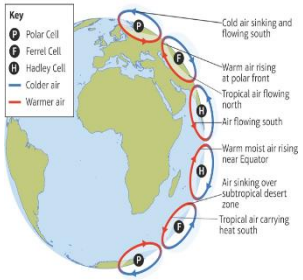
Topic 1A Hazardous Earth: Climate

Key Terms
Coriolis Effect
Polar Cell
Ferrel Cell
Hadley Cell
Weather
Jet Streams
Isobars
Millibars
Intertropical convergence zone
Source areas
Prevailing winds
High Pressure
Low Pressure
Milankovitch cycles
Glacial
Solar variation
Volcanism



<u>The Atmosphere operates as a global system which transfers heat around the Earth.</u>

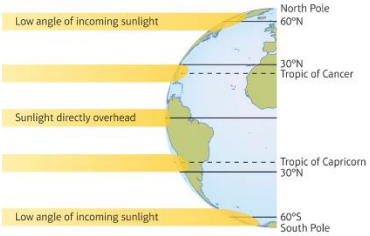
The earth's atmosphere is constantly moving; the wind movements form a clear global circulation pattern. The movement of air within the atmospheric circulation cells is controlled by heating and cooling. The sun receives all of its heat from solar radiation from the sun. The solar radiation passes through the atmosphere and heats the ground directly. As the ground heats up, it warms the air above it, so warm air rises and transfers heat to the atmosphere. Later this cools, becomes denser and sinks towards Earth.

As the earth is roughly spherical, more solar radiation is received at the Equator, the hottest part of the Earth's surface. This means the poles are the coldest as they receive the least solar radiation as there is a larger distribution area and the radiation has travelled further and lost heat along the way.

Winds are caused when the air moves from a high (air sinks) to low (air rises) pressure. However, because the Earth rotates, the air does not flow in a straight line, so winds flow in a curved path called the CORIOLIS EFFECT. In the Northern Hemisphere winds are deflected to the right and in the Southern Hemisphere to the left.

JET STREAMS can also have an impact on air movement. Jet Streams form mostly at the boundaries of the main circulation cells (e.g. at the boundary of the Polar Cell and the Ferrel Cell) where there is a significant temperature difference. These are high winds that occur. These streams can affect the movement of other weather systems and can therefore change the weather for different areas.

The oceans also redistribute heat effectively around the Earth. The water near the Equator is hotter than near the poles and again water moves from hot to cold areas. This is helped by the movement of the wind across the ocean. The currents in the ocean move as the cold water sinks and warm water rises. This means a locations proximity to water can have a large effect on its climate as water can hold heat for a long time.



<u>Exam questions</u>

1. Explain how the Gulf Stream redistributes heat (2)
2. Explain the difference in solar radiation received at the Equator compared to the poles. (4)
3. Explain how high and low atmospheric pressure systems occur (4).
4. Explain how ocean currents transfer heat energy around the Earth. (4)

Eccentricity - The orbit of the Earth changes approximately every 100,000 years. This means that sometimes the Earth's orbit around the Sun is more circular, making us warmer (Interglacial), and sometimes the orbit becomes more elliptical, making the Earth cooler (Glacial).

Several natural processes can lead to climate change. One of these processes is **Milankovitch Cycles.** These are natural changes to the Earth's orbit and position that affect how much solar radiation we receive from the sun.

Axial Tilt - The Earth is tilted so that the poles are rotated approximately 23° from a vertical position. This is what creates seasons. Over a 40 000 year period the angle of the tilt changes. This means the Earth is tilted further away from the sun making the seasons more pronounced or nearer to the sun making the differences in seasons less obvious.

Precession - As the Earth rotates on its axis, it doesn't rotate perfectly. It tends to 'wobble' as this happens, the direction the axis is facing changes. This affects our seasons and creates a greater or smaller difference between summer and winter. This happens every 24,000 years.

Climate change refers to how the average climatic conditions of the planet vary over time. The Earth has gone through cycles of warm (interglacial) periods and cold (glacial) periods. The planet's climate during the Quaternary period (the last 2.6 million years) has changed many times.

Evidence for natural climate change -

Ice Cores - Ice sheets in Greenland or Antarctica has built up over hundreds of thousands of years (800,000 in Antarctica). In some places the ice is 3000 metres deep. As the snow falls and gets compacted it creates layers of ice. As the ice forms it traps air bubbles, which contains a sample of the atmosphere at the time it was frozen. As well as this water has isotopes depending on temperature which are also frozen in the ice. When scientists analyse the ice they can tell what the temperature was like and what the atmosphere contained. To get the ice cores scientists drill bore holes into the ice.

Tree Rings- As trees grow they produce growth rings that can be seen in a cross section of a trunk. Growth rings are wider in warmer and wetter regions and narrower in cold and dry climates. Analysing the rings can indicate what the climate was like for 100-1000 years.

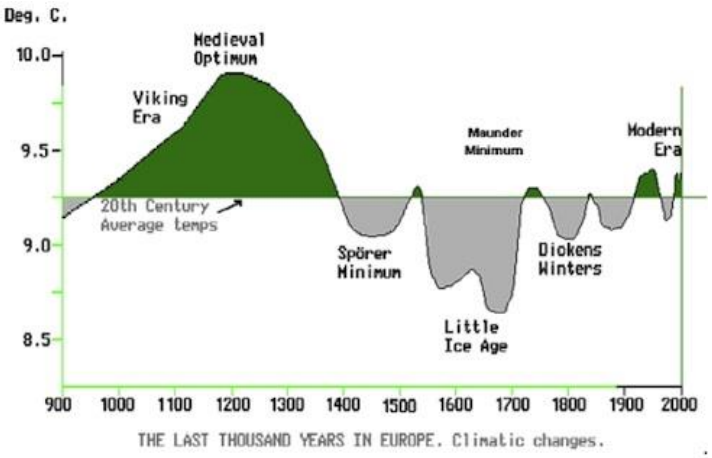
Historical sources - Historical documents such as diaries, paintings and religious records, to examine more recent historical climates. These documents describe the climate of the time e.g. the Anglo-Saxon Chronicles were recorded by English Monks from 890 to the middle 1100s.

Other natural causes of climate change

- Solar variation - The amount of radiation the Sun produces varies over time. Periods of lower solar activity are likely to lead to glacial periods and those with higher activity to lead to interglacial periods.
- Volcanism - Large-scale volcanic eruptions can eject huge volumes of ash and dust into at the atmosphere. Some eruptions produce so much that the volcanic material partially blocks out solar radiation, reducing global temperatures and causing cooler periods.
- Surface impact - Large cosmic material, such as asteroids and comets can impact the Earth's surface. This can eject large volumes of dust into the atmosphere blocking solar radiation, which can lead to glacial periods.

Exam questions

1. Climate change refers to the average climatic conditions of the planet over time. Explain how eccentricity can affect our climate. (4)
2. Explain how tree growth can help us prove past climatic conditions. (4)
3. Assess the following statement. 'The causes of past climate change and current global warming are different.' (8+3)



The global climate is now changing due to human activities and we are uncertain about the future.

The greenhouse effect— A natural process which keeps the Earth warm. Greenhouse gases in the atmosphere act as a blanket and trap solar radiation that is being radiated back out to spade from Earth. Without this the Earth would be much cooler.

The enhanced greenhouse effect—Human activity has increased the amount of greenhouse gases being released into the atmosphere. This means the Earth absorbs more solar radiation and as a result is becoming warmer.

Human activities—

Energy—The demand for energy is increasing as the population increases, standard of living improves, technology improves and people become more affluent.

Industry—As people have more disposable income increases so does the demand for products from consumers leading to industrial growth. This leads to more fossil fuels being used.

Transport—As cars are becoming more affordable more people are buying and using them. As well as this, flights are now cheaper so people fly more. All modes of transport rely on fossil fuels at present.

Farming—As the population has grew the need for more food has increased leading to more intensive agricultural practices that require machinery.

Evidence of human induced climate change

1. Measurements of average global temperatures have risen more rapidly from the 1950s.
2. There is an increase in CO2 in the atmosphere since 400,000 years ago.
3. Measurements of sea levels show that they have risen globally by 20cm since 1900 due to thermal expansion and melting ice sheets.
4. Global sea temperatures have increased on average by 1°C.
5. The extent of sea ice has decreased each year.

Exam questions

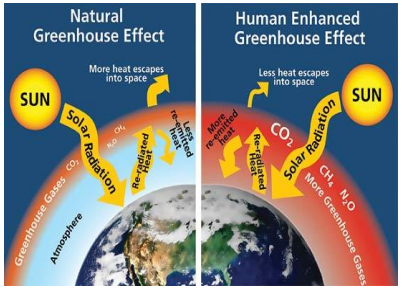
1. Humans can impact climate change by producing excessive amounts of greenhouse gases. Explain one way in which greenhouse gases can be produced by human activity. (2)
2. Climate change can have negative impacts on people and the environment. Suggest one way in which climate change can have negative impacts (2)
3. 'It is not possible to make accurate predictions about the possible consequences of climate change' Assess this statement (8+4 SPAG)

Consequences of climate change

1. Biodiversity loss
2. Rising sea levels leading to flooding
3. More intense and frequent tropical cyclones.
4. Pests and diseases more widespread
5. Food supplies affected
6. Water supply issues due to loss of glaciers
7. Longer and more frequent droughts
8. More frequent and intense rainfall

Increased temperatures

Warmer temperatures can impact on food production as some areas will have more drought conditions. Also diseases will spread quicker as warm weather encourages the spread of pests. Water supplies in some places will reduce having consequences on people's health and lifestyle. Habitats will change which will reduce biodiversity as animals and plants struggle to adapt.



Tropical cyclones are caused by particular meteorological conditions

Tropical cyclones - Large scale rotating storms that form over oceans in tropical regions.

Structure:

⇒ Above tropical cyclones they have a dense canopy of cirrus clouds due to uplift of warm, moist air as the cyclone is forming.

⇒ Swirling around the centre of a cyclone are rain bands—these can stretch 1000km from the centre of a cyclone

⇒ At the centre of the tropical cyclone is the eye (calm conditions), and around it is the eye wall (strongest rainfall and winds) which can rise 15km into the atmosphere.

⇒ The eye is an area of high pressure as air falls, the eye wall is an area of intense low pressure.

Formation

- High sea temperatures (above 26.5^{o}C) cause air to rise in a low pressure system. The rising air creates thunderstorms which group together, creating a strong flow of warm, rapidly rising air.

As well as this several other conditions are needed for the low pressure system to become a full tropical cyclone:

- Time of year (season) when ocean temperatures are higher
- Winds converging at the ocean surface causing the air to rise
- Formation away from the Equator so Coriolis can take effect
- As the storm rotates winds accelerate inwards and upwards, making the depression stronger and forming an eye.

Intensity of Tropical Cyclones

Tropical cyclones need warm water to form, they also need the Coriolis effect for them to rotate hence they are not located at the Equator. As well as this they need—

- High humidity– there must be a lot of moisture in the atmosphere.
- Rapid cooling– rising air must condense quickly to form the rainbands
- Low wind shear– if winds are blowing in different directions in the atmosphere a cyclone cannot form.
- Pre-existing low pressure– for the air to rise and generate a storm.

ITCZ influence - All the factors above tend to occur at the ITCZ This is the main source area for tropical storms as the air rises and travels towards the poles in the Hadley cell.

Intensity - Tropical cyclones are powered by heat energy that is released as warm air condenses. The majority of this air is used to force air upwards into the atmosphere. Only a small amount is used to create a cyclone. Therefore, the warmer the water the more intense the storm.

Dissipation – when cyclones lose their energy and decrease in intensity due to:

1. When it reaches land it loses the fuel for energy (warm water)
2. When it moves to an area of cold water (below 26 degrees)
3. When it runs into another weather system where the wind is blowing in an opposite direction.

Why do they spin?

Winds are created due to air moving from an area of high pressure to low pressure. However, this is affected by the Coriolis effect meaning the rushing winds are deflected into a spin as the Earth rotates.

Northern Hemisphere—Counter clockwise

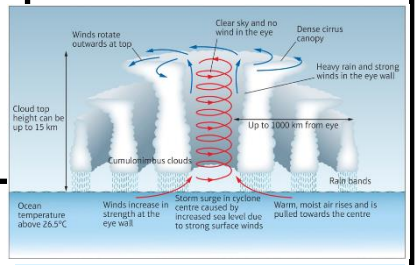
Southern Hemisphere– clockwise

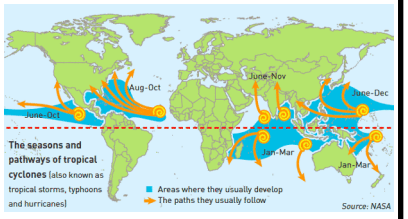
Source areas and Track

The area where a tropical cyclone is formed is called a source area (Areas with the formation conditions).

Tropical cyclones have seasonal distribution e.g. June to November in the Northern Hemisphere and April to November in the Southern Hemisphere.

Cyclones travel in the direction of the prevailing wind and ocean currents this is called its Track.



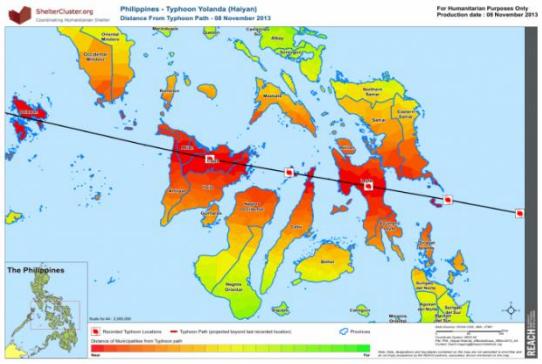


Exam questions

1. Suggest two reasons for the distribution of tropical cyclones (4)
2. Describe what would happen if a tropical cyclone moved into an area of colder sea water (2)
3. Explain the conditions needed to form a tropical cyclone (4)
4. Suggest reasons why some tropical cyclones track further and are intensify more than others (4)
5. Identify 4 features of a tropical cyclone (4)

Tropical cyclones present major natural hazards to people and places.

Name of the hazard	Impact on people	Impact on the environment
High Winds	Infrastructure such as power lines damaged Buildings destroyed Loss of life, injury	Trees uprooted
Intense Rainfall	Damage property Injury Potential loss of life	Flooding Pollution of water systems
Storm surges	Coastal defences destroyed Flooded inland areas contaminating farmland Damage to properties	Beaches and coastal habitats destroyed
Coastal Flooding	Peoples lives and properties at risk of destruction Farming, tourism and industry at risk of	Salt water intrusion Habitats destroyed Water contamination
Landslides	Settlements destroyed/damaged Transport routes cut off Loss of life and injury Displacement	River flooding if a channel is blocked Habitats destroyed Debris contaminated water



Exam questions

1. Explain why some areas are more vulnerable to the impacts of tropical cyclones than others. (4)
2. Explain how a storm surge is created (2)
3. What is the most important feature the Saffir-Simpson model measures? (1)
4. Explain the social, economic and environmental impact of the physical hazards created by a tropical cyclone (6)

Saffir–Simpson Hurricane Scale		
Category	Wind Speed (mph)	Type of Damage
1	74-95	Some Damage
2	96-110	Extensive Damage
3	111-129	Devastating Damage
4	130-156	Catastrophic Damage
5	157 and above	Catastrophic Damage

Measuring cyclones

The Saffir-Simpson scale is used to classify tropical cyclones. It is based on the wind speed generated by the cyclone and estimates the damage.

Vulnerability to cyclones

Physical vulnerability

Coastal areas are at a significant risk to the hazards created by tropical cyclones as they form in oceans and seas. This does not mean inland areas don't suffer from the effects. Island nations such as the Maldives and the Philippines are more vulnerable as they are surrounded by warm water and have a low relief. Therefore, they are more likely to suffer from flooding, storm surges and high wind speeds. However, areas of high relief are at risk of heavy rain and landslides.

Social Vulnerability

Social inequality can make some areas more vulnerable. Areas with high poverty are more vulnerable as the houses and infrastructure will not be as stable, therefore it will be easily damaged or destroyed. The after-effects are also felt more in poorer regions as people may not have access to food, water and shelter or medical supplies. Therefore, more people are likely to suffer and die compared to people in more affluent areas who may be more prepared.

Age is another social inequality. Areas with higher or lower average ages are more vulnerable. Older people and younger people are more likely to suffer an injury during disasters and have more difficulty evacuating. The young and old are also more vulnerable to catching illnesses and diseases as their immune systems are not as strong.

Economic Vulnerability

Countries with higher levels of development are likely to have access to accurate weather prediction and monitoring systems so they can predict the tropical cyclones landfall and evacuate people. They may also have coastal defences meaning that storm surges pose less of a hazard. Affluent countries will also have well-stablished evacuation procedures and disaster response teams prepared for any impacts.

The impacts of tropical cyclones are linked to a country's ability to prepare and respond to them

Preparing depends on accurate forecasting and effective communication to people at risk.

Ways of preparing:

- Atmospheric Pressure—Measuring atmospheric pressure is the most common forecasting method, and the one that gives the earliest information on a potential tropical cyclone hazard. Areas of very low pressure are likely source areas for tropical cyclone formation.
- To get accurate readings of what ocean temperature and atmospheric pressure conditions are like, scientists use buoys which are anchored in the ocean. Ships in the area also measure conditions and send readings to shore. The readings enable forecasts to be made about possible storm surges so people can evacuate and board their houses.
- Satellite tracking and radar– Satellites allow huge areas of ocean to be monitored for the formation of distinctive cloud formations in tropical areas. The progress and track of cyclones if formed are tracked in this way so a prediction about landfall can be made. Once a cyclone has developed an eye it is easy to locate, before this it can be difficult. Radar can also be used this registers the amount of precipitation in an area, so it can provide information about rainfall. However, these are both expensive technologies.
- Modelling—Atmospheric pressure data, sea temperature data and information on wind speeds can be put into sophisticated computer modelling systems that estimate the likely track of cyclones and the predict the amount of devastation it may create. Expensive .
- Communicating information– When a cyclone is forecast to make landfall, the government will activate any defences in the area, order evacuations in areas at risk and prepare emergency services. Shelters will be prepared inland. In areas vulnerable to cyclones, people are regularly given information and training about being prepared. Information about the cyclone will also be broadcast by the media.

CASE STUDY—Typhoon Haiyan, Philippines (Emerging country), 2013

2/11/2013— Typhoon Haiyan was the strongest tropical cyclones on record which was a category 5 on the Saffir-Simpson Scale

Preparation— The Philippines was assisted with tracking the typhoon by Japan. The Government used the Public Storm Warning Signal (PSWS) to warn people across the country. Originally only a level 1 warning was given. Those that were in areas at risk of flooding or landslides e.g. Samar and Leyte) were evacuated to safer areas. The military were ordered to send planes and helicopters to the region to help with the aid effort. 5m high storm surges.

Response –7 provinces were placed under a 'state of national calamity'. The relief effort was slowed by blocked roads and damage to airports. Some areas were isolated for days. No sources of clean water available due to burst pipes and contamination. People in cities such as Tacloban needed evacuating as there was no electricity, clean water, food or shelter. However this could only happen during daylight hours. More aid went to Tacloban than any other area meaning other areas felt abandoned.

Exam questions

1. 'Effective preparation is the best way to reduce deaths from tropical cyclones' Assess this statement. (8+4SPaG)
2. Explain the difference between preparing and responding to a cyclone (4)
3. Give one example of preparation for a developing country (1)
4. Give an example of preparing for a developed country (1)
5. Explain why developed countries prepare better than developing and emerging countries. (6)

Responding to Tropical Cyclones

Response refers to how people deal with the effects of a cyclone after it has occurred.

- Teams of rescue workers will search for people who are trapped in rubble and collapsed buildings.
- The government and charities will provide food, water, shelter and medical care where needed so that victims are safe.
- Repair and construction will occur in the affected area, power will be restored and roads cleared for transport.

CASE STUDY—Hurricane Katrina, USA (Developed country), 2005

29/08/2005, Hurricane Katrina a category 3 hurricane, made landfall on the South coast of the USA.

Preparing—Very good forecasting and tracking services monitored Katrina and predicted where it would make landfall. The Mayor of New Orleans ordered an evacuation of the city. Many were unable to leave as they didn't have access to a car. The local football stadium (Superdome) was a designated shelter and could hold 1000s of people. Approximately 80% of the city was evacuated. Levees and barriers were built to prevent flooding, however they were overwhelmed by the storm surge and had not been maintained properly so areas such as the 9th ward were flooded.

Response—the local and national response was criticised for not being fast enough. The people in the Superdome were trapped with limited resources (food, water). FEMA were unprepared for the scale of destruction. There were more people that needed help than they prepared for. The poorer areas were the most affected.