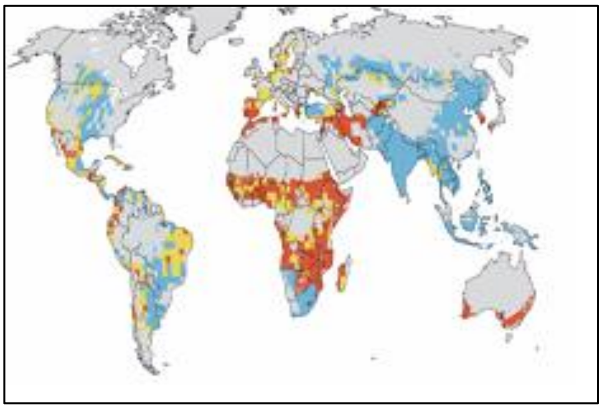
GEOGRAPHY
A Level

A2 Unit 4
Section B – Contemporary Themes

4.5 Weather and Climate



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Part of A2 Unit 4

Section B: Contemporary Themes (two optional topics)

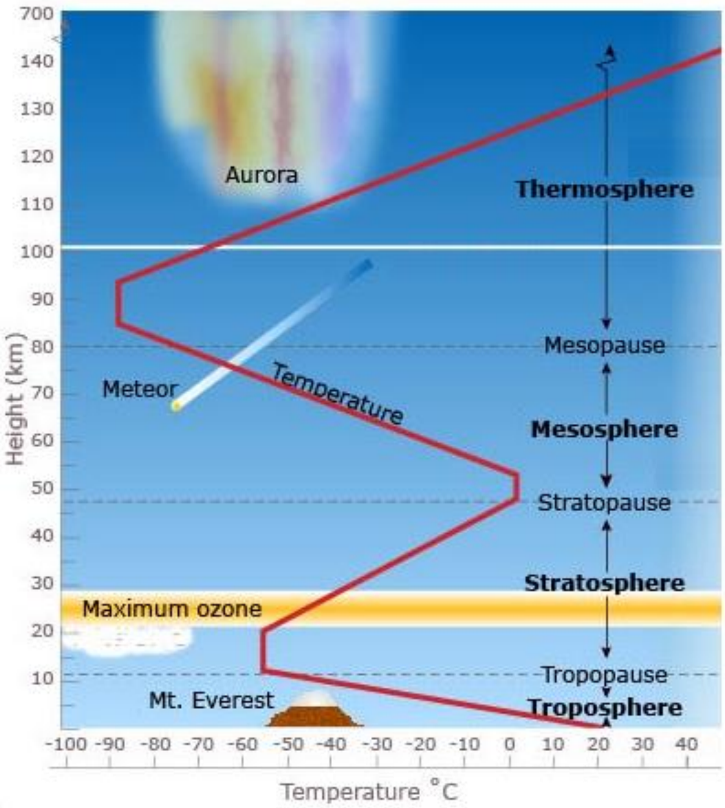
4.5 Weather and Climate

Focus	Geographical content	Revision
4.5.1 Global controls on climate	• Structure of the atmosphere including the characteristics of different layers and their role in climate regulation and the atmospheric heat budget • Processes of global atmospheric circulation including the tri-cellular model • Distribution of the world's high and low pressure belts and their impact on planetary surface winds; oceanic circulation and its impact on climate; the regional impacts of continentality and altitude on climate	
4.5.2 World's major climate types	• Major climatic types and their distinctive characteristics including temperature, precipitation, winds and pressure • Seasonal variations in the position of the ITCZ including migrations of the heat equator, wind and pressure belts • Monsoon climate including seasonal changes of precipitation, temperature, winds and atmospheric pressure	
4.5.3 Climate and weather of Wales and the UK	• Characteristics of the climate in Wales and the UK • Sources and characteristics of air masses and their influence on Wales and the UK's weather • Impacts of variations in the position, pattern and amplitude of the jet stream on the UK's weather	
4.5.4 Extreme weather events	• Causes and consequences of recent and cyclic climate change including extreme weather events • Changing vulnerability of populations to weather and climatic hazards including exposure to climatic variability, sensitivity to stress and adaptive capacity	
4.5.5 Impacts and management of climatic hazards	• Impacts of hazards associated with low-pressure systems on the environment and human activity • Impacts of hazards associated with high-pressure systems on the environment and human activity • Strategies to manage climatic hazards	
4.5.6 Impacts of human activities on the atmosphere at local and regional scales	• Impacts of urban areas on temperature, wind, precipitation and humidity • Impacts of urban areas on air quality including particulate pollution, photochemical smog and acid rain • Strategies to reduce the impact of human activity on urban climates and air quality	
4.5.7 People, climate and the future	• Global impact of anthropogenic climate change on shifting climate belts • Consequences of reaching atmospheric tipping point including environmental and economic impacts • Strategies to mitigate and adapt to climate change at a variety of scales	

4.5.1 Global controls on climate

INTRODUCTION

The atmosphere is predominantly composed of nitrogen although significant roles are played by other gases such as water vapour (precipitation and heat transfer), ozone (absorption of harmful UVB radiation) and CO_2 (trapping of radiation within the earth's atmosphere). The atmosphere is considered to extend to around 1000km form the surface of the earth. It has a layered structure, with four main layers:



1) Thermosphere – This layer has most of the satellites orbiting within it but has so little oxygen that it is almost considered a vacuum.
2) Mesosphere – Temperatures drop in this zone which has the highest clouds from sublimated water vapour.
3) Stratosphere – temperatures rise with height in this zone due to absorption of UV radiation from the sun by the ozone layer which is found here. The lower boundary of the stratosphere is known as the **Tropopause**. This caps the main area controlling the weather.
4) Troposphere – the layer where most of the earth's weather is contained. Temperature drops with height as it is mainly heated from reflected radiation from the surface of the planet. It rises to about 14km from the surface.

The Atmosphere and Heat

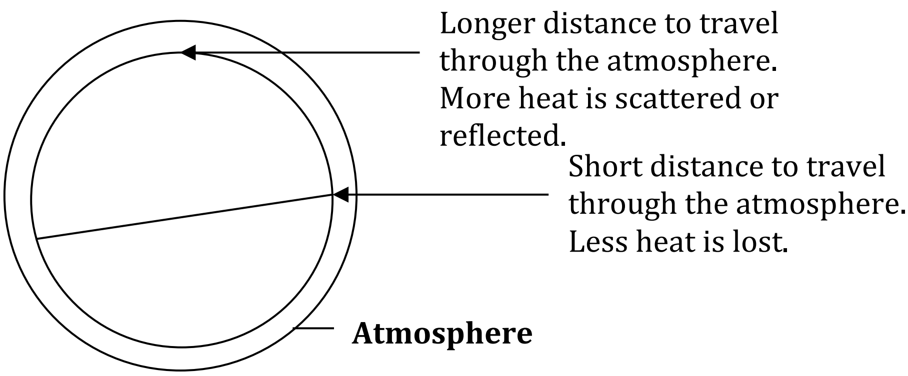
a) The Heating of the Atmosphere - The source of all energy and what is responsible for our weather systems is the **SUN**. The atmosphere is however heated not directly from the sun, but by radiation from the ground surface. The incoming heat energy from the sun id called **INSOLATION** and is in the form of short wave radiation which the ground absorbs and converts into heat thus warming up the ground surface. It then re-radiates this heat into the atmosphere as long wave radiation.

Only 47% of solar energy (insolation) reaches the ground – 53% is lost as it passes through the atmosphere, where it is absorbed by clouds, gases, dust and water vapour; scattered by dust particles; and reflected by clouds and by the ground surface.

b) The **Energy Balance** or **Heat Budget** - The amount of incoming solar energy (insolation) must be compensated by outgoing heat (**EXSOLATION**) to maintain a state of equilibrium.

The amount of incoming solar energy received from the sun varies with **LATITUDE**. About 3 times as much arrives at the Equator than at the Poles. This is due to:

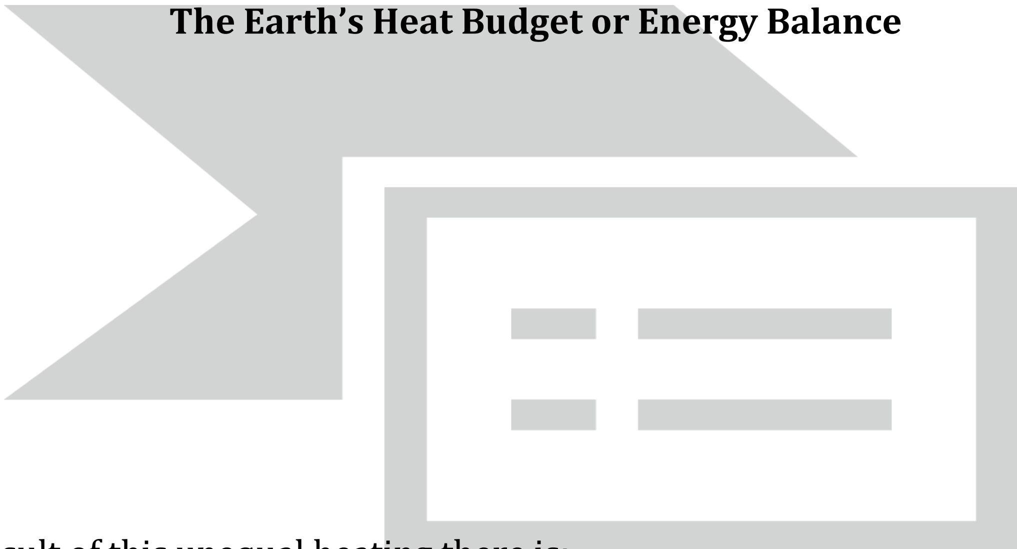
- The high angle of the sun and so the high concentration of solar energy at the Equator.
- Less thickness of atmosphere for the sun's rays to pass through, and so less heat is lost by absorption, reflection and scattering.



- A lower **ALBEDO** effect (loss of heat by reflection) than at the Poles. Ice and snow have a high albedo.

The amount of outgoing radiation (exsolation) is more evenly spread across the latitudes (see the line on the diagram on the next page).

The Earth's Heat Budget or Energy Balance



As a result of this unequal heating there is:

- An **ENERGY SURPLUS** between the Equator and 35ºN and S.
- An **ENERGY DEFICIT** between about 35ºN and S and the Poles.

To compensate for the energy deficit pole wards of 35^{o}N and S, it is necessary to transfer and redistribute heat energy from areas of surplus to areas of deficit. And so heat is transferred from the Tropics (low latitudes) towards the Poles (higher latitudes).

*** If this did not happen then the Tropics would get hotter and hotter year by year and the Poles would get colder. This is clearly not happening ***

This heat transfer is called **GLOBAL ATMOSPHERIC CIRCULATION**. This air circulation is confined to the lower atmosphere i.e. the Troposphere and gives us our weather systems and climatic conditions. The Tropopause acts like a lid to confine our weather systems in the lower atmosphere.

Processes of Global Atmospheric Circulation

Heat energy can be transferred either:

1) By vertical movements of air. This occurs by **CONDUCTION** - as the land surface is warmed it heats up the narrow zone of air in contact with the ground. **CONVECTION** - as the land surface is heated, the air rises by convection. **LATENT HEAT** - when water vapour rises as a result of convection, latent heat is carried into and stored in the atmosphere. This takes up heat and so the atmosphere is cooled. When rising air cools, condensation occurs. Water vapour is changed into liquid (water droplets) as clouds and latent heat is released, so warming up the atmosphere.

2) By horizontal movements of air. 80% of horizontal air movement is carried by wind and 20% by ocean currents. Wind is caused by pressure differences between locations on the Earth's surface.

As suggested previously heat is transferred from the Equator to the Poles by a variety of methods. If this circulation of heat took place on a non-rotating Earth, then the pattern seen here would form. Simple convection cells would form where:

- Warm air is less dense so rises
- This warm air would move to the Poles
- Cold, denser air would sink
- This would move to the Equator
- As a result, heat would be transferred.

However, the Earth is rotating and this complicates the whole system. Also the air that has risen cools too quickly and sinks before travelling all the way to the Poles.

Still the most generally accepted model (although simplified) of global air circulation is the **TRI-CELLULAR MODEL**.

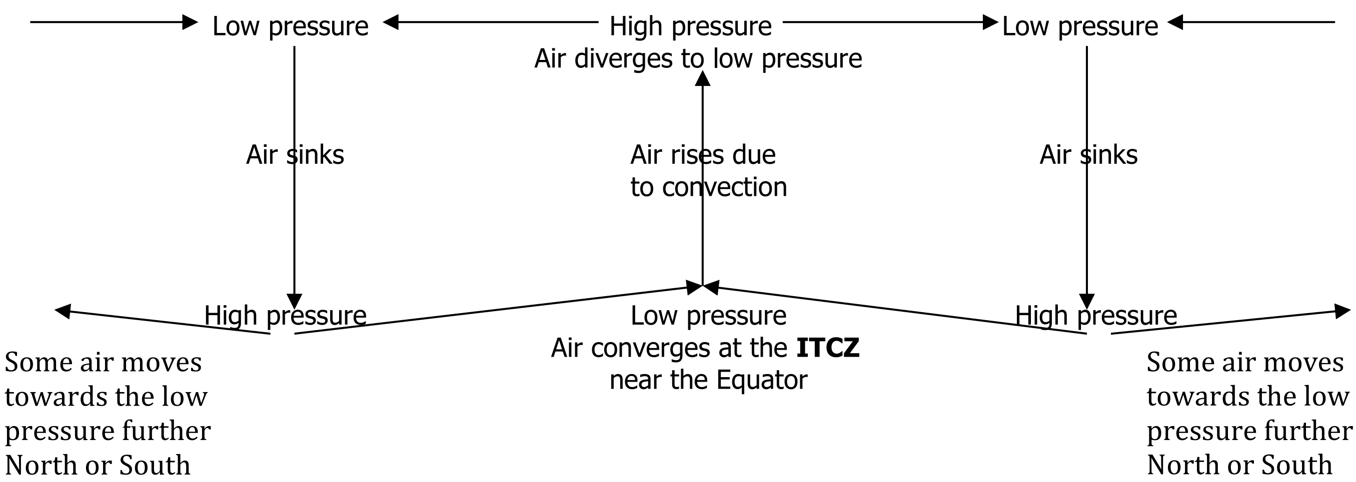
The principles behind the tri-cellular model are:

- Warm air rises by convection to leave less air behind, low pressure at ground level.
- Cold air sinks to add more air, high pressure at ground level.
- Air always moves from high to low pressure areas.

Differential heating (remember that):

- The Equator receives more insolation (heat) because the sun is at a higher angle in the sky and so is more concentrated on the ground.
- At the poles the angle of the Earth means that insolation (heat) from the sun has to pass through a greater distance in the atmosphere. So more is reflected, absorbed or scattered before it reaches the ground.
- The Equator would continue to get hotter and hotter, and the Poles colder and colder if there was no air circulation spreading out the heat and thus balancing the Earth's temperature.

Hadley cell



1. At the Equator warm air rises due to convection as it does it releases latent heat and leaves behind an area of low pressure (Doldrums).

2. The air continues to rise but is forced to diverge or spread toward the Poles.

3. At approximately 30°N and 30°S the air becomes so cooled (denser) that it begins to sink and thus warms.

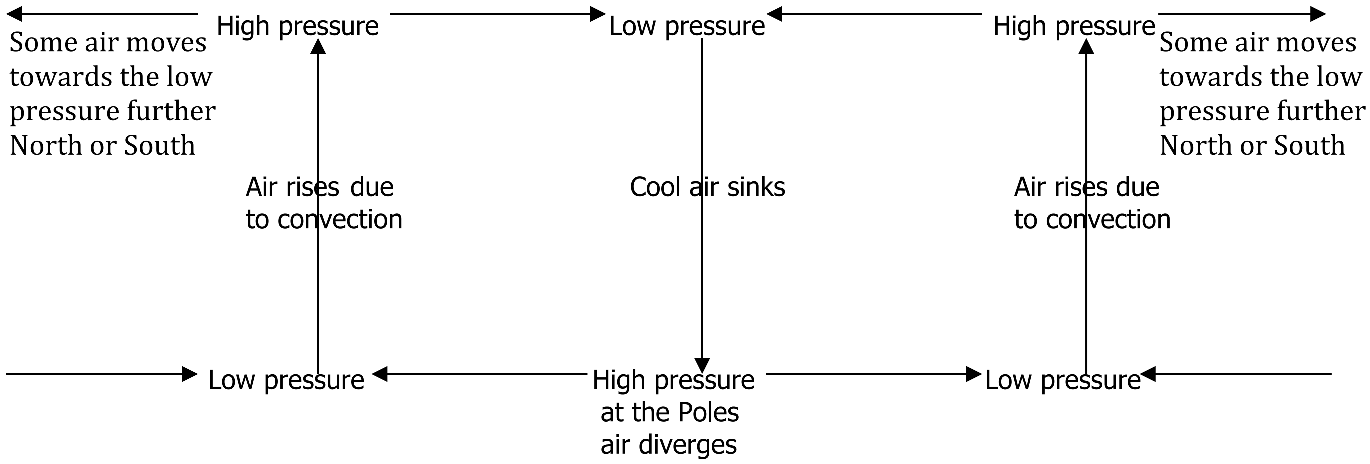
4. This leads to a sub-tropical high pressure area known as the Horse Latitudes.

5. At the ground surface the air is forced to diverge. Some of the air is drawn back to the low pressure area left at the Equator while some is drawn towards the Poles.

6. Where the air is drawn back to the Equator it forms an area of converging air known as the **INTER TROPICAL CONVERGENCE ZONE** or **ITCZ**. The moist air is heated and will rise again.

Ferrel cell – As shown on the previous page the Ferrel cell begins with air moving North or South from the Hadley cell.

Polar cell



1. At the Poles the air is very cold and dense and so sinks to the ground.

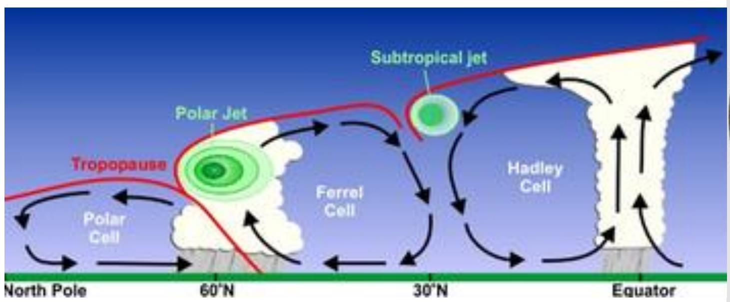
2. This creates a high pressure system. At ground level the air ids forced to diverge and move away from the Poles towards the mid-latitudes or temperate regions.

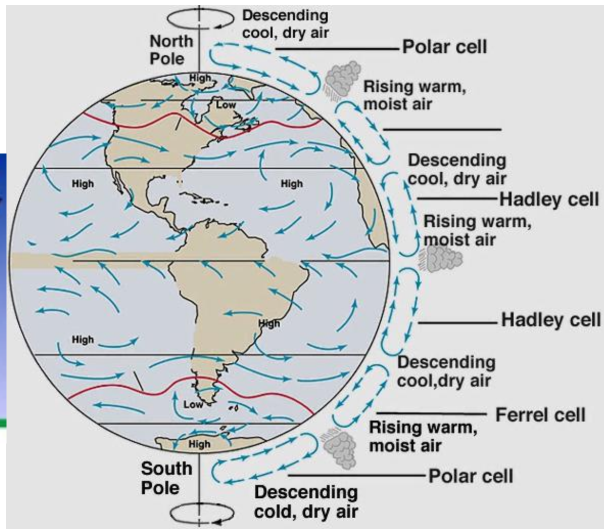
3. At the ground at around 55ºN and 55ºS this cold polar air converges with the warm tropical air that has come from the sub-tropics. The point at which they meet is called the **POLAR FRONT**. Here as the air converges at the surface, the air is forced to rise forming a low pressure system.

4. 80% of heat energy is carried by wind. This model shows that wind moves along the earth's surface from **HIGH** to **LOW** pressure areas. Weather systems are therefore responsible for the transfer of enormous amounts of energy.

So in summary the three cells transfer heat from the hotter latitudes near the Equator to the colder latitudes near the Poles. This balances out the Earth's heat budget and controls the global weather patterns.

THE COMPLETE TRI-CELLULAR MODEL





* Notice the deflection of the wind belts due to the Coriolis Effect *

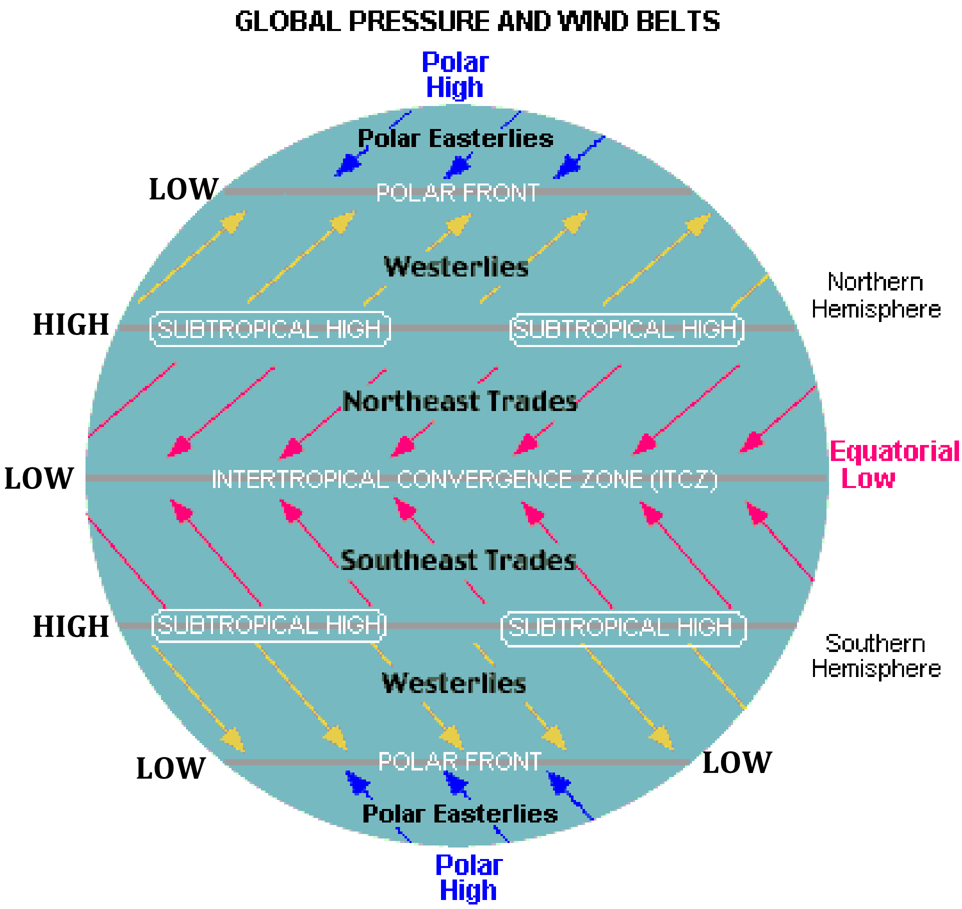
Distribution of High and Low Pressure Belts

The global pattern of pressure systems and wind belts stem from the Tri-cellular model.

The model shows us that:

- Heating / cooling of the air leads to air rising / sinking, so creating low / high pressure systems.
- Air moves vertically and horizontally within the atmosphere.
- Air movement at the earth's surface (wind) blows from high to low pressure.

However, the West to East rotation of the earth (Coriolis effect) deflects the wind from a straight path to the right in the Northern hemisphere and to the left in the Southern hemisphere (see diagram on the next page). This leads to a global pattern of wind and pressure which remains reasonably constant for most of the year. This gives us patterns such as the prevailing South Westerly winds in the UK.



Other Factors controlling Climatic Zones

There are a number of other factors that control the world's climatic zones that largely work independently of the tri-cellular model. These include:

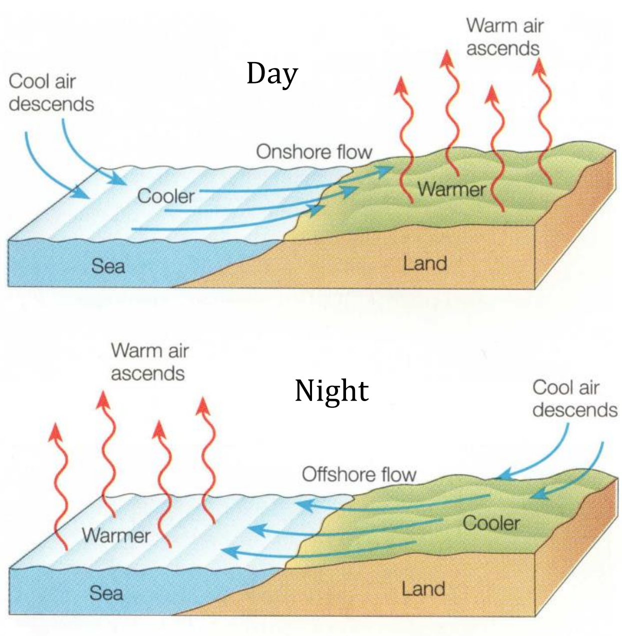
1) Ocean currents – Oceans act as thermal reservoirs absorbing and storing heat to great depths. As a result, the sea has a greater specific heat capacity than land i.e. it requires more energy to heat up the sea than the land.

The oceans provide the water vapour for the atmosphere. For water to be converted into water vapour by evaporation, a great deal of heat energy is required. This is **LATENT HEAT**. When this water vapour rises by convection, the latent heat is carried into the atmosphere and results in the cooling of the air (heat energy is being taken up). When water vapour condenses into liquid form, latent heat is released and the atmosphere is warmed.

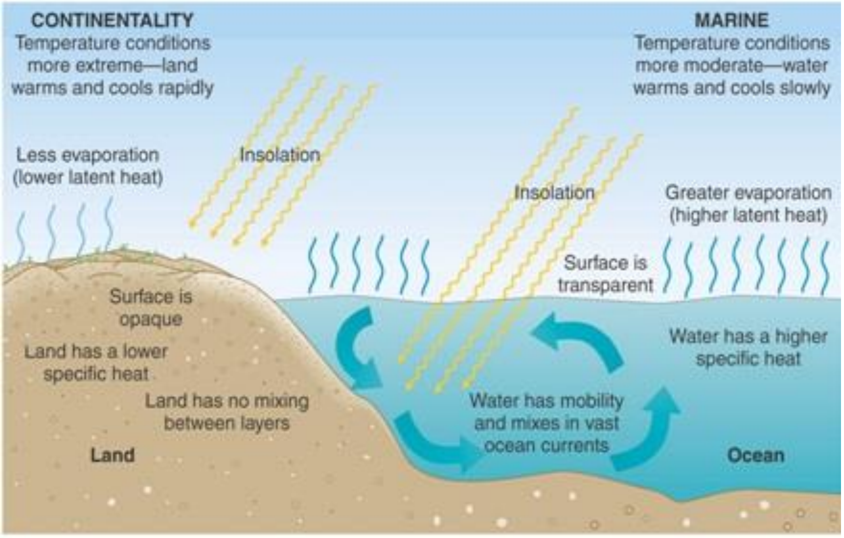
Thus the oceans, their currents and their temperature act as vital controls on the earth's climate. When warm they provide heat energy and vapour that can produce violent storms.

The ocean currents act along with the atmospheric factors to control the seasonal variations in weather around the globe.

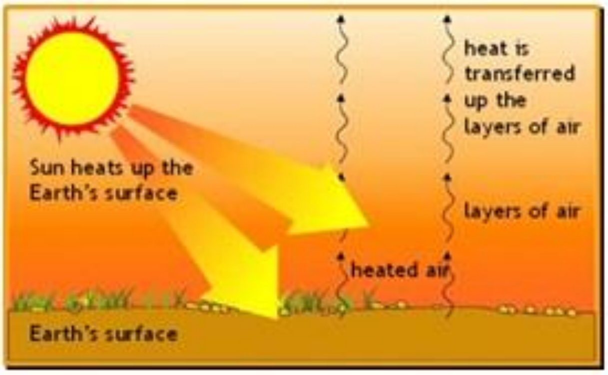
The diagram to the right shows that the difference in temperature between the land and sea can also cause changes to the weather conditions. When the land warms rapidly during the day in summer air rises leaving low pressure. Cool air from the sea moves in from high pressure areas. The opposite is true at night and during the winter as the sea retains its heat for longer.



2) Continentality – this is the effect on the climate of moving further into a continent. As you do the weather conditions become more extreme with a greater range of temperatures between summer and winter. This is due to the fact that the land takes longer to heat and then cannot retain this heat.



3) Altitude – Since the atmosphere is mainly heated by conduction from the earth, so places nearer to the earth's surface are generally warmer than those higher up. Thus temperature decreases with increasing height above sea level. This rate of decrease with altitude (lapse rate) is never constant, varying from place to place and from season to season. The average drop is around 0.6^{o}C per 100 metres. In the earth's atmosphere, pressure, which is related to the number of molecules per unit volume, decreases exponentially with altitude. Thus, if a parcel of air from the surface rises, it undergoes an expansion, from higher to lower pressure. When air expands, it cools.



4.5.2 The world's major climatic types

Climatic types and their characteristics

The global patterns of pressure, wind, ocean currents and atmospheric circulation control the resulting climate all around the World. The World can broadly be divided into three climatic regions:

- **Tropical** (found between the Tropics, typically hot and wet or dry)
- **Temperate** (found between Tropics and Polar regions, distinct seasons)
- **Polar** (near to poles, lack of summer conditions)

Within these broad regions there are more specific local climatic zones, mainly controlled by the location of a place in relation to its ocean currents, prevailing winds, distance from the sea, altitude and latitude. Each of these climatic zones has a distinctive pattern of temperature, precipitation, wind and pressure.

* A map of these major climatic types can be seen on the next page *

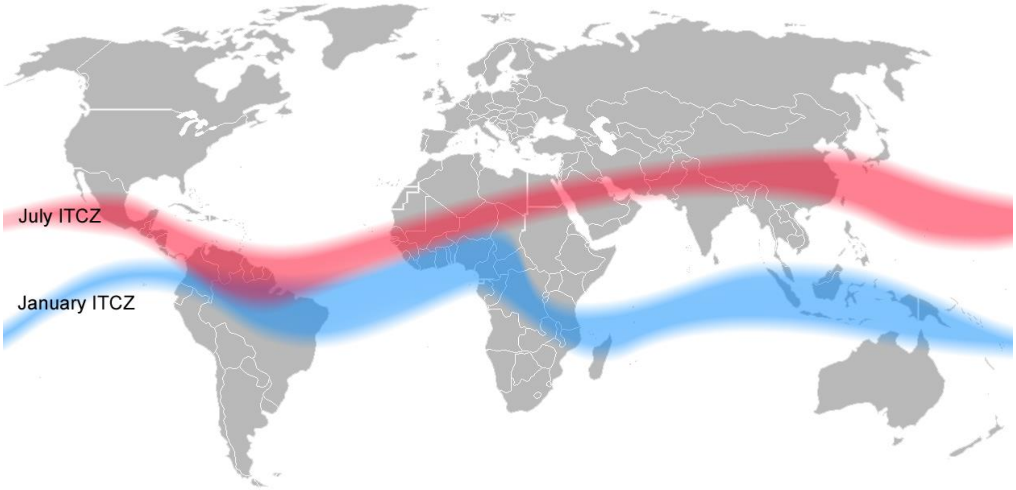
These climatic zones are controlled by a number of factors:

a) **The movement in the sun's overhead position**
b) **The subsequent seasonal movement of the heat equator**
c) **The migration of the ITCZ and thus the pressure and wind belts**
d) **Ocean currents**
e) **The differential heating/cooling of the land vs the sea**

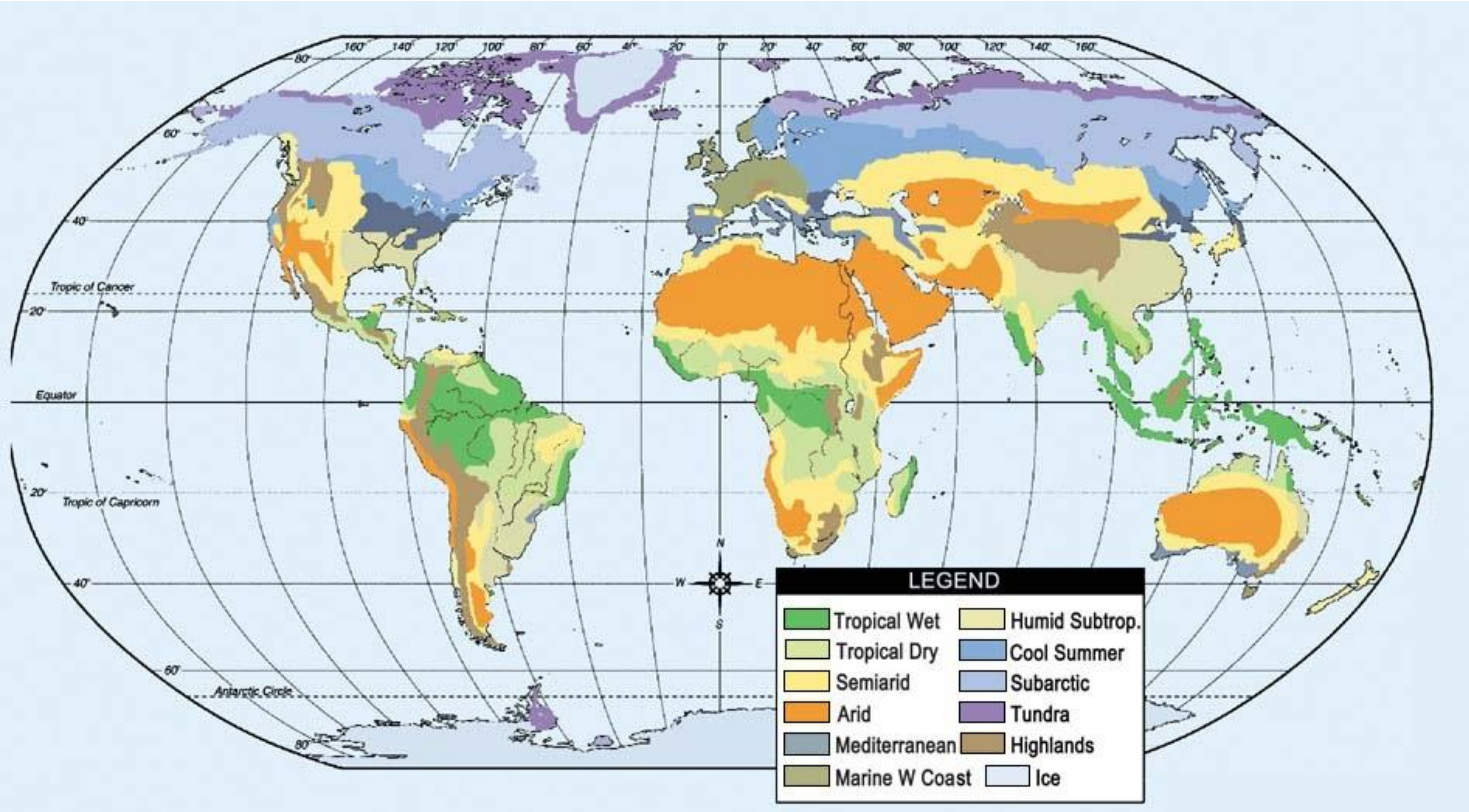
All of the above factors help to generate **seasonal variations** in climate in each of these climatic zones.

MOVEMENT OF THE ITCZ

The World map below shows that the ITCZ is not always over the Equator as suggested in the Tri-cellular model. It migrates as the sun's position and heat equator move during the year. This shifts the three cells and hence changes pressure belts and wind patterns.



Major Climatic Zones of the World



TROPICAL CLIMATIC ZONES

These are characterised by constant high temperature (at sea level and low altitude) with all twelve months of the year having average temperatures of 18°C or higher. They are found between the Tropic of Cancer (23½°N) and the Tropic of Capricorn (23½°S).

They can be further subdivided into:

a) Tropical Wet
b) Monsoon
c) Tropical Dry
d) Semi-arid
e) Arid

TEMPERATE CLIMATIC ZONES

Temperate climates are characterised by having an average temperature above 10°C in their warmest months, and a coldest month average between 0°C and 8°C. They are typically located between the Tropics and the Arctic or Antarctic Circles.

They can be further subdivided into:

a) Mediterranean
b) Marine West Coast
c) Cool Summer

CLIMATIC ZONE CASE STUDY – TROPICAL MONSOON

The map below shows the distribution of this climatic zone.

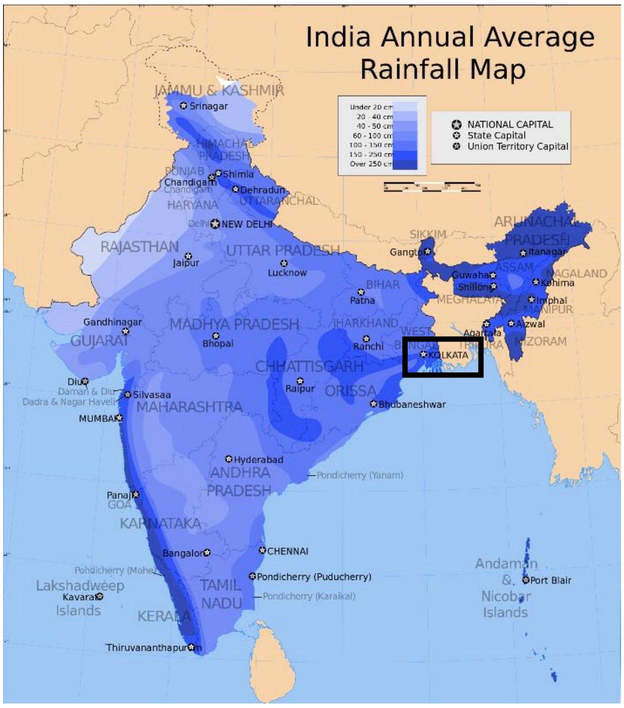
Tropical monsoon climate

Location:

The monsoon climate occurs mainly on the eastern side of continents in the Tropics from about 5-20°N and S of the Equator.

Climate characteristics:

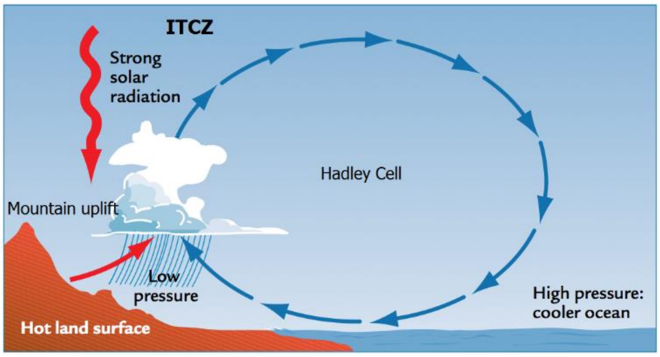
The climate is marked by a distinct hot, wet season and a cooler dry season. These are determined by the annual movement of the ITCZ between the Tropics and associated movement of pressure belts and the seasonal reversal of winds associated with this.



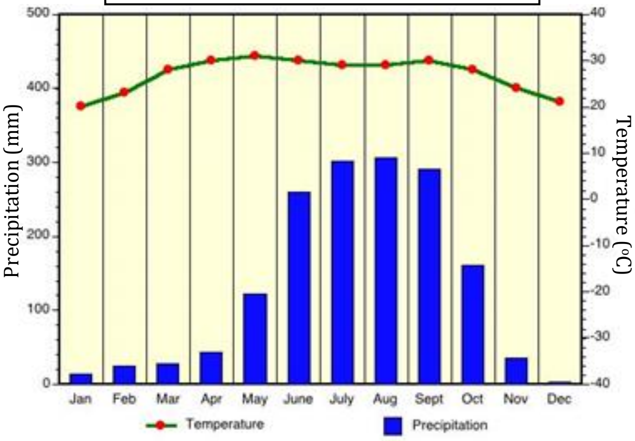
Examples:

The Monsoon climate is most clearly seen over India but exists in other regions north and south of the Equator. In India the hot/wet monsoon season occurs with the movement of the ITCZ into the region bringing an area of low pressure and drawing in hot moist winds from off the Indian ocean. Rainfall is increased by uplift of the air over the Western Ghat mountains in India.

Formation of the summer monsoon



Climate graph for Kolkata, India

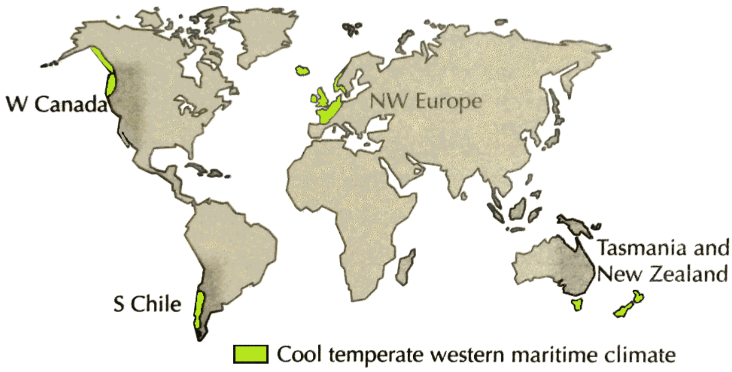


In Kolkata temperatures are high averaging 30°C in the monsoon season and humidity is also very high. Average rainfall is around 2000m for the season (Barry receives just over 1000mm per year) decreasing with distance inland. Cyclones (tropical storms) are frequent towards the end of the rainy season. The cooler dry season coincides with the extension of continental high pressure as the ITCZ moves back towards the Equator. With high pressure dominating there is sinking air and dry winds blowing off the land. Temperatures remain relatively high at 25°C and evaporation rates increase.

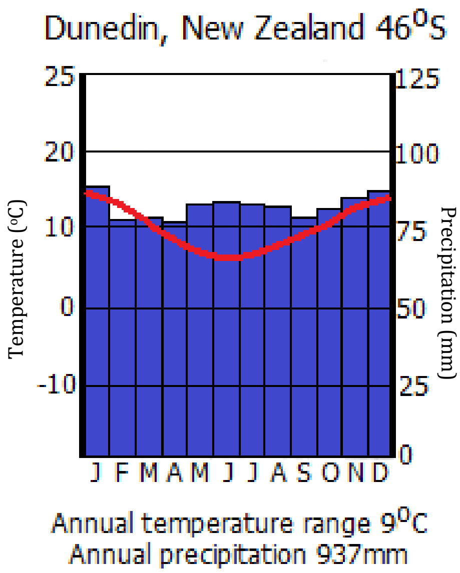
4.5.3 Climate and weather of Wales and the UK

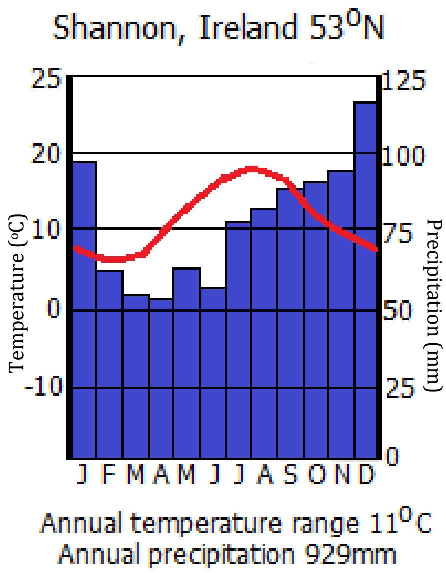
Characteristics of our climate

The UK is found within the climatic type known as **Cool temperate western maritime/margin** (**CTWM**). This climatic type is found in a number of places around the world:



This climatic type is characterised by relatively mild temperatures (average seasonal range 5–20°C), along with high humidity and precipitation (in the range of 600 -1200mm) throughout the year. However, precipitation totals are significantly higher over upland areas in the face of prevailing moist westerly winds coming off the ocean, e.g. in the Cambrian Mountains of mid Wales or the Southern Alps in New Zealand. Conversely, precipitation totals are low in rain-shadow areas, e.g. the lowlands of eastern England.





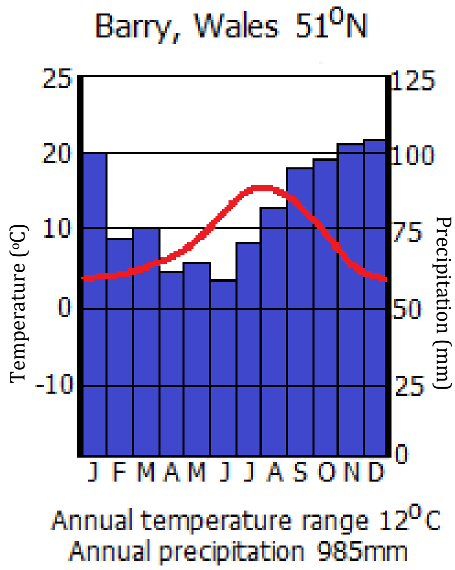
THE UK

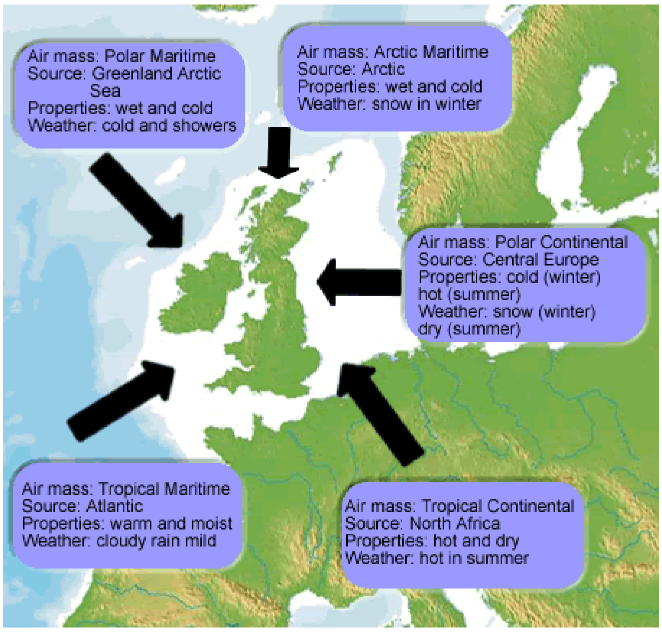
The temperatures and precipitation figures for the UK are mainly influenced by:

- Our mid-latitude position – where we receive varying amounts of insolation during the year. Highest on 21st June and lowest on December 22nd.
- The fact that we are dominated by low-pressure belts due to our position near the polar front during the winter months.
- The UK receiving mild westerly prevailing winds from the south west. These winds are warmed by the Gulf Stream ocean current originating in

the Gulf of Mexico and heading across the Atlantic towards the western side of Europe.

- Our position close to the ocean (maritime) lead to us receiving plenty of precipitation, particularly as moist air is forced to rise over the mountains of Wales and Scotland. The sea also regulates our temperature keeping us warmer in winter and milder in summer.
- Finally, the CTWM climatic zone is found where a number of different **air masses** (large bodies of air with similar pressure and weather condition's) meet. These different air masses tend to bring with them specific conditions (pressure, temperature and precipitation) as suggested by their names.

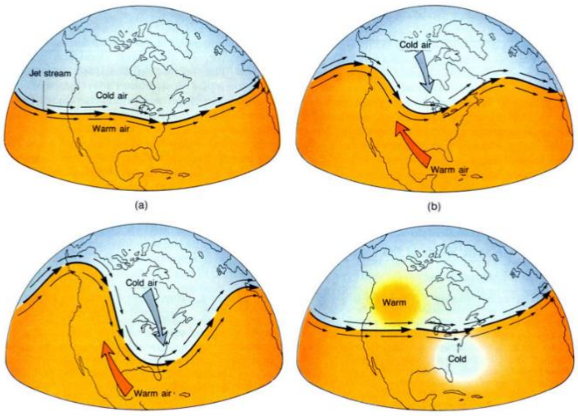




The weather in the UK is also strongly influenced by variations in the jet stream. **Jet streams** are high-altitude winds (about 1200m+) that can reach speeds of over 200km/h. There are three main jet streams located at the boundaries of the three cells. They occur where warm and cold air mix high in the atmosphere and they therefore allow the transfer of large amounts of energy.

The mid-latitude stream, at about 40° to 50°N or S guides depressions from west to east across the Atlantic Ocean. When it periodically migrates to the south into warmer water it develops depressions (low pressure systems) and powerful storms such as the one that struck the UK in January 2014. However, if it moves north it can lead to a long period of high pressure and stable weather conditions such as the long drought of 1976. Why the jet steams change position no-one is sure, but many have suggested that changes in ocean temperatures lead to slow changes in the position of the jet streams.

As can be seen on the right the jet streams do not flow in a straight line. They tend to meander just as a river does. They are formed as a result of the Earth's surface being uneven with mountain chains and oceans. These giant meanders at high altitude are known as **Rossby waves**. This movement is the beginning of the anticlockwise movement of a depression or low pressure system and generates our prevailing south-westerly winds.

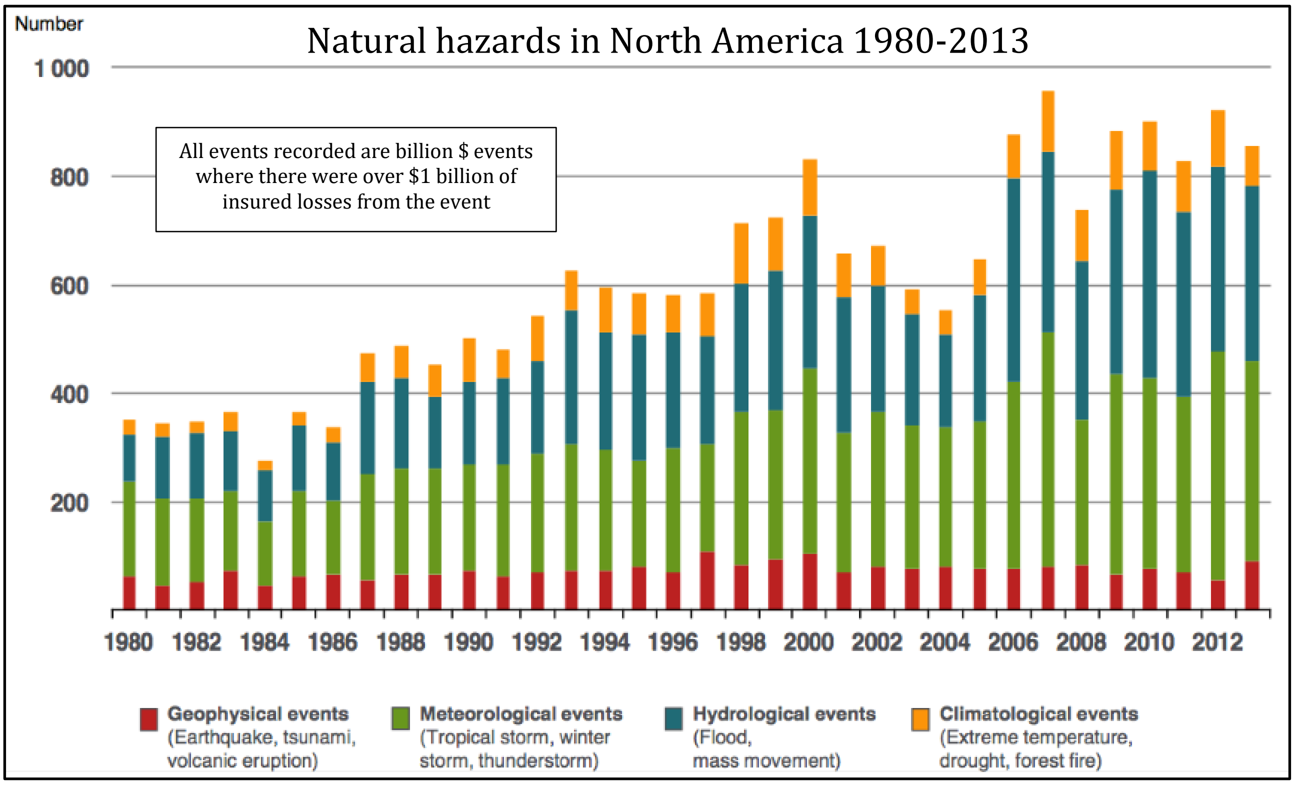


The effect of Rossby waves on the jet stream

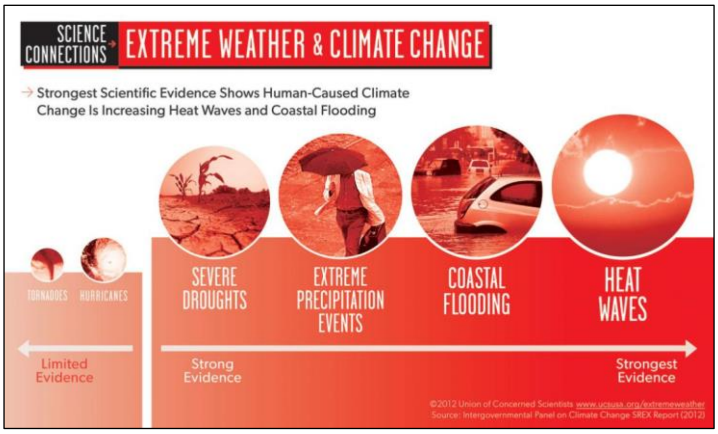
4.5.4 Extreme weather events

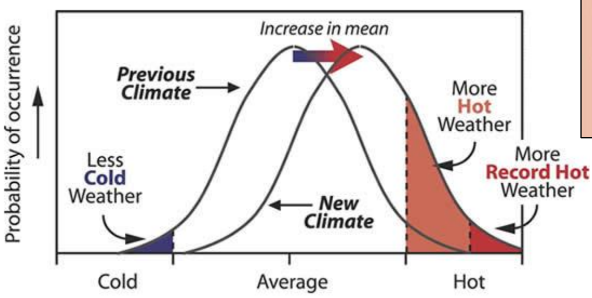
Recent and cyclical climate changes

There is now strong evidence that the enhanced greenhouse effect has led to an increase in the average temperature of the atmosphere. There is also an increasingly strong link between this global warming and an increase in the number of extreme weather events.

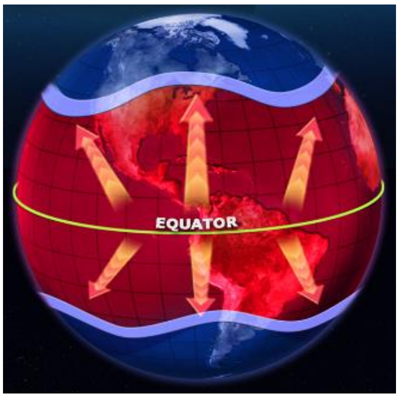


The infographic alongside shows that there is more evidence for certain extreme weather events being linked directly to climate change. In some locations (such as Australia, China and the central states of the USA), the occurrence of heat waves has more than doubled due to human influence.



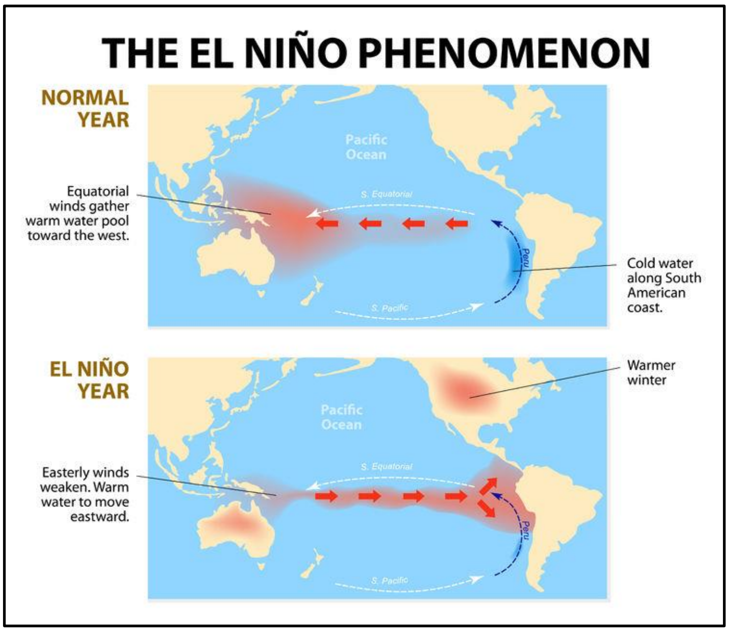


Increases in heavy precipitation have probably also occurred over this time, but vary by region. It is likely that the number of heavy precipitation events over land has increased in more regions than it has decreased in since the mid-20th century. In the future, it is likely that the global frequency of tropical cyclones will decrease or stay the same, although maximum wind speeds and rainfall will increase.



In recent years the UK has seen increasing number of severe winter storms (depressions). These seem to be becoming ever more intense as sea temperatures rise. In fact, the tail end of many Atlantic hurricanes now reach the UK. This intensification of storms may be linked to a poleward shift in the Northern Hemisphere jet streams.

PERIODIC CLIMATE CHANGES



El Niño ('Christ child'), sometimes known as the ENSO (El Niño southern oscillation) is an abnormal warming of the surface water in the southern Pacific Ocean. It happens periodically and can have major effects on climates around the World, as far away as Africa (where droughts occur in El Niño years). El Niño events typically bring heavy, drenching rain to South America, while Indonesia experiences drought conditions. And during La Niña this is reversed.

La Niña ('child girl') is the term for the opposite condition (or extreme 'normal' conditions). This is where the surface water of the eastern Pacific Ocean is cooler than normal. The Western Pacific is therefore warmer and generates more energy, storms and rainfall. The general effects of this phenomenon are that drier areas get drier and wetter areas get wetter.

SUMMARY

On the basis of current evidence about the observed impacts of climate change on environmental conditions, climate change will be an increasingly important cause of human insecurity globally in the future. The greater the impact of climate change, the harder it will be to adapt.

4.5.5 Impacts and management of climatic hazards

Impacts of low pressure hazards

A **natural hazard** is a natural event that may cause harm to people, property or the environment.

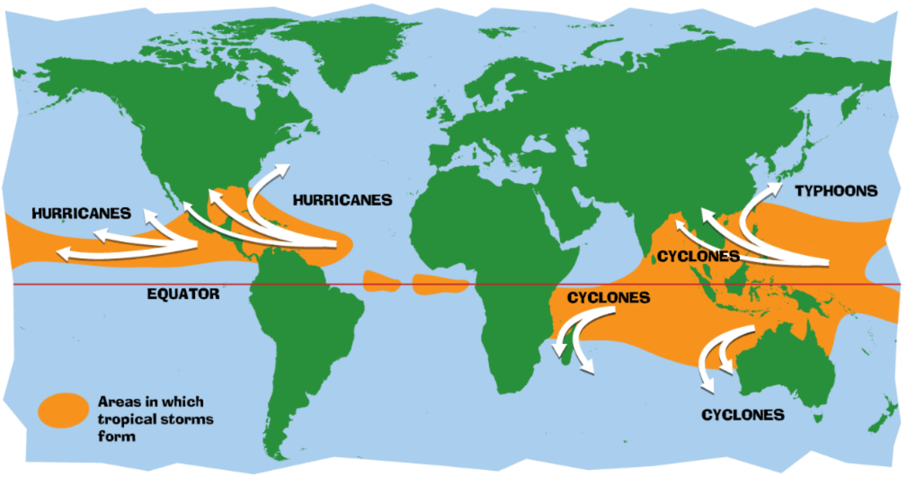
A **climatic hazard** is an extreme climatic/weather event(s) causing harm and damage to people, property, infrastructure and the environment. It includes not only the direct impacts of the climate/weather event itself but also the other (secondary) hazards 'triggered' by that event e.g. landslides 'triggered' by torrential rain.

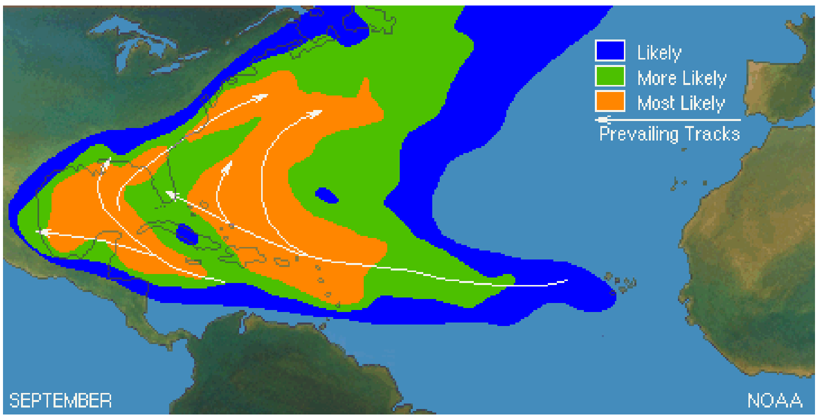
TROPICAL STORMS

What are they?

- Intense low pressure systems – far more intense than a depression.
- Rapidly rotating around a central zone
- Areas of very high rainfall
- Areas of very strong wind (over 120km/h, record speed - 360km/h).
- They usually last between one and two weeks
- They can cover areas up to 600km in diameter

In the Northern Hemisphere storms rotate anticlockwise and move in an east to west path following the easterly trade winds. At around 30°N they swing to the north and then east as they move into the Ferrel cell and the westerly winds begin to dominate. Over land hurricanes lose their supply of moisture and thus latent heat. They slowdown as there is greater friction with the uneven land surface. Eventually they become a depression and then die out.





THE EFFECTS OF LOW PRESSURE HAZARDS

The effects of a tropical storm (hurricane, cyclone or typhoon) can be devastating, causing widespread damage to property and land, disrupting communications and causing loss of life.

The Impacts of Tropical Storms

1) <u>Short term</u> - A large tropical storm releases more energy in a day than the USA consumes in a year. Although the powerful winds and intense rainfall cause a huge amount of damage, by far the most dangerous impact is the **STORM SURGE**. This occurs mainly due to the intense winds and power of the storm bulldozing sea water in front of it. The very low pressure associated with the storm also raises the surface of the sea. This can produce exceptionally high sea levels and waves. Vast areas of land can be flooded as happened with Hurricane Katrina in 2005.

Hurricanes lead to widespread **DESTRUCTION OF PROPERTY**, especially by wrecking buildings that are poorly constructed. In MEDCs buildings often suffer no more than broken windows and roof damage, although flood damage is always a major problem. Loss of property may lead to homelessness and family breakdown.

Loose objects such as bins, cars, plants and tiles can be picked up and tossed around by the **STRONG WINDS** and cause damage. In addition to the above problems **COMMUNICATIONS** can be severely disrupted as power lines fall, mobile phone mast collapse and roads/railways etc. are blocked. Other economic impacts include the closure of businesses, loss of jobs and the cost of rescue and rehabilitation.

In many LEDCs animals are killed and crops destroyed. **AGRICULTURE** can be affected for a long time. Flooding can also lead to a lack of fresh drinking **WATER** in the area. The overall effect on an area is to severely damage the **INFRASTRUCTURE**. Roads, railways and bridges may become damaged and limit the ability of emergency services to operate effectively.

Other **SECONDARY HAZARDS** can sometimes be triggered such as landslides, mudflows and increased coastal erosion.

2) <u>Longer term</u> – Many LEDCs take years to recover from the devastation. Crops and livestock are lost and livelihoods are destroyed. This can cause **FAMINE** and loss of **INCOME**. Inundation of the land with salt water can create the problem of **SALINISATION** causing long term crop failures. Shortages of clean freshwater can lead to the **SPREAD OF DISEASE**. As a result of a major event **MIGRATIONS** of groups of people may take place altering the demography of an area permanently.

Houses take time to rebuild and the breakdown in communication can make it very difficult to distribute aid to those who need it the most. Large hurricanes have actually led to **INSURANCE** companies going out of business as the number of claims rockets. This has in turn led to some people in high risk areas finding it impossible to get their property insured. Other longer term economic impacts include the cost of rebuilding the infrastructure and ensuring that strategies are put in place to mitigate the effects of future events.

Longer term environmental impacts can include the loss of vegetation such as coastal forests and the degradation of saltmarshes and sand dunes.

TOURISM is another industry that can be severely affected by the impact of a tropical storm. Many popular destinations including Mexico, Florida and the Caribbean are particularly prone. Travel companies and hotels often find themselves liable for huge claims and as a result rarely now take out insurance. This can lead to potential tourists perceiving these areas as too high a risk.

The extent of the impacts of a hazard are dependent upon the following factors:

Physical

- The severity of the event (the category of the tropical storm)
- The path/track that the storm takes
- The spatial extent (size) of the storm

Human

- The density and distribution of the population
- Density and types of human activity in the areas affected
- The overall preparedness of the people in the affected area
- Capacity of the authorities to cope with the impacts (**resilience**).

In order to investigate the impacts of tropical storms and the resilience of the people and authorities, we are going to study in detail two contrasting case studies:

CASE STUDIES

Hurricane Katrina and **Cyclone Nargis**

For each you will need to gather the following information:

Locations affected	Date	Tracking and prediction
Formation	Costs	Development of the storm
Detailed impacts	Recovery	Associated hazards
Responses	Casualties	Short and long term effects

The extent of any prediction, protection and preparation in place

Strategies put in place since the event to improve future resilience

Impacts of high pressure hazards

High pressure hazards are created when periods of stable, dry, descending air sit over a region for a period of time. They most commonly occur the subtropical high areas between 10-30^{o} north and south of the Equator. The effects of these hazards are at their most severe in summer. However, in winter high-pressure systems are associated with frost and fog and secondary hazards may include temperature inversion with air pollution intensifying the fog conditions. In tropical regions high-pressure systems are associated with low rainfall, high evaporation rates causing **drought**. This can subsequently trigger secondary hazards of a falling water table, loss of vegetation, wild fires, soil erosion and desertification.
In temperate regions high-pressure systems can also result in droughts, but these are often far less severe. They can also trigger falling water tables and the loss of vegetation.

DROUGHT

A drought is period of below-average precipitation in a given region, resulting in prolonged shortages in its water supply. There is no definitive precipitation total as different areas expect different average amounts. The effects of drought are felt all over the World in places as far away as Australia and the UK. However, the effects are far more severe and long lasting in areas that are already semi-arid. Areas that have poor infrastructure and are poorly developed are also highly prone to damaging droughts.

THE EFFECTS OF HIGH PRESSURE HAZARDS

The Impacts of Drought

1) Short term - the most obvious immediate effects of drought are the problems brought on by the **LACK of WATER**. This can lead to large scale **CROP FAILURES** and **ANIMALS** suffering as irrigation channels and watering holes dry up. Shortages of clean water lead to a **SPREAD of DISEASE** and childhood **HEALTH PROBLEMS**. These problems can eventually lead to death. Water rationing is introduced in many MEDCs and as a result, businesses can suffer.

2) Long term - As **AGRICULTURAL OUTPUT FALLS**, many LEDCs suffer as **EXPORTS DROP** and imports cannot be paid for. For example, in 2010 after two years of drought Zimbabwe's GDP dropped by 11%. Many poorer rural areas suffer very badly and as a result people decide to move away and **MIGRATE** to the cities in search of a better lifestyle. When areas are abandoned people often become homeless and **ENVIRONMENTAL REFUGEES**. A major problem with long term drought is that it can lead to **DESERTIFICATION**. As the land becomes drier and **VEGETATION DIES** the soil becomes loose and fragile. Wind storms blow the soil away (**SOIL EROSION**) and previously fertile land turn to desert.

This process of desertification can lead to the loss of some of the country's most productive land. As a result, a country's **FOOD INFRASTRUCTURE** can suffer. As people look for other sources of income **DEFORESTATION** can become a problem. Over time the **OVERUSE of GROUNDWATER** supplies can lead to their exhaustion and sometimes **SALINATION**.

CASE STUDY

In order to investigate the impacts of tropical storms and the resilience of the people and authorities, we are going to study in detail two contrasting case studies:

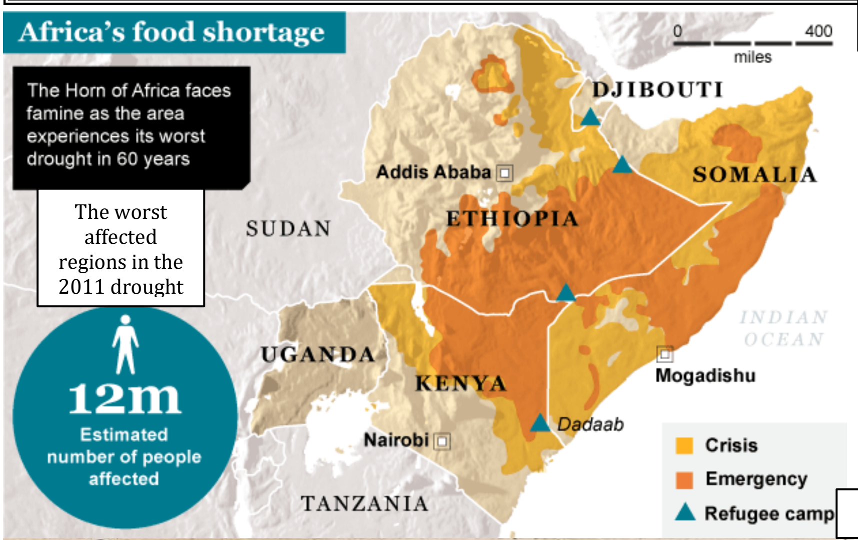
Horn of Africa Drought 2011

You will need to gather the following information:

Countries affected	Dates	Tracking and prediction
Detailed impacts	Costs	Associated hazards
Casualties	Water supply	Short and long term effects
Recovery	Responses	

The extent of any prediction, protection and preparation in place

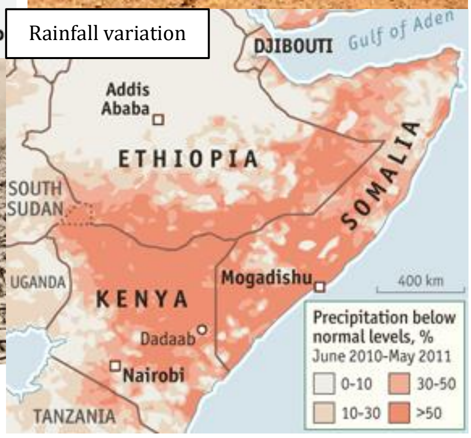
Strategies put in place since the event to improve future resilience



Water shortages

Livestock dying

Desertification



Rainfall variation

Strategies to manage climatic hazards

There are a wide variety of methods employed aimed at reducing the impact that a climatic hazard can have on a region. These include:

1. Monitoring and prediction
2. Immediate response to lessen the impact
3. Long-term planning for hazard **mitigation**.

MANAGING LOW PRESSURE HAZARDS – Tropical Storms

Monitoring and prediction – Satellite images and forecasts are used to track storms as they develop over the oceans. This is called a 'Storm Watch'. A storm warning is then given about 24 hours before the hurricane is expected to make landfall. People are then able to protect themselves and their homes from the storm. Much emphasis is now being placed on developing prediction measures (including advanced computer modelling and simulations) and investing in appropriate technology and research. Forecasting however is not always a perfect art as Hurricane Katrina in 2005 proved.

Protection measures – If detailed warnings are issued then evacuations can be organised on a large scale as in parts of New Orleans prior to Hurricane Katrina in 2005. These can save many lives providing that the transport infrastructure is good enough to move people out. People can take simple measures to protect their homes from the worst of the storm damage. Windows and doors can be boarded up and sand bags used to prevent flood waters entering. Finally hazard resistant designs can be used to reduce the impact of the high winds and floods.

Land use planning – Attempts are being made to restrict building in hurricane prone areas, especially in southern Florida, Texas and Louisiana in the USA. Many insurance companies are raising premiums in high risk areas forcing people to rethink the areas in which they choose to live. Some areas are now being abandoned and allowed to return to saltmarshes, thus providing a natural barrier to storm surge.

Community preparedness: In many areas of the World storm drills are promoted to prepare people. Programmes are shown informing people of such things as availability of building materials and emergency assistance. Leaflets and posters are distributed with lots of information on what to do in the event. People are also encouraged to store emergency supplies of food, fuel and water.

Reducing wind speeds: Tropical storms cannot be prevented but research has been done into reducing winds speeds and thus the damage caused. Cloud seeding projects involve the release of silver iodide (dry ice) into the storm. This promotes the release of latent heat and so reduces the power of the storm. Reductions of up to 15% in wind speeds have been seen. However, the cost of projects is prohibitive and most have been abandoned.

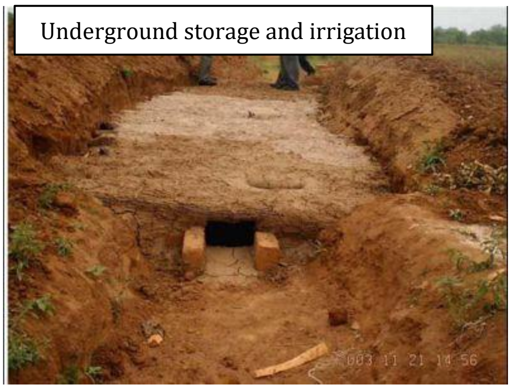
Through a combination of these methods it is hoped that communities can be made more **resilient** and that many of the worst impacts of the storms may be **mitigated**.

MANAGING HIGH PRESSURE HAZARDS - Drought

Monitoring and prediction – Increasingly satellite technology is being used to monitor oceans currents and sea surface temperatures. This information allows El Niño or La Niña events to be noticed earlier and strategies put in place to reduce their potentially damaging effects. Reference to historical climate data also allows far more accurate predictions and computer models to be undertaken. Remote sensing is also used to map reduction in vegetation cover and soil degradation. Areas at risk can be targeted with aid or local projects to prevent further damage. Food and nutrition surveys are also carried out regularly by governments and the UN to pick up patterns of drought and its effects. Famines have been prevented by prediction methods such as this.

Protection methods – Many local, low-tech improvements can be made to try to reduce the impact of droughts by improving water supply. Many of these come under the heading of rainwater harvesting:

- Increasing storage capacity by building simple earth dams to store water.
- Storing water in underground reservoirs to reduce evaporation.
- Using water tables to collect water in recycled plastic bottles.
- Water butts are used to store water in the rainy season.
- Using groundwater sustainably, by monitoring levels and usage.


Underground storage and irrigation



Reducing water waste and losses



Water butts or water tables with recycled plastic bottles

Other methods can be used to try and prevent further land degradation, soil erosion and desertification:

- Trees are planted to provide wind breaks and to retain moisture in soil.
- Mulches (leaves etc. placed on ground) are used to retain moisture.
- Trees are harvested (coppiced) for fuel, so the tree still survives.
- Drought resistant crop varieties or livestock can be bred and farmed.
- Drip irrigation is used to prevent water being wasted and evaporating in the hot temperatures.
- Building of terraces to retain soil and moisture.
- Stone lines or earth walls are used to prevent soil erosion. These also trap water and crops can be grown along them.


Mulch squares (dead grass) help to shade and protect the soil


Drip irrigation give each plant all it needs


Magic (stone) lines trap moisture and protect the soil


Terraced slopes retain water and prevent soil erosion


Coppicing lower tree branches for fuel wood so that the tree stays alive

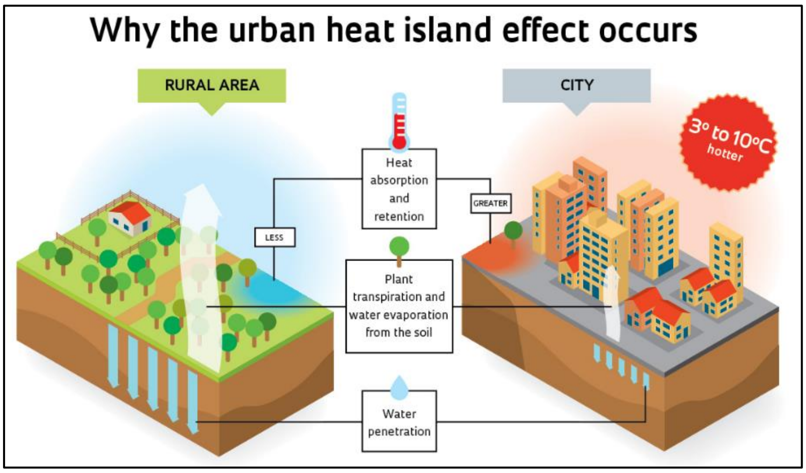

Planting tree lines to reduce wind speed and erosion

Community preparedness - In many drought prone areas of the world education is the key to successfully mitigating the future effects. If locals are educated in efficient use of water and in land management techniques, then the effects of climate change may be reduced. Population control is also an important factor that cannot be ignored. Land in areas such as the Horn of Africa is under increased pressure as people try to produce more food and use more water in vulnerable areas.

4.5.6 Impacts of human activities on the atmosphere

Impacts of urban areas on climate

The main impact of human activity on the atmosphere at both the local and regional scale is the formation of **urban microclimates**. The existing microclimate of an area is destroyed and a new one is created. Urban areas affect all of the microclimate variables:

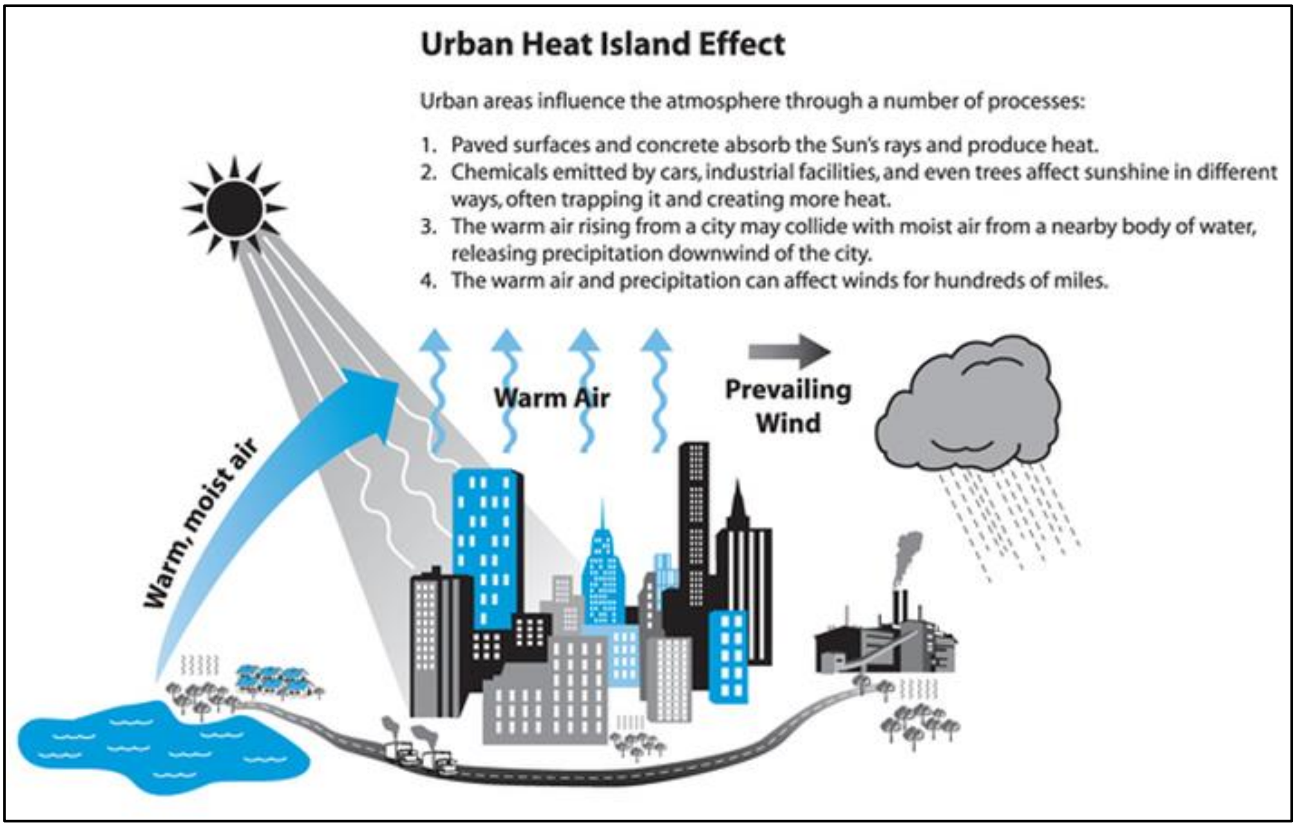


- **Temperatures** increase, particularly during anticyclonic conditions, in the night and in winter.

- **Wind** characteristics are altered, including wind speed (reduced through friction or increased through channelling between tall buildings) wind direction and turbulence.

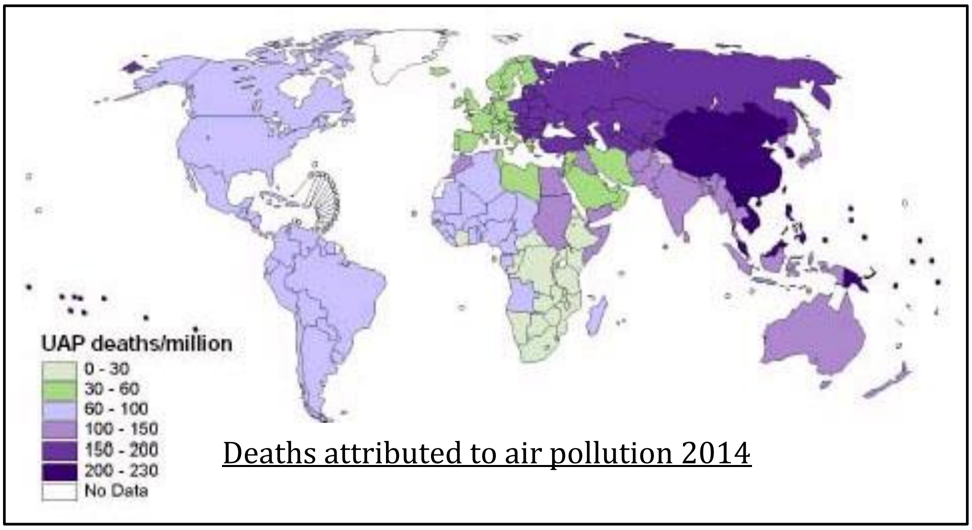
- **Precipitation** levels are higher with thunderstorms and hail more likely.

- **Humidity** levels tend to be lower and evapotranspiration rates higher.



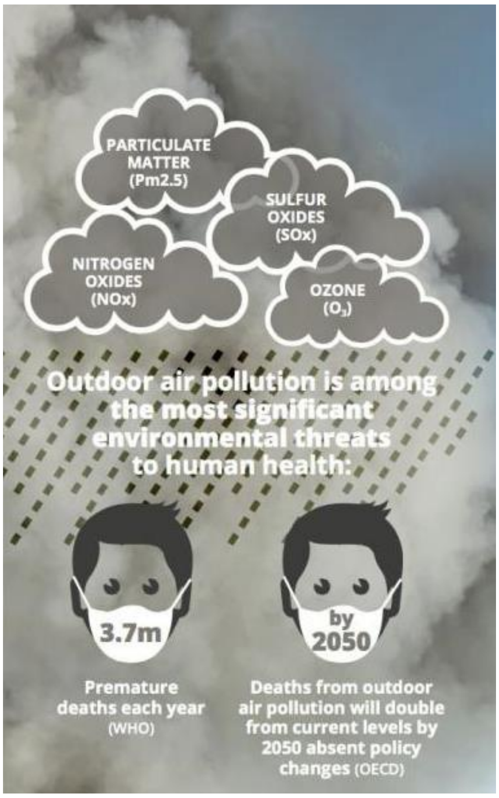
Impacts of urban areas on air quality

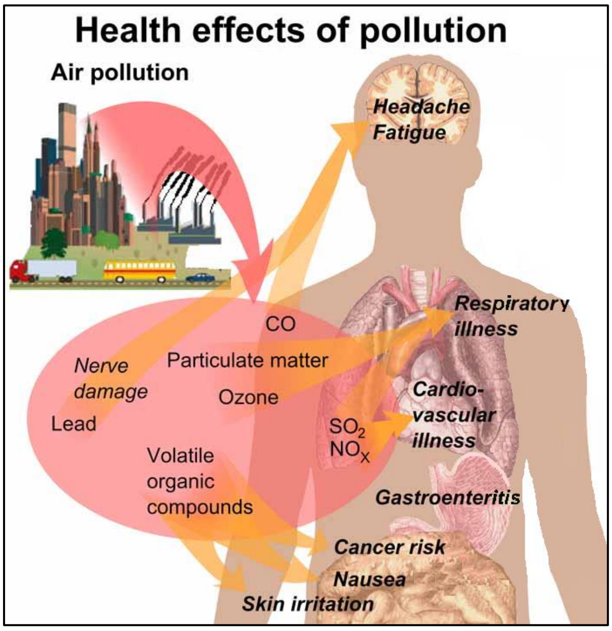
With an increase in urbanisation across the world has come a subsequent decline in urban air quality. While in MEDCs some strides have been made to reduce urban air pollution, in LEDCs and NICs urban air quality continues to decline.



Deaths attributed to air pollution 2014

The increase in particulate matter (ash, dust etc.) results in a higher frequency, duration and intensity of fog in urban areas. This intense and dense mass of pollutants can sit over a city for weeks in calm, high pressure conditions. This reduces the amounts of sunshine and increases cloud cover. Human activity also induces changes in atmospheric composition, higher concentrations of gases such as carbon dioxide and sulphur dioxide and particulates leading to **particulate pollution, photochemical smog** and **acid rain.** All of these can have dramatic effects on the health of the local population.





Dense smog over Beijing, China in 2015

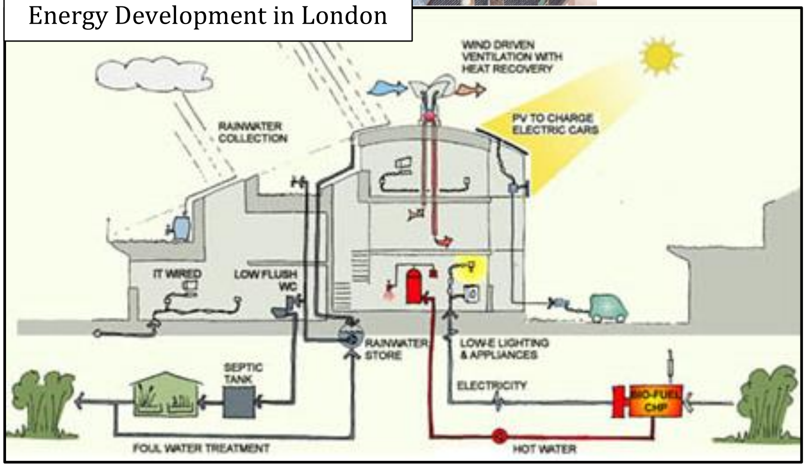
Strategies to reduce the impacts

There are a variety of strategies that can be employed to reduce the impact of human activity on urban climates. This can be achieved through:

- Better land use planning within urban areas
- Improved urban design
- Improving air quality through a variety of transport policies, legislation and technological solutions.

Land use planning and improved urban design

BedZED – The Beddington Zero Energy Development in London



By planning how urban areas are distributed spatially, planners can help to overcome some of the worst problems associated with urban climate conditions. Many things can be done to reduce the heat island effect such as incorporating more green areas to increase water absorption and particulate pollution. Sustainable transport strategies will help to reduce air pollution and heat. The layout of the city can be made far less dense with fewer high rise buildings and renewable technologies can be incorporated in all buildings. The BedZED development in London has shown that, on a small scale at least, sustainable communities with zero emissions can be created.

Improving air quality

Urban Greening has many benefits

The ways that trees can help to clean the air should not be overlooked. The most serious pollutants in the urban atmosphere are ozone, nitrogen oxides (NO_2), sulphur dioxide (SO_2) and particulate pollution. Vehicle emissions, emissions from industrial sites and chemical solvents are the major sources of these. Trees are an important, cost-effective solution to reducing pollution and improving air quality. With an extensive and healthy urban forest air quality can be drastically improved. Trees help to lower air temperatures and reduce runoff into rivers. Trees also reduce pollution by actively removing it from the atmosphere. The pores on the leaf surface, take in polluting gases which are then absorbed by water inside the leaf.

Ideally, trees should be selected that take in higher quantities of polluting gases and that are resistant to the negative affects they can cause. In addition to the uptake of harmful gases, trees also act as filters intercepting airborne particles and reducing the amount of harmful particulate matter.

London air quality strategy 2010

Policy 1 – Encouraging smarter choices and sustainable travel

- Encourage walking and cycling
- Fines for idling vehicles
- Promote car sharing
- Efficient freight transport
- Improve public transport
- Encourage eco-driving

Policy 2 – Promoting technological change and cleaner vehicles

- Increasing the use of railways
- Support a switch to electric vehicles
- Scrapping or retro-fitting older, more polluting vehicles

Policy 3 – Identifying priority locations and improving air quality through a package of local measures

- Improve access to major transport hubs e.g. Heathrow and Gatwick
- Work with local councils to support local 'greening' strategies

Policy 4 – Reducing emissions from public transport

- Encourage the use of hybrid and gas powered buses and taxis
- Electrification of the entire rail network

Policy 5 – Non transport measures

- **Reducing emissions from construction sites**
- **Making new developments 'air quality neutral or better'** - ensuring that new developments do not have a negative impact on air quality in London
- **Moving towards a zero carbon energy supply**
- **Energy efficiency schemes** – making buildings more energy efficient
- **Improving air quality in public spaces** - by planting urban vegetation
- **Encouraging innovation** – encouraging new ideas that will improve air quality
- **Raising awareness** - by highlighting the impact of poor air quality on health

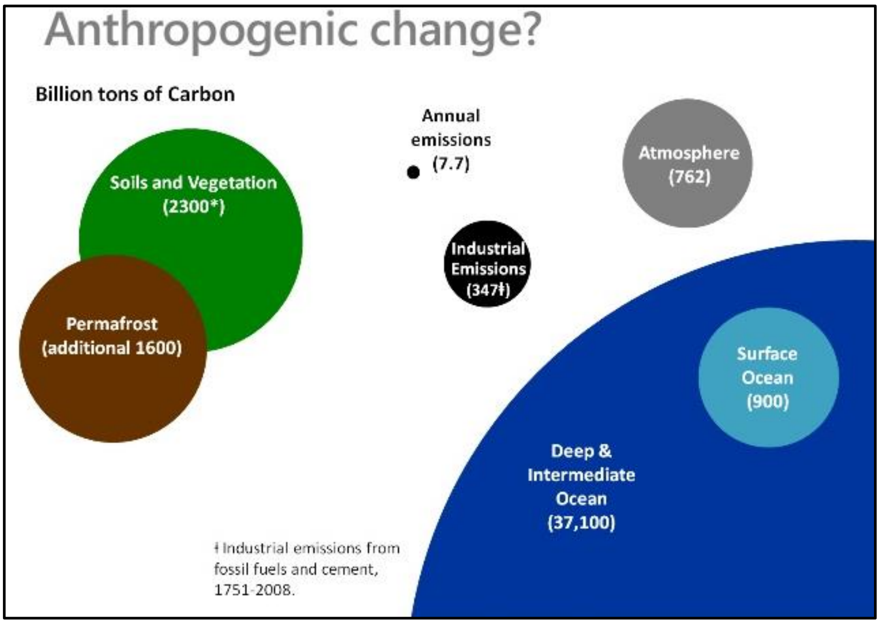
Have a look at the 2015-2020 update below:

https://www.cityoflondon.gov.uk/business/environmental-health/environmental-protection/air-quality/Documents/city-of-london-air-quality-strategy-2015.pdf.

4.5.7 People, climate and the future

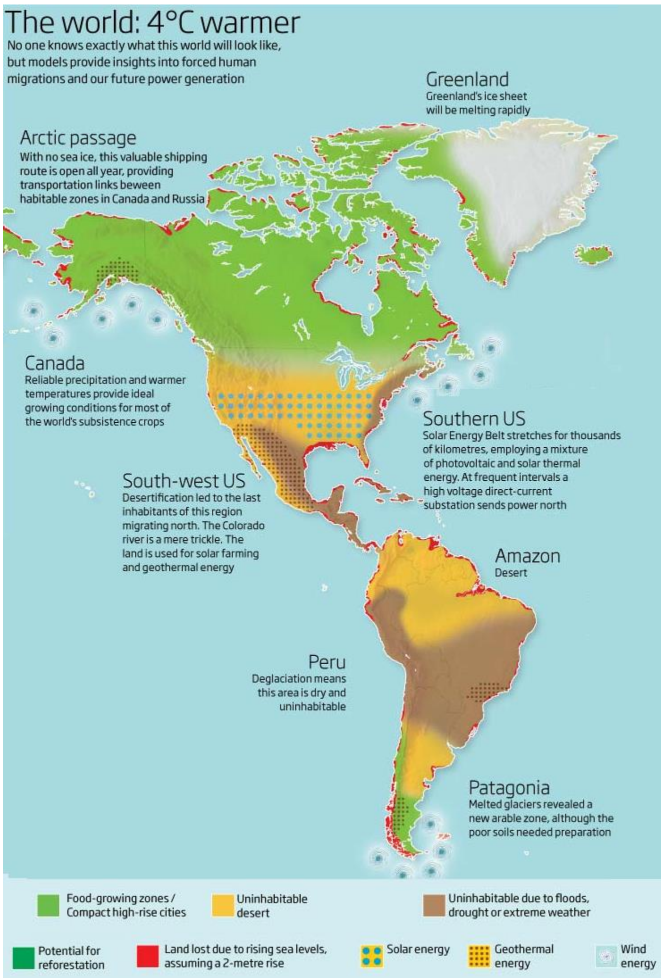
Global impacts of climate change

Anthropogenic climate change caused by the enhanced greenhouse effect is changing the balance of carbon on the planet. As the proportions of carbon stored in a variety of locations changes, so does then climate. Some of these stores may become unlocked as the earth continues to heat up and climatic belts begin to shift. This shift could happen slowly or very suddenly leading to devastating effects for people all over the world. There is a high risk that the large magnitudes and high rates of climate change this century will result in abrupt and irreversible regional-scale changes to terrestrial and freshwater ecosystems, especially in the Amazon and Arctic. This would then lead to additional climate change as more carbon is released into the atmosphere and the earth's albedo is reduced.



Many areas of the world will see dramatic shifts in climatic belts and vegetation (some beneficial and others harmful). The map alongside illustrates some of the potential shifts in the Americas. For the full map visit:

https://universe-review.ca/I09-20-climate.jpg



Some of the major shifts may include:

- The **Amazon rainforest** transforming to a far less dense, drought and fire-adapted ecosystem or potentially a semi-desert or scrub area. This would risk reducing biodiversity in one of the most important ecosystems on the planet. It would also reduce the amount of carbon absorbed from the atmosphere through photosynthesis and increase the inputs of carbon as the forest declines. It would also reduce the amount of evaporation, increasing the warming locally and reducing local precipitation.
- In the **Arctic** and **Tundra** regions there may eventually be no summer sea ice affecting many marine and land species that rely on the ice. A lack of sea ice will lead to a further increase in temperature as the albedo is reduced. Warmer seas could lead to the release of vast stores of methane stored in cold sea sediments. Loss of large areas of permafrost could result in more rapid coastal erosion and release of carbon stored within frozen soils. Vegetation changes will take place as many plants from lower latitudes will begin colonise the once permanently frozen ground, this may change the entire ecosystem of the region.

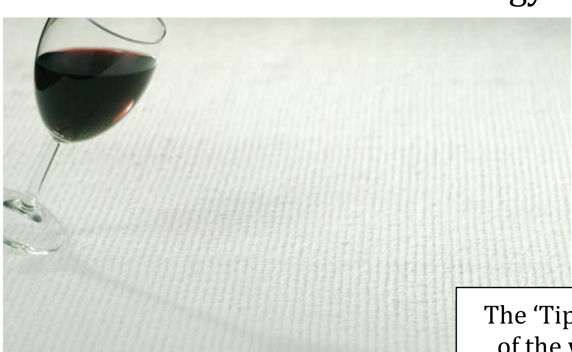

Thawing permafrost leading to rapid erosion in northern Canada

Consequences of reaching the 'tipping point'

The tipping point is a theoretical moment when the earth's temperature reaches a point at which rapid and irreversible climate change will take place. It is a critical threshold when global or regional climate changes from one stable state to another stable state. The tipping point may or may not be reversible. It may also be a point at which climate change accelerates out of control as one change triggers another.

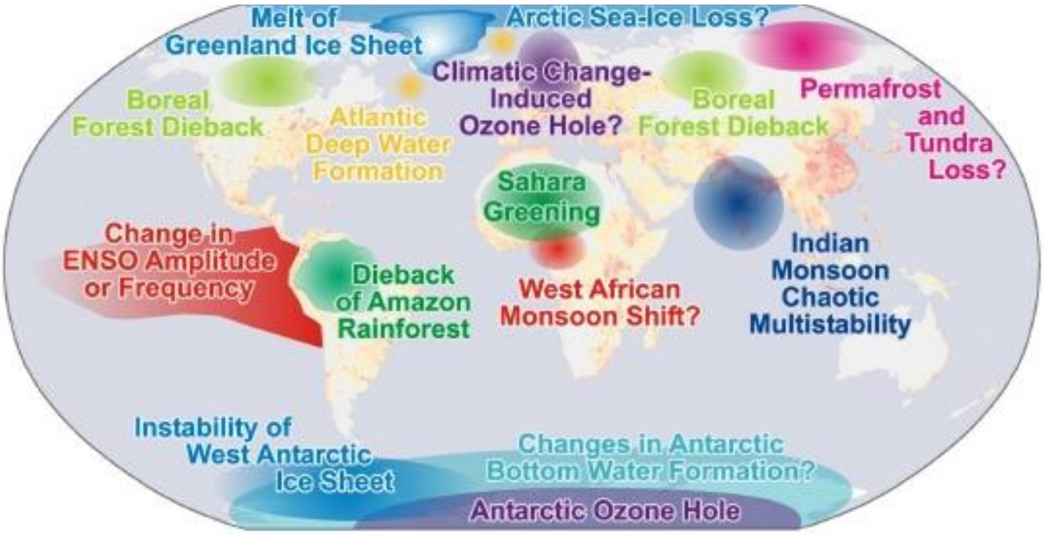
A critical threshold at which a small change in human activity can have large, long-term consequences for the Earth's climate system.

An often used analogy is that of the wine glass.



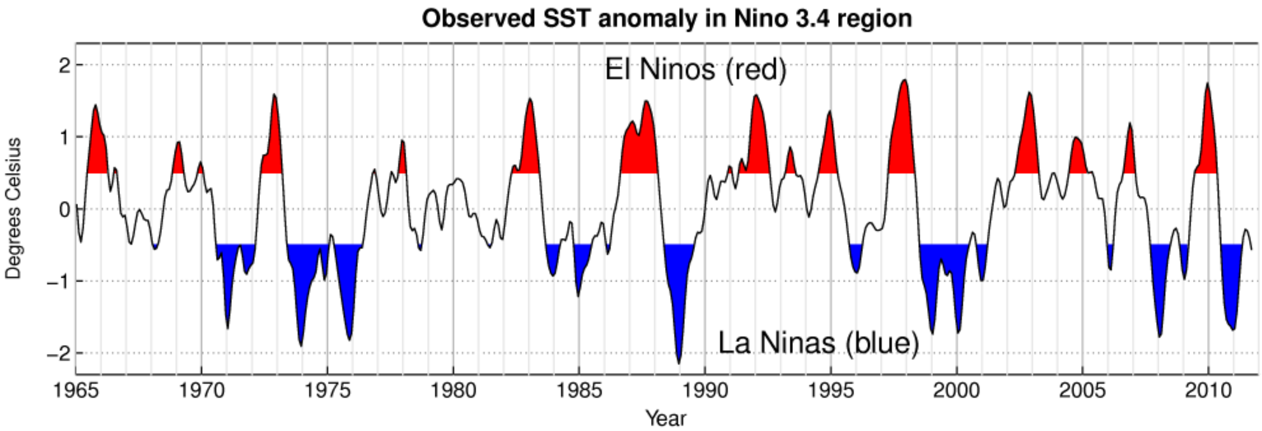
The 'Tipping Point' of the wine glass

Early warning of climate tipping points



The map above shows a number of early warnings signs of a climate tipping point for the earth's biosphere. Some of these have already begun to happen and may lead to a raid acceleration in others.

- **ENSO frequency**



- **Breakup of the West Antarctic Ice Sheet**

Strategies to mitigate and adapt to climate change

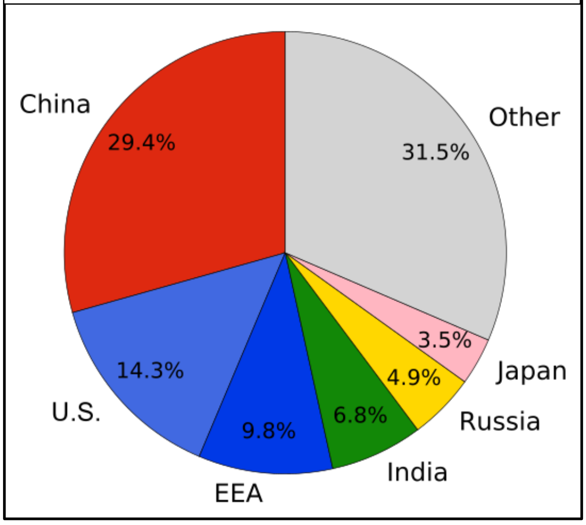
There are a huge variety of strategies that can be implemented at the international, national and local level to both mitigate and adapt to the potential effects of climate change. The strategies to address climate change are not simple as the precise nature of the process itself is not yet fully understood. Not all countries agree with the strategies that have been drawn up internationally. Also there are issues arising because greenhouse gases travel across international boundaries, this can cause conflict between countries.

The strategies that have been devised to address climate change can largely be split into 3 main groups;

International – Strategies that have been devised by a collection of different countries.

The **United Nations Framework Convention on Climate Change** (**UNFCCC**) was set up prior to the Rio de Janeiro Erath Summit in 1992 and entered into force in 1994. Since 1995, when the UNFCC first met officially in Berlin, there have been a number of international conferences with varying degrees of success and agreement. The Kyoto (1997) and Montreal Protocols (2005) were the first to set clear emissions targets for countries. However, many of these targets allowed countries to undertake carbon trading and to offset their emissions. The United States government never fully ratified the agreement and so were not bound to its targets. The Copenhagen conference of 2009 was meant to strike an ambitious agreement to take targets beyond the end of the Kyoto agreements in 2012. No binding agreements were struck. However, in 2015 at the Paris climate change conference 98% of parties agreed on ambitious targets to be met from 2020 onwards. Only Syria (due to civil war) and Nicaragua (unhappy with a lack of penalties for those not hitting targets) failed to sign. However, in early 2017 the USA pulled out of the agreement siting potential negative economic impacts.

Global CO_2 Emissions per country 2015



A major international player in addressing climate change is the **IPCC** or **Intergovernmental Panel on Climate Change** which was set-up in 1988.

The IPCC website can be found at: http://www.ipcc.ch/

The IPCC is a scientific intergovernmental body set up by the World Meteorological Organization (WMO) and by the United Nations Environment Programme (UNEP). As climate change is a very complex issue: policymakers need an objective source of information about the causes of climate change. Climate change has potential environmental and socio-economic consequences. This is why WMO and UNEP worked together to establish the IPCC.

The IPCC is a scientific body: the information it provides with its reports is based on scientific evidence and reflects existing viewpoints within the scientific community. The comprehensiveness of the scientific content is achieved through contributions from experts in all regions of the world and all relevant disciplines including, where appropriately documented, industry literature and traditional practices, and a two stage review process by experts and governments.

National – Strategies that are implemented by the Governments of different countries to address both the causes and potential results of climate change.
In the UK the Government set its first ambitious targets in the 2008 Climate Change Act. The Act makes it the duty of the Secretary of State to ensure that the net UK carbon account for all six Kyoto greenhouse gases for the year 2050 is at least 80% lower than the 1990 baseline.

Other policy pledges in recent years include:

- Setting targets for energy companies to move to renewable forms of energy.
- Incentives for wind, tidal, solar, biomass and HEP power stations.
- Increased investment in nuclear energy.
- Taxes on business energy use.
- Ambitious targets for energy intensive industries such as concrete and steel.
- Changes to building regulations to reflect energy efficiency.
- Tax incentives for electric and hybrid transport.
- Phasing out of diesel and other polluting vehicles.
- Increased energy efficiency for new and council homes.
- Grants to improve household energy efficiency and renewable energy use.
- Improving customer information on products (e.g. washing machines).
- Afforestation schemes with grants for farmers in rural areas.

Local – Strategies that are implemented by Local Governments, pressure groups and individuals on a smaller scale. Research the two following areas:

1) Climate Change policies pursued by:

a) Vale of Glamorgan Council
b) Pressure groups (Greenpeace etc.)

2) What can be done by individual households to combat climate change?