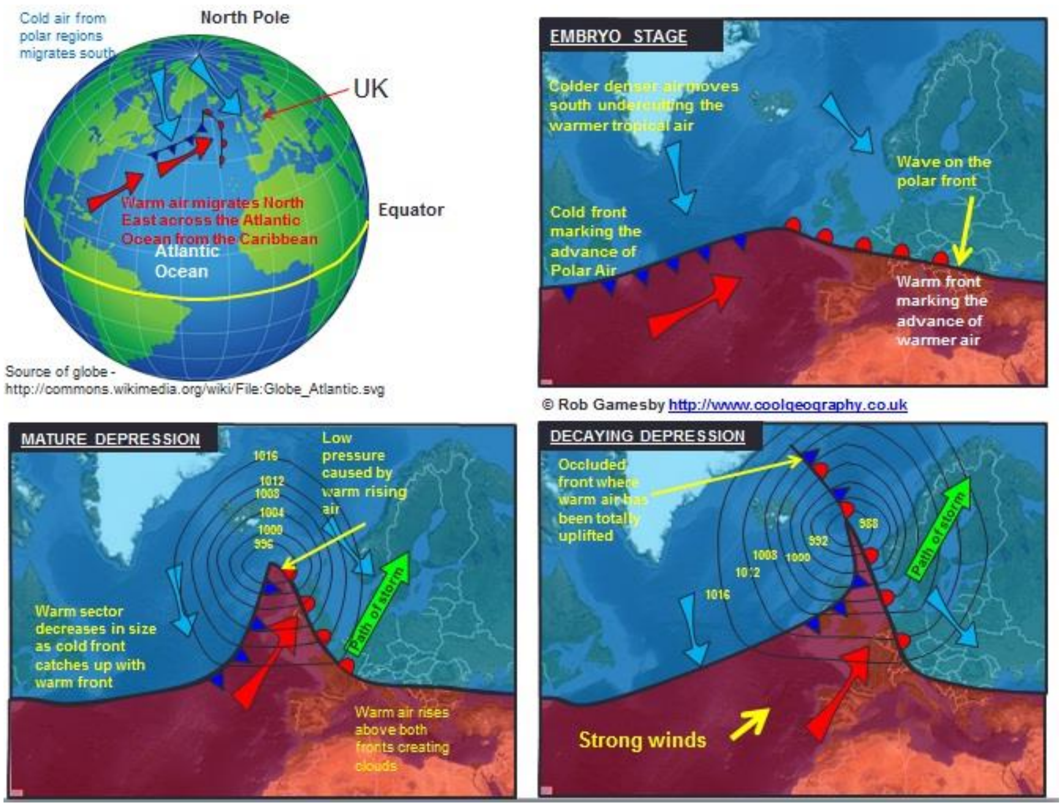


Figure 33 - the formation of a depression

DEPRESSIONS

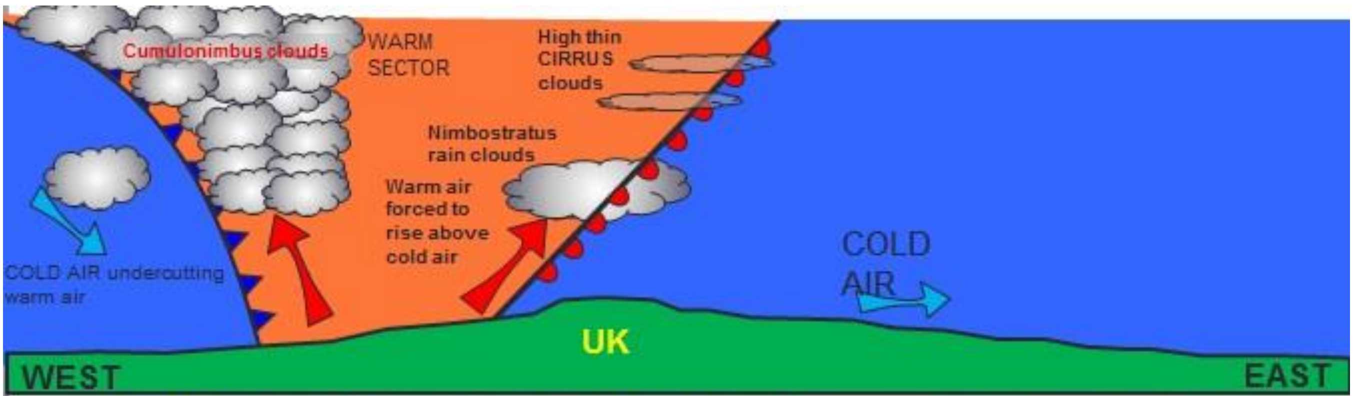
A **depression** is an area of **low atmospheric pressure** and the British Isles experience them throughout the year but the most severe and frequent occur in autumn & winter. They bring **strong winds** and lots of **rainfall**.

The formation of a depression

1. Depressions are low pressure storm systems and affect the British Isles throughout the year. The often occur at the Polar Front, which is also associated with a jet stream above that front, and bring wet and windy weather to the British Isles.
2. Warm Tropical air migrates north from the Tropics, and meets cold polar air migrating south from the Arctic Regions over the Atlantic Ocean. They meet at a point called the Polar Front. These storms are characterized by large scale bands of precipitation, several hundreds of kilometers long and up to 160km wide.

3. Where these 2 air masses meet an EMBRYO depression is formed, which is recognized as a wave in the polar front.
4. The warm air is undercut by the advancing cold air at the fronts and because it has more energy and is less dense is forced to rise upwards at a COLD FRONT. Ahead of this, warm air advances into cold air and is also forced to rise above this denser cold air at a WARM FRONT. The air rises in a spiral motion, and this creates low pressure at the earth's surface at the center of the storm.
5. At both fronts air is rising, so it cools down and creates water droplets (cloud formation) and eventually rain (once the droplets have collided enough to be big enough to fall) AT BOTH FRONTS.
6. The cloud types at the 2 fronts are different however. Cirrus, cumulus and Nimbo stratus are common on the warm front where warm air is slowly lifted over the cold air in front of it. This gives prolonged but lighter rainfall. Cumulonimbus and stratus clouds form at the trailing cold front, as the uplift of warm here is more rapid.
7. Air rushes in from higher pressure areas around the depression giving the high winds we often associate with depressions.
8. The final stage of the depression life cycle model is where the cold front catches up with the warm front and an OCCLUDED FRONT is created. This is the decay stage of the storm where there is no warm Tropical Maritime air in contact with the ground, it has all been uplifted.

These storms are hazardous because they bring extreme rainfall at both fronts, very high wind speeds and these winds also create huge waves which batter our coastline (and could cause coastal flooding).



	COLD SECTOR	COLD FRONT	WARM SECTOR	WARM FRONT	AHEAD OF WARM FRONT
Pressure	Continues to rise	Starts to rise	Steadies	Continues to fall	Starts to steadily fall
Temperature	Cold	Drops	Warm	Rises	Cold but rising
Cloud Cover	This, some cumulus	Thick, sometimes cumulonimbus	Thin with breaks in cloud	Cloud base low and thick, nimbostratus	Some clouds – cirrus and altostratus higher up
Wind speed and direction	Squally	Speeds increase with change in direction	Remain steady	Wind changes direction and blustery strong gusts	Speed starts to increase
Precipitation	Showers	Heavy rain	Turns to drizzle then stops	Showers & at times heavy rainfall	None at first, then rain closer to the front

Figure 34 - The Weather across a depression

© Rob Gamesby http://www.coolgeography.co.uk

Cross section through a depression

ACTIVITIES 1.12

1. List all of the extreme weather events that affect the UK that you can think of.
2. Explain fully how a depression forms.
3. Contrast a depression weather system with an anticylcone

Anticyclones

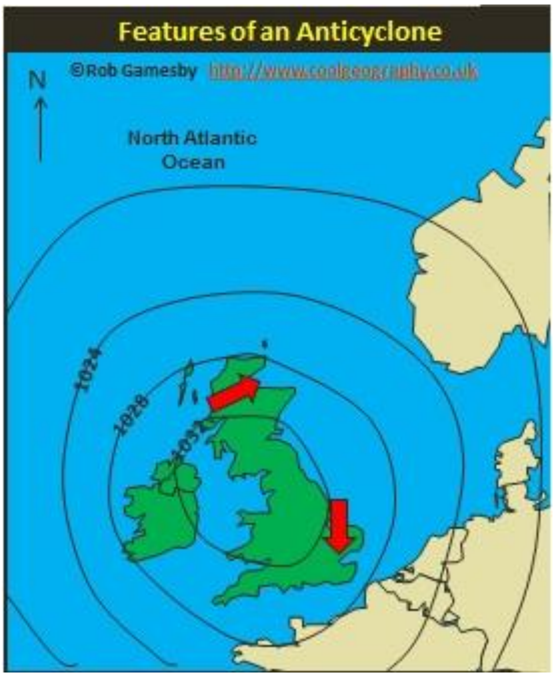


Figure 35 - features of an anticyclone

Anticyclones are the **OPPOSITE** of depressions. They are areas of **high pressure** where **air sinks** to the earth's surface. As the air sinks it warms so condensation does not occur and there are very few clouds. This gives clear skies. Anticyclones have **low wind speeds**, widely spaced isobars and stable conditions. Anticyclones only involve one type of air mass which usually cover large areas and do not have any fronts. Anticyclones can occur in both winter and summer.

Anticyclones can be **very large**, at least 3,000 km wide which is much larger than depressions. They can give several days of settled weather.

In winter

In winter the longer nights combined with clear skies leads to intense cooling of the land. There is an increased risk of dew, frost and thicker, more extensive fog patches which may be slow to clear or even persist.

Under very calm conditions, both frost and fog may persist for several days. An anticyclone's very stable conditions and little air movement means that pollution is trapped at low levels, resulting in very poor air quality such as smogs.

In summer

In Britain in summer an anticyclone will mean heat waves during the day. At night, however, as there are no clouds, heat will be quickly lost. The ground will cool sufficiently to cause condensation of water vapour in the descending warm air and mist or heavy dew may form. This will clear quickly in the morning sun. After a few days, a layer of hot air builds up at ground level, which eventually will give rise to thunderstorms, ending the anticyclone. Indeed, summer anticyclones can result in "Heat wave" conditions with temperatures significantly above average. One such event occurred in the summer of 2003 affecting continental Europe and the UK, it proved to be particularly hazardous to humans.

Figure 36 - typical winter anticyclone frosts

1.13 Evidence that weather is becoming more extreme in the UK.

The UK's weather appears to be becoming more extreme. Temperatures seem to be following the global pattern and continually and slowly rising.

The ten hottest years on record have all come within the last 20 years.

In addition, 6 of 10 wettest years on record have come in the last 20 years.

There have been a number of major weather events over the past 2 decades including;

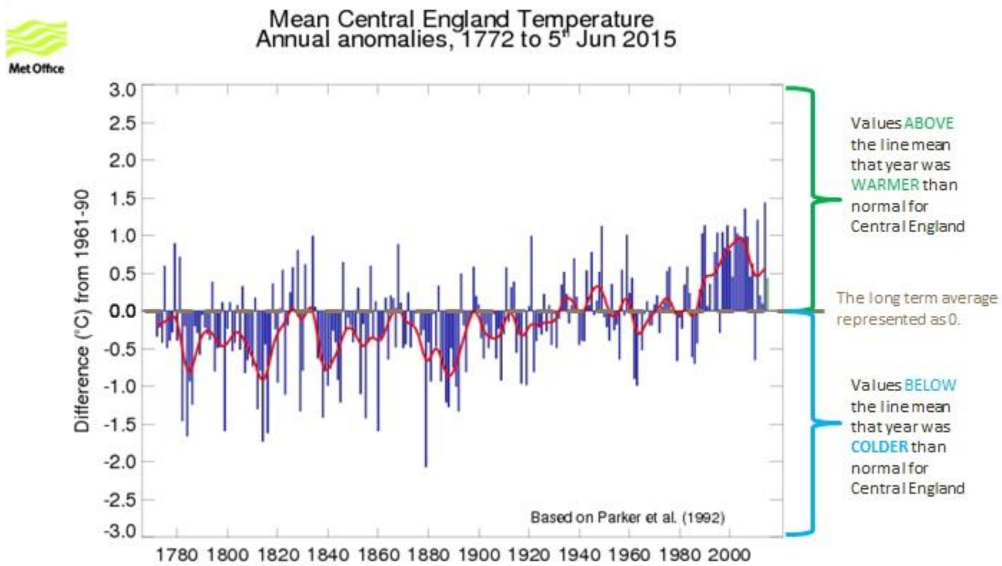
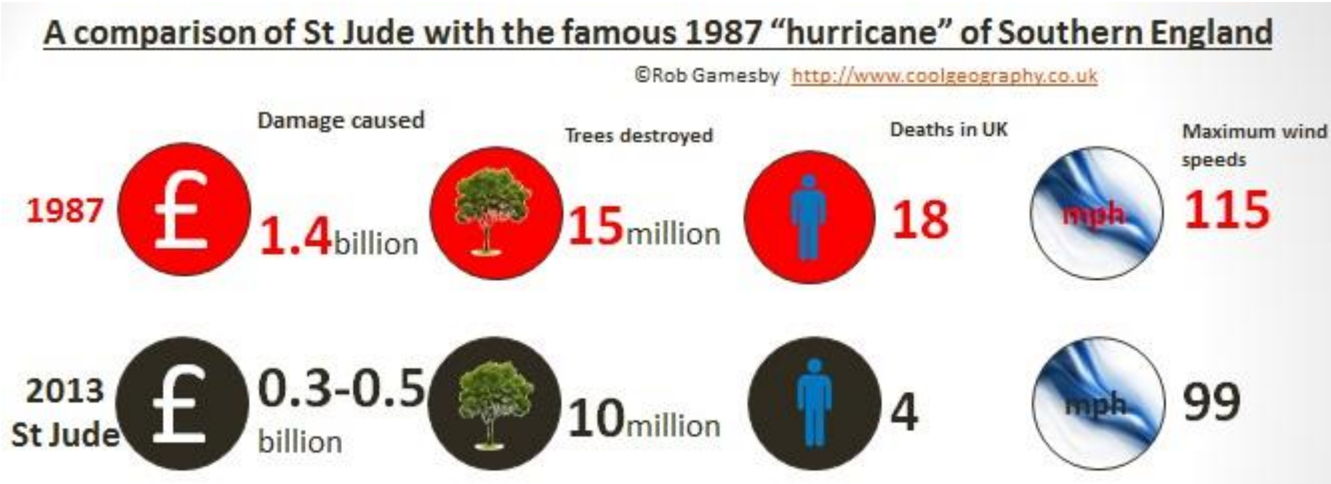


Figure 37 - Temperature records for Central England

- 2000 – **Atlantic depressions** brought lots of **rain and gale force winds** that hit large parts of the south of the UK, disrupting people's lives
- 2003 – The UK was affected by a summer anticyclone which brought a period of settled weather. This allowed a heat wave to develop that gave the highest ever recorded temperatures of 38.5°C at Faversham in Kent. The heatwave was responsible for 2,000 deaths in the UK alone, with more across Europe.
- 2007 – Flooding affected huge parts of the country and caused widespread damage to people's homes. Flood events affected Hull and Sheffield in the North, and Toll Bar near Doncaster. The south of the UK also suffered, Tewkesbury on the River Severn made the headlines as flooding totally isolated the town and other parts of Gloucester were affected. Large areas of farmland were destroyed, the A38 was impassable and crops and livestock were affected.
- **2008** – A **wet summer** resulted in many more flooding events as water could not soak into saturated ground. Parts of Somerset were affected as well as Morpeth in Northumberland.
- 2009-10 – The winter big freeze, mean temperatures were only 1.2°C, the lowest since 1978-79. Huge amounts of snowfall paralysed the country and brought roads to a standstill, closed schools and put enormous strain on the NHS
- 2010 – March 2012 – large parts of England suffer a major drought with reservoir levels falling to very low levels. This was caused by very low rainfall levels.
- 2012 – April- July – record flooding events – caused by record rainfall events – includes Thunder Thursday which brought Tyne and Wear to a standstill
- 2013-14 – A winter of incredibly powerful storms that caused coastal flooding in large parts of the UK and damaged a railway line along the coast in Dawlish, Devon
- **2014** – The **hottest year** ever on record - the UK's mean temperature for the year 2014 was 9.9 °C, which is 1.1 °C above the long-term (1981-2010) average and beats the previous record of 9.7 °C set in 2006.
- **2015 – 2016** – **flooding** across the North of the UK after a sequence of depressions hit the country, including storm Desmond

1.14 Extreme weather event in the UK – The St Jude storm of 27th and 28th of October 2013



The St. Jude storm was a huge LOW PRESSURE DEPRESSION that struck the UK between 27th and 28th of October 2013 before going on to affect other parts of Northwest Europe. It caused 17 deaths across Europe and was also known as **Cyclone Christian**

Key words

Extreme weather - This is when a weather event is significantly different from the average or usual weather pattern, and is especially severe or unseasonal. This may take place over one day or a period of time.

Immediate responses - The reaction of people as the disaster happens and in the immediate aftermath.

Long term responses - Later reactions that occur in the weeks, months and years after the event.

Causes

1. The storm started as a depression forming off the east coast of the United States in the North Atlantic along the Polar Front, the boundary between warm and cold air.
2. It headed east helped by a strong jet stream, a high up ribbon of fast moving air circling the globe in a West east direction.
3. As the storm moved east it passed by the remnants of ex-tropical storm which added extra warm air and energy to the storm.
4. This, together with a strong jet stream, led to a rapid deepening of the St. Jude low before it hit the UK then Western Europe as a strengthening storm.
5. The storm system was swept across the Atlantic at a rapid pace moving eastwards with an average speed of 77 km/h (48 mph),

Storm facts

1. It crossed over 2000 km (1240miles) in less than 26 hours.
2. Pressure were very low, reaching in the UK
3. The storm got worse over the North Sea and pressure dropped to 965Mb in Denmark which also suffered its fastest ever recorded winds of 120.8mph
4. Winds were enhanced by a sting jet – where cooled air rapidly descends from the upper atmosphere

Forecasting

The Met Office predicted the passage of the storm with a **good degree of accuracy** which contrasts to the famous "hurricane" of 87 when they got the forecast wrong.

It was forecast in the week before it occurred using a supercomputer. On the 24th of October warnings were given that the south coast would be affected. Later, it was forecast that the storm would pass over the United Kingdom on a more northerly track, affecting all areas south of the Midlands.

Predictions were for 20–40 mm (0.6–1.2 in) of rain, with wind speeds of 80 miles per hour (130 km/h) falling in a period of six to nine hours. These were later updated, with winds of Force 11 (a violent storm of 102.4–117.4 km/h) predicted.

The Met Office issued weather warnings for the affected areas including "Yellow – be aware" warnings

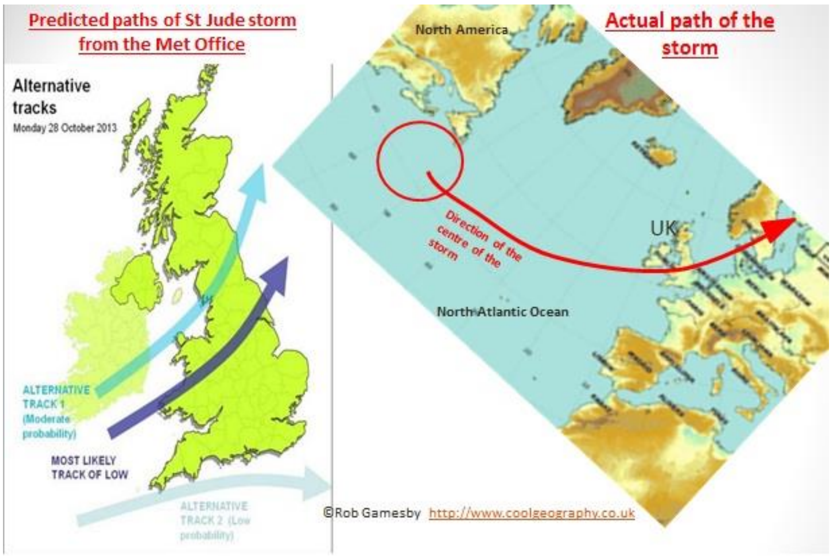


Figure 38 - the path of the St Jude Storm

Ahead of the storm, London's Metropolitan Police Service advised people to only use the 999 emergency telephone number in an emergency, and to use the 101 Single Non-Emergency Number service for reporting non-emergency situations, anticipating the emergency services being stretched by the storm's passage.

Impacts

- The storm had lots of impacts after it finally reached the UK early on the 28th of October. There were very fast winds, **a gust of 99 miles per hour** (159 km/h) was recorded at The Needles Battery, Isle of Wight.
- The environment was badly affected in the UK, with **trees being brought down** by the wind as many had still not yet dropped their leaves so had a larger surface area to be affected by the wind. These trees fell onto buildings, cars and power lines.
- Overall structural damage to residential and commercial buildings was limited in the United Kingdom, with most damage to roofs, cladding and glazing. A helter-skelter was blown over in Clacton, **cranes collapsed in London** and construction sites had to close down for the day.
- There were unfortunately casualties, in London, **two people were killed** when a gas explosion destroyed three houses and damaged two after the storm blew a tree down. A 14-year-old boy was swept out to sea and never found, whilst a man died in Watford when a tree fell on his car. A 17 year old girl died in Kent after the storm blew a tree onto the static caravan in which she was living.

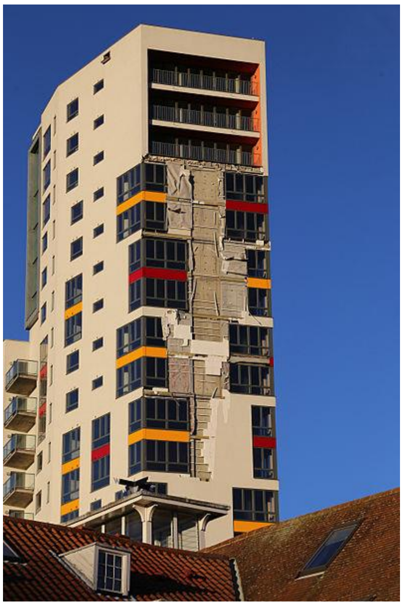


Figure 39 - Damage to cladding of a building in Ipswich - By Steven James Fosdick on Wikimedia

- A double-decker bus with two passengers on board was blown over and in Devon a wind turbine was blown over.
- Major disruption was caused by loss of power supplies, and more than **850,000 homes lost power** in the UK at some point. Nuclear power reactors at Dungeness B had to be shut down.
- There was major transport chaos, with 130 flights from Heathrow Airport were cancelled in total, trains services massively scaled down, slowed down for safety reasons or cancelled in the south of England with knock on effects on services further north. On top of this many roads had to be closed including the A249 Sheppey Crossing whilst channel ferry crossings were cancelled

Responses & Management

The actions of forecasters and authorities limited the impacts of the storm and although causing inconvenience to people kept them away from the damaging effects of the storm. The Met Offices supercomputer worked with a good level of accuracy.

Insurance companies had to take on extra staff to cope.

Estimates of the total costs to the insurance industry of the storm were likely to range **between £300 million and £500 million** in the UK on 29 October 2013.

A massive effort from the electricity companies meant that by the first of November only 3,110 homes were still without

The Met Office worked closely with utility companies (such as electricity), Government agencies and Transport agencies and companies (road, rail, air and sea) to help them prepare. They also communicated warnings using social media, apps their website and national news media such as the BBC.

ACTIVITIES 1.14

1. **Draw then complete the case study table to summarise the ESSENTIAL information about this earthquake;**

Background (where, when, size)		
Causes		
Effects	Short term	
	Long term	
Responses	Individuals	
	Agencies	
	Governments	

2. Was this event well managed? Justify your response

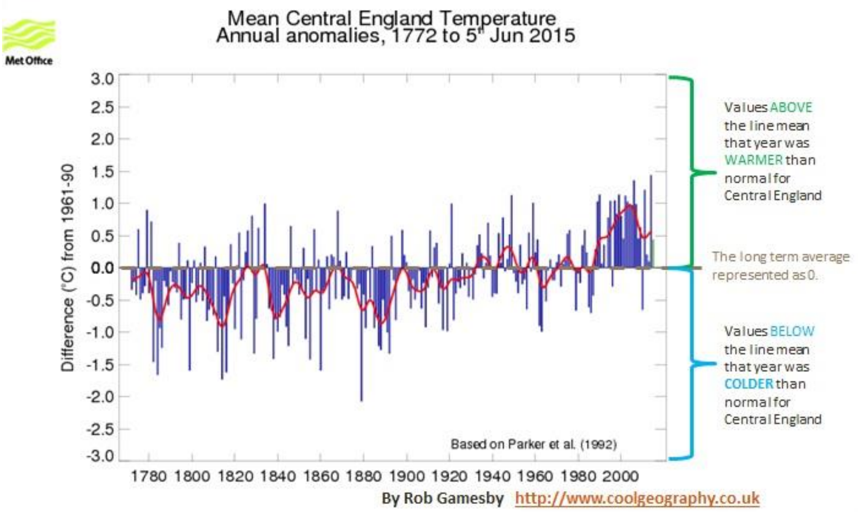
1.15 Evidence for climate change

Climate change is a long-term change in the earth's climate, especially a change due to an increase in the average atmospheric temperature. However, we could consider changes to wind, ocean currents and for many parts of the world changes to precipitation which could affect access to that vital life giving resource, water. Part of this is the current phenomenon of Global warming, which can be defined as the recent trend of an increase in global temperatures.

There are several sources of evidence for Climate change, including;

1. **Instrumental readings**

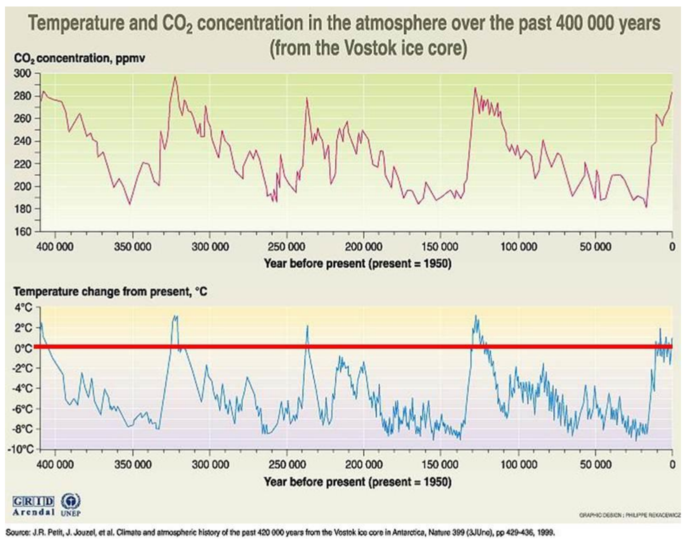
   It has been shown that over the last 100 years, **Earth's average surface temperature increased by about 0.8 °C** (1.4 °F) and the rate of temperature increase sped up towards the end of that time frame. Scientists are more than 90% certain most of it is caused by human activities which have increased concentrations of greenhouse gases such as deforestation and burning fossil fuels.



> Key words
>
> **Orbital changes** - Changes in the pathway of the Earth around the Sun.
>
> **Quaternary period** -The period of geological time from about 2.6 million years ago to the present. It is characterized by the appearance and development of humans and includes the Pleistocene and Holocene Epochs.
>
> **Global warming** - A gradual increase in the overall temperature of the earth's atmosphere generally attributed to the greenhouse effect caused by increased levels of carbon dioxide, CFCs, and other pollutants.
>
> **Quaternary period** – the current geological period dating from 2.6million years ago to the present day. We live in the Holocene epoch of the Quaternary period, which covers the last 12,000 years since the end of the last ice age.

2. **Retreating glaciers and shrinking ice sheets**

   The World Glacier monitoring Service collects information every year on the sizes of glaciers around the world. Data shows that **glaciers are shrinking significantly** all around the world. The Arctic ice sheet has also thinned to half its thickness over the past 30 years, and we have seen the breakup of huge Ice Shelves in Antarctica.



3. **Ice cores**

   Scientists have drilled out a huge core of ice in Antarctica. The air trapped in bubbles in the ice can be analysed and this has shown that the Earth is normally cooler than it is now and that Ice ages are common. It also shows a very strong link between CO_2 concentrations and temperature.

4. **Seasons shifting – such as spring arriving earlier**

Spring is arriving earlier in the UK. Birds are nesting earlier and bulbs such as daffodils are flowering earlier. The Telegraph reported that spring now arrives 11 days earlier than in the 19th century.

1.16 Natural and human causes of climate change

Natural causes;

Volcanic activity

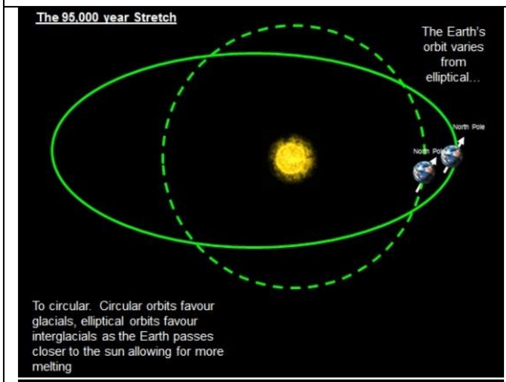
Volcanic activity can reduce global temperatures because of the **dust and ash** that goes into the atmosphere and sulphur dioxide that creates aerosols. These volcanic materials reflect incoming radiation back out to space cooling the Earth. The Mount Pinatubo eruption of 1991 resulted in cooling of 0.4°C.

Sunspots

Sunspots are storms on the sun's surface that are marked by **intense magnetic activity** and play host to solar flares and hot gassy ejections from the sun. Increased sunspot activity has been noted at times of increased temperatures, and decreased activity in cooler times.

Variations in the way the Earth orbits the sun over time,

The Earth's journey around the sun changes slowly over time, it does three things that sound like a dance – stretch, tilt and wobble!

<table>
<tr><th>The 95,000 year stretch</th><th>The 42,000 year tilt</th><th>The 21,000 year wobble</th></tr>
<tr><td>
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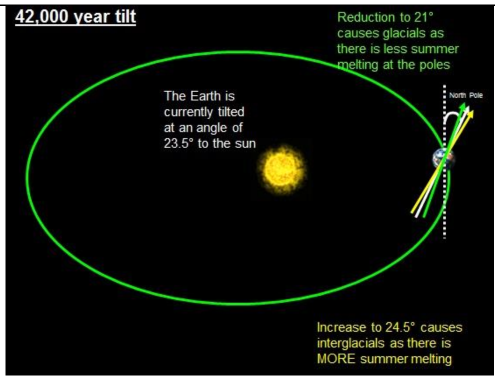
<td>
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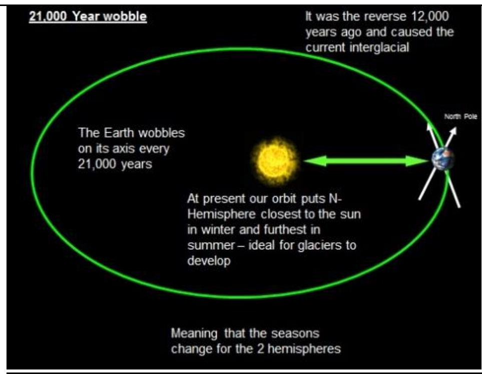
<td>
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<tr><td>The Earth's orbit slowly changes from elliptical to circular and back again over a 95,000 year period. Circular orbits favour glacials, elliptical orbits favour interglacials as the Earth passes closer to the sun allowing for more melting</td>
<td>The tilt of the earth varies slowly over 42,000 year cycles. The Earth is currently tilted at an angle of 23.5° to the sun but it can reduce to 21° causes glacials as there is less summer melting at the poles and increase to 24.5° causes interglacials as there is MORE summer melting.</td>
<td>The Earth wobbles on its axis every 21,000 years meaning that the seasons change for the 2 hemispheres. At present our orbit puts N-Hemisphere closest to the sun in winter and furthest in summer – ideal for glaciers to develop. It was the reverse 12,000 years ago and caused the current interglacial</td></tr>
</table>

Human causes

Fossil Fuels

We use **fossil fuels** (including coal, oil and gas) in power stations across the world to generate energy.

Coal is the remains of ancient plants and trees that grew over 200 millions of years ago. Oil and gas is made up of the remains of microscopic plankton. Over millions of years these remains become the carbon-rich coal, oil and gas we can use as fuel.

When fossil fuels are **burned they release carbon dioxide into the atmosphere** which contributes to global warming. Using fossil fuels to generate energy also releases pollutants into the atmosphere - such as sulphur dioxide.

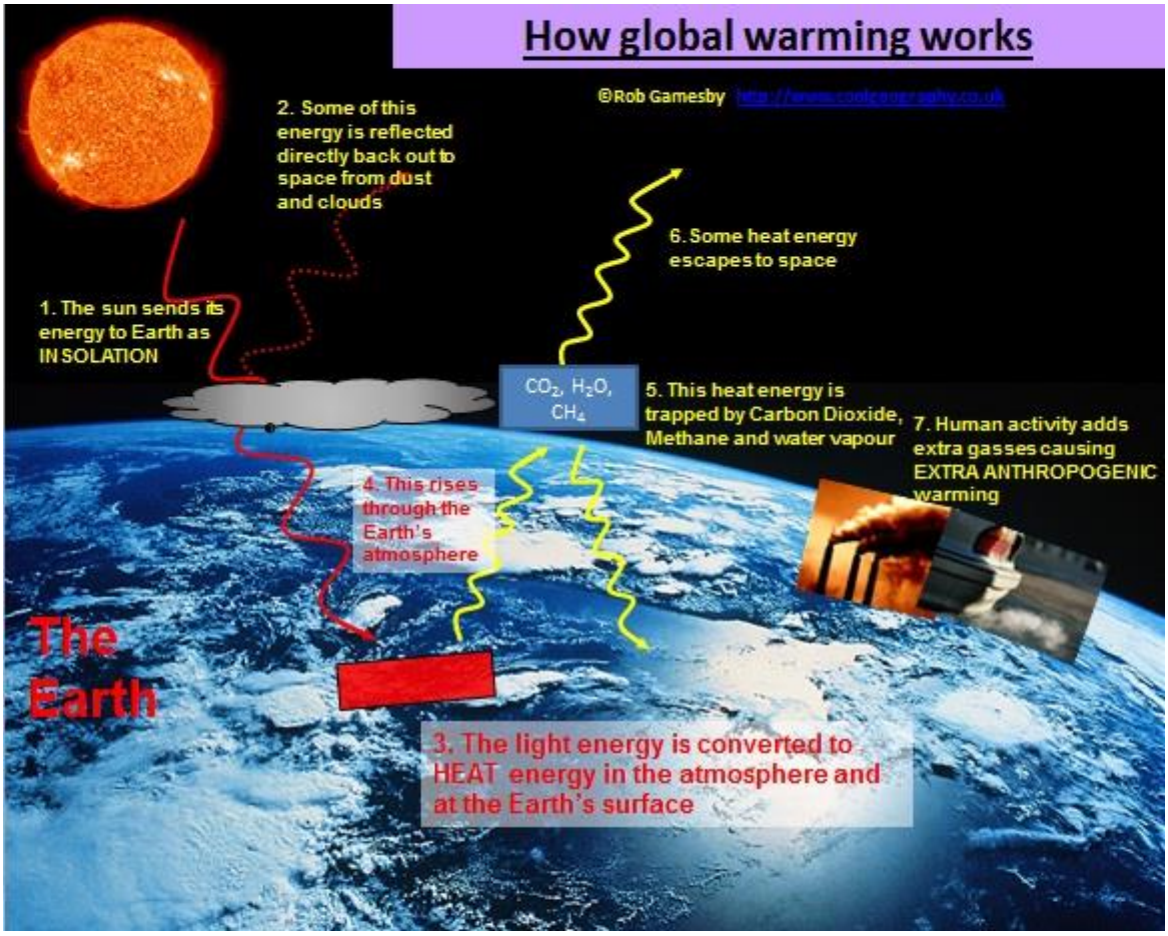

Figure 40 - How global warming works

Agriculture

Producing food globally uses a lot of fossil fuels in the **production of fertiliser and pesticides**, and in the **transportation of food**. **Changing forest cover and marshes to farmland** also releases greenhouses gases and removes a greenhouse gas store. Some types of agriculture also create a lot of greenhouse gases. Keeping animals in large quantities for meat production or dairy products produces a lot of Methane (CH_4), a potent greenhouse gas. Rice paddies are also known to produce lots of greenhouse gases

Deforestation

Forests have a vital role to play in the fight against global warming. **Forests absorb and store carbon** in their trees and soil. But if forests are cleared or disturbed, this carbon is released as carbon dioxide and other greenhouse gases. Up to a fifth of global greenhouse gas emissions come from deforestation and forest degradation.

ACTIVITIES 1.16

1. Distinguish between climate change and global warming.
2. Rank the causes of global warming in an order of importance. Include both physical and human causes.
3. Justify your ranking in exercise 2

1.17 Managing the impacts of climate change: MITIGATION & ADAPTATION

Mitigation 1 - Alternative energy production

The major current cause of the rise in the World's temperature is that people are reliant on the burning of fossil fuels for producing energy, for heat and for transport. To mitigate against this as a planet we need to reduce the amount of non-renewable fossil fuels that we burn, as these produce Carbon Dioxide in large quantities when burnt.

Instead we could look at alternative **RENEWABLE forms** of energy.

Energy Source	Facts and description	Advantages	Disadvantages
Wind	Modern windmills, called wind turbines, turn wind energy into electricity. If the turbines are in a group it's called a wind farm.	This is a **renewable energy source**, that's because we will never run out of wind. The **price of wind energy is stable**; it doesn't go up and down like the price of coal or oil. The UK gets lots of wind annually	There is some local opposition and concern **about noise and impact on landscape.** Wind is **more expensive than fossil fuels** to set up and wind levels fluctuate over time.
Solar Power	Solar power is the conversion of sunlight into electricity. Sunlight can be converted directly into electricity using photovoltaics (PV), or indirectly with concentrated solar power (CSP), which normally focuses the sun's energy to boil water which is then used to provide power	Solar panels **give off no pollution**; the only pollution produced as a result of solar panels is the manufacturing, transportation and installation. Solar energy produces electricity very quietly & can be used globally. Can be used in remote locations that are not linked to a national grid and batteries allow capture of energy during the day for use at night.	Solar **panels cost a lot**. Currently, prices of highly efficient solar cells can be above £1000, and most households may need more than one. Solar energy is only able to generate electricity during daylight hours. The **weather can affect the efficiency** of solar cells.
Hydroelectric Power	Hydropower is energy generated from the movement of water through rivers, lakes and dams.	Once built, the power stations **do not release the greenhouse gas carbon dioxide.** Hydropower is not vulnerable to changes in price like oil or gas.	Power stations which **rely on rainfall can be vulnerable to drought.** Large dams and reservoirs have a **big impact on the environment** and the people who live near them.
Nuclear Power	Radioactive minerals such as uranium are obtained by mining. Electricity is generated from the energy that is released when the atoms of these minerals are split (fission) or joined together (fusion) in nuclear reactors.	Once built, the power stations produce only a small amount of the gas Carbon dioxide. That's important as the UK Government wants to reduce this gas as part of a plan to slow down global warming. Nuclear power stations produce a reliable, steady stream of electricity.	Nuclear power stations are very expensive to build & to shut down and have safety concerns. The radioactive nuclear waste must be dealt with very carefully. It's harmful to people so it must be treated and then kept in special stores to keep it safe.

Mitigation 2 - Carbon capture

Carbon capture is the trapping of the carbon dioxide released when we burn fossil fuels.

1. During the production of energy the CO_2 is captured in the factory before gases are released into the atmosphere
2. The CO_2 until it turns into a dense liquid.
3. It can then be pumped through pipes into porous rock layers a kilometre or more underground where it can be held by overlying layers of impermeable rocks for tens of thousands of years or longer.

There are many possible sites for Carbon capture, including;

- Saline aquifers (vast underground water-containing rock formations),
- Un-mineable coal seams,
- Old oil and gas wells.

The Intergovernmental Panel on Climate Change (IPCC) and other studies indicate that CCS can decrease the CO_2 emissions to atmosphere of a typical coal-burning power plant by up to 90%, making development of this technology an attractive prospect.

Key words

Adaptation - Actions taken to adjust to natural events such as climate change, to reduce potential damage, limit the impacts, take advantage of opportunities, or cope with the consequences.

Mitigation - Action taken to reduce or eliminate the long-term risk to human life and property from natural hazards, such as building earthquake - proof buildings or making international agreements about carbon reduction targets.

The **UK has good potential for Carbon Capture**. The North Sea has gas and oil fields and saline aquifers where we could store CO_2 produced by the UK's gas and coal-fired power plants.

The positives of this are that we can reduce our carbon emissions whilst still being able to use cheap fossil fuels to produce our electricity. It has lots of potential for storing CO_2 and will reduce our carbon emissions. The negatives are that it means we remain stuck using a non-renewable resource and not all CO_2 can be captured. It is also very expensive to "capture" the carbon.

Mitigation3 - Planting trees

A practical way to mitigate climate change is to plant more trees in order to take more carbon out of the atmosphere. This is known as **afforestation**.

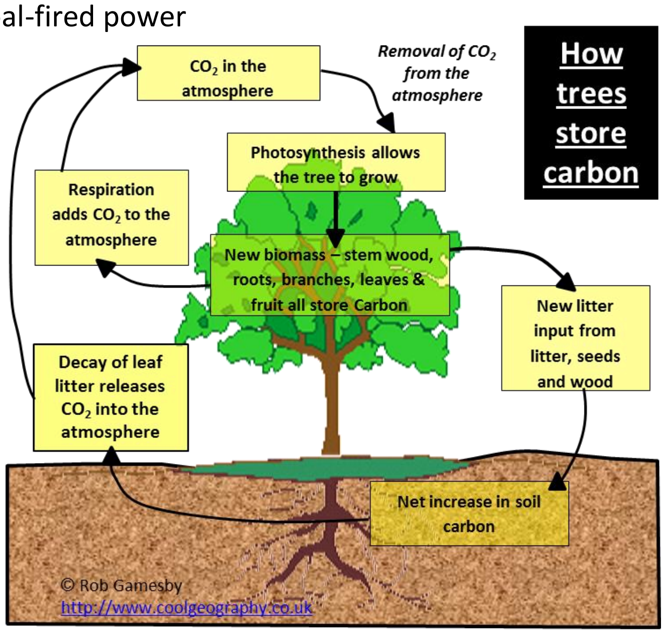

Figure 41 - how trees capture carbon

Younger trees absorb carbon dioxide quickly while they are growing, but as a tree ages a steady state is eventually reached, and at this point the amount of carbon absorbed through photosynthesis is similar to that lost

Figure 42 - How trees trap carbon

through respiration and decay. If trees are harvested carefully near this time in the growth cycle, and new trees are planted or allowed to regenerate, then this can keep the forest as a net **"sink" of carbon**. Therefore careful woodland management can mean that woodlands are able to take up the maximum amount of carbon possible.

Mitigation 4- International agreements

Climate change is a global issue, so it needs all countries to work together to try and sort it out. Global warming was identified as an issue that needed sorting out in 1988 when the IPCC (**Intergovernmental Panel on Climate Change**) was established to assess the "risk of human-induced climate change".

The **Earth Summit followed in 1992** in Rio de Janeiro, and wanted to stabilize greenhouse gas levels to prevent dangerous human interference with the climate system.

The Earth summit agreement was then followed by an update, the Kyoto Protocol of 1997. This was agreed by nearly every country in the world except the USA (plus 4 others), which wanted developing nations to have to cut their emissions as well.

The most recent UN climate talks were held in Paris in 2015. It was agreed that the EU would put its current emission-cutting pledges inside the legally-binding Kyoto Protocol, a key demand of developing countries. Most major countries have signed up to the **Paris Protocol**.

Figure 43 - The EU's vision for the Paris Climate Change summit, 2015. ©European Commission

The UK and its action

The UK is a leading nation in the battle against climate change, as a country we have committed to reducing CO_2 levels to 80% of the 1990 level by 2050. Indeed, the **Climate Change Act 2008** made the UK the first country in the world to have a legally binding long-term framework to cut carbon emissions. The UK is part of a wider program as part of the European Union's emission trading system which was the first large emissions trading system in the World.

Adaptation 1 - Change in agricultural systems

Agriculture (farming) will need to adjust to climate change. There will be positive and negative impacts for agriculture from climate change;

In the UK we can expect increased yields for current crops such as wheat, sugar beet and potatoes, better grass yields for feeding livestock and the introduction of new crops and tree species. Certain fish stocks, like plaice, may increase as species move north.

However, farmers could experience crop losses due to flooding and the forestry industry could see timber yield and quality reduced by drier weather and spreading pests. Some fish species could shift north, reducing the UK's cod fishery.

To adjust farmers and governments will need to consider;

1. Altering the species they farm to the climate of the future
2. Use technology to "harvest" water such as dams and reservoirs and conserve soil moisture in areas where rainfall decreases.
3. Draining water to prevent water logging, erosion, and nutrient leaching where rainfall increases.
4. **Altering the timing or location** of cropping activities. The South of Britain is increasingly becoming a great vineyard for example.
5. Improving pest, disease, and weed control as these might change location with climate change.
6. Using climate forecasting to reduce production risk.
7. Use **Genetically Modified species** that have a capacity to cope with drier, hotter or wetter conditions. For example, drought tolerant wheat SeriM82 has deeper root systems to help it access more water.

Adaptation 2- Managing water supply

Fresh water is crucial to human survival; we use it for drinking, farming, washing and many other activities. Only 2% of all of the water on planet Earth is fresh, and of that fresh water 70% is locked up as snow and ice.

Climate change is expected in the future to;

- Make **water supplies** in some parts of the world **increasingly scarce** in the future. This includes regions in the sub-tropics such as the Sahel region south of the Sahara, where water is already scarce.
- Make **some parts of the world wetter and more humid**.
- Make the air warmer so it can hold more water, which will lead to **more and heavier rainfall**.
- Melt land ice and snow more quickly, many millions of people rely upon this as a water source and will be vulnerable if it disappears

The overall effect is likely to be more extreme floods and droughts globally. The IPCC say that many dry regions including the Mediterranean and southern Africa will suffer badly from reduced rainfall and increased evaporation. They estimate that around **one billion people in dry regions** may face increasing water scarcity.

There are other factors increasing water scarcity;

1. Increasing global population
2. Increasing demands from farming (agriculture)
3. Water pollution limiting supply
4. Rising wealth in some countries means a larger number of people living water-intensive lifestyles, including watering of gardens, cleaning cars and using washing machines and dishwashers.

SOLUTIONS

The solutions against possible climate change impacts include many engineering solutions. The common method is reservoirs to store it and pipelines to transfer it. An example of this is the Kielder water transfer scheme in the North east of England

Some areas are using desalination to recover freshwater from the oceans.

Efforts are also being made to increase water saving, reuse and recycling, and in the UK there is currently major investment into education and water-saving technology by the government and water industry.

Tube wells can be sunk in regions to tap into groundwater sources as well, as have been used in Bangladesh

Figure 44 - Water Pump
SOURCE:http://www.impact.org.uk/priorities/safe-water-sanitation/

Adaptation 3 - Reducing risk from rising sea levels

Climate change is causing sea levels to rise. The Intergovernmental Panel on Climate Change (IPCC) predict a rise in global sea levels of between 28 and 43cm by the end of the century. The IPCC projections of sea level rise can be seen below.

In the UK rising sea levels could hit beaches, low lying land and buildings including tourist attractions and historical monuments, with knock-on impacts for businesses that rely on them. Rising sea levels could also flood large parts of our valuable agricultural land. Flooding costs could rise from the current £1.2 billion a year to between £2.1 billion and £12 billion a year by the 2080s, with issues including insurance industry exposure to UK flood risks, the availability of insurance and provision of mortgages to at-risk properties.

To reduce the risk of this (APE);

ABANDON - We can abandon areas at most risk and not worth saving economically. Already in the UK homeowners can get a £6000 grant to help with the costs of demolishing their home from Defra if at risk from being destroyed by coastal erosion.

PLAN - Shoreline Management Plans have been put in place LOCALLY to plan to provide a strategy for long term coastal adaptation to rising sea levels on a local scale.

ENGINEER – we could build more costly coastal defences using hard engineering such as sea walls and groynes or soft engineering such as sand dune creation. The Thames Barrier defends central London and would need replacing at a cost of £7 billion.

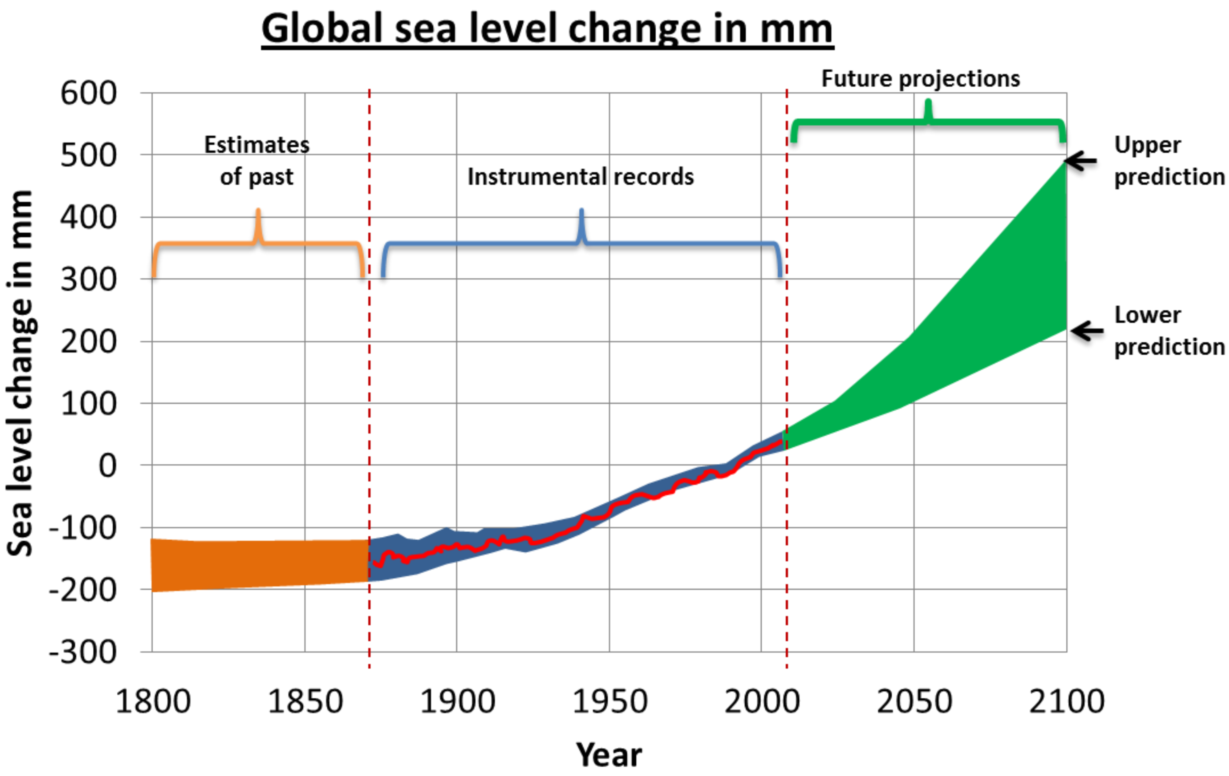

Figure 45 - a graph of sea level change

ACTIVITIES 1.17

1. Describe the changes in sea level predicted on the graph above. Ensure that you include data in your answer.
2. Read through all of the options to mitigate and adapt to climate change.
3. Produce a clear 4 point plan for the UK government on the KEY things we should do as a country to cope with climate change. Your plan should be in the form of a catchy A4 poster.