CAIE Geography Pre-U

3A: Meteorological Hazards

Detailed Notes

Definitions, classification and distribution

A **hazard** is a potential threat to **human life** and **property** caused by an event. Hazards can be human caused or occur naturally (natural hazards). An event will only become a **hazard** when it is a threat to **people**. E.g. if a hurricane hit an uninhabited desert island it would not be classed as a hazard.

Methods of classification

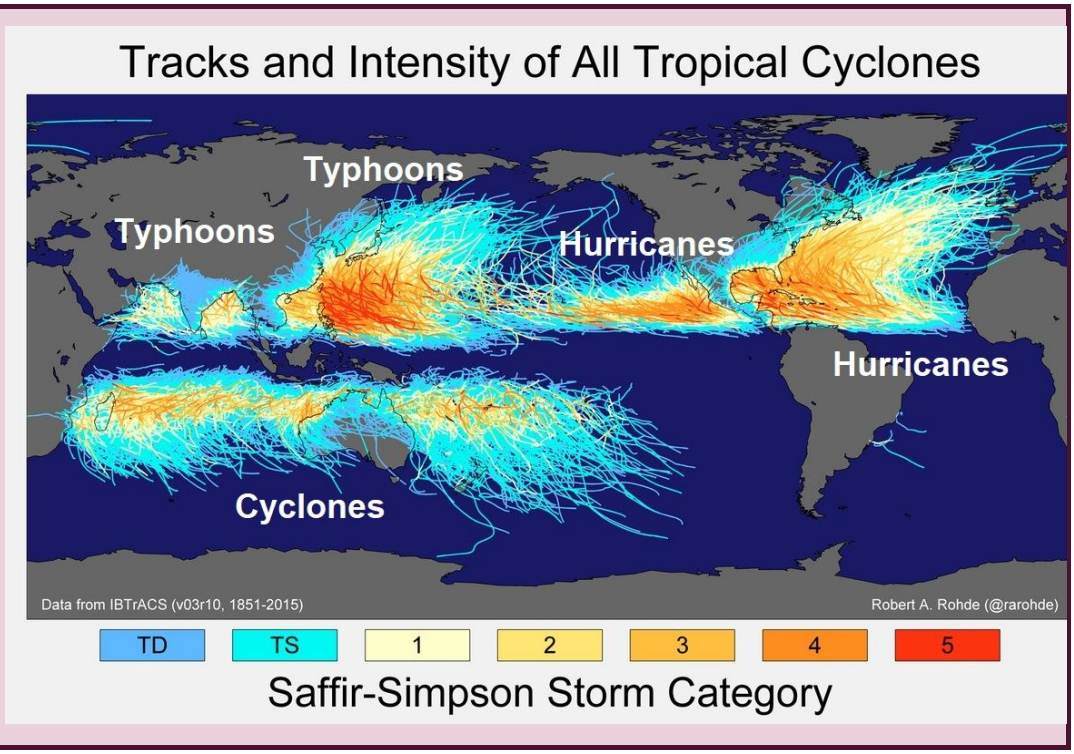
There are different ways of classifying meteorological hazards.

- **By scale** eg. local or regional **and frequency**
- **By nature of the hazard** eg. wind, precipitation, temperature
- **By the scale of intensity for wind hazards** eg. the Saffir-Simpson scale
- **By wind speed for wind hazards** eg. depression, tropical depression, tropical, storms, tropical cyclones

Distribution

Tropical cyclones are mainly found in the tropics. They occur near the coast and are mainly on the east side. Tropical cyclones track away from the equator.

Spatial Distribution



Areas that are at risk from **drought** are mainly found in the southern parts of the continent in areas surrounding deserts.

Areas at risk from **floods** are usually by the coast or by major rivers. Also occurs in areas which are affected by tropical cyclones. Floods occur in every continent.

Regional-scale hazards and their explanations and causes

Causes of the global distribution in relation to the global energy budget

Vertical transfers: Heat energy can be transferred by four methods. By **conduction** which is during contact, by **convection** which is by matter, by **radiation** which is the transfer of solar energy and by **latent heat** which is by evaporation/condensation. The amount of heat energy is not evenly distributed across the Earth causing some to have a net surplus and some to have a net deficit of heat energy. This affects the climate of the area and so will cause different meteorological hazards.

Horizontal transfers: As the Earth is not heated evenly, heat energy needs to be transferred from areas of surplus to areas of deficit. This occurs by the **tri-cellular model**, **ocean currents** and the **jet stream**. Areas within the **Hadley cell** of the tri-cellular model, between the equator and 30 degrees north/south, are at most risk from cyclones and storms due to the correct sea surface temperature and rising warm, moist air from the equator. Cyclones need an area of low pressure to form.

Coriolis force: Due to the rotation of the Earth, wind that moves from areas of high pressure to low pressure is **deflected**. This means that cyclones cannot occur at the equator as air is not being deflected, this means that cyclones can only happen further north or south but still in areas of low pressure. Watch this video on the Coriolis force

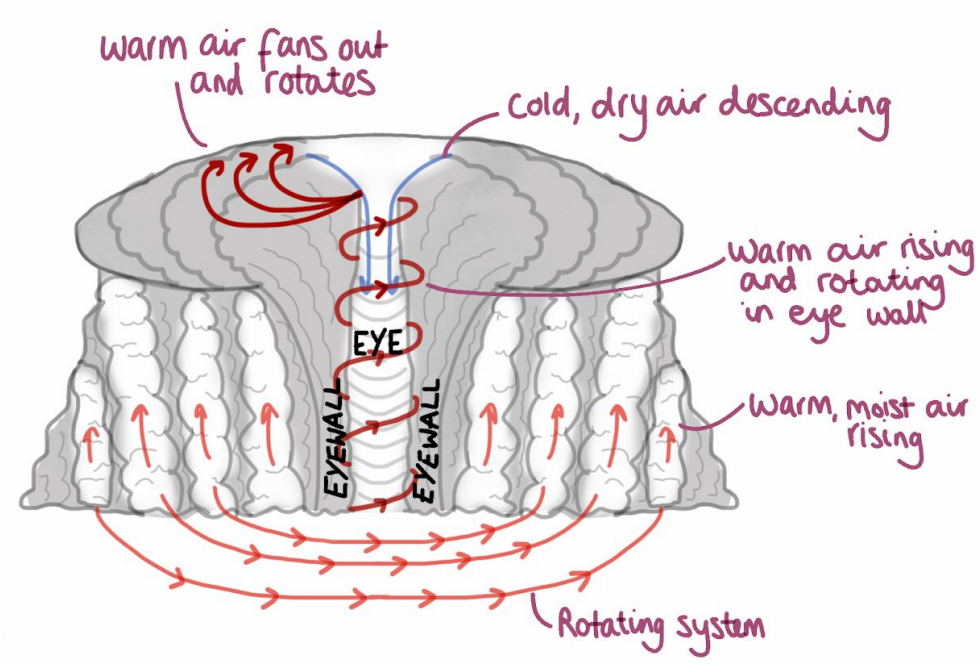
The formation of tropical storms and cyclones

There are certain **conditions** for a tropical storm to form and develop:

- **Temperature:** Ocean temperatures must be around **26 - 27°C** and at least 50 metres deep. Warm water provides the storm with **energy**.
- **Air pressure:** Must be in areas of **unstable air pressure** - usually where areas of high pressure and low pressure meet (**convergence**) - so that warm air rises more readily and clouds can form (this air must also be humid for cloud formation). Warm air rises because it is **less dense** than cold air.
- **Wind shear:** Winds must be present for the **swirling motion** to form, but not too strong or the storm system will be **ripped apart** in the early stages.
- **Rotation:** Tropical storms only form around the equator, but no less than **5° on either side**. The **Coriolis Effect** is the effect of the **Earth's rotation** on weather events. The storm spins because the Earth is spinning; but there is **no Coriolis Effect at the equator**, hence why these storms will only form a certain distance away from it.
- **A trigger:** a pre-existing thunderstorm, a spot of very high sea surface temperature, an area of low pressure and many other factors can act as a **trigger** for a storm to develop, which will only further develop when the **other conditions are present**.

Formation

1. **Warm, moist air rises**, leaving an area of **low pressure below**. This causes warm air from surrounding areas of higher pressure to **move into this low pressure area** and rise too. Overall, **warm air is constantly rising** and accumulating in the atmosphere.
2. When the warm air rises, it **cools**, condensing into **thunderstorm clouds**.
3. The whole system is spinning due to the **Coriolis effect**. In the **southern** hemisphere, the storms spin **clockwise**; in the **northern**, **anticlockwise**.
4. The **constant addition of energy** from the warm air causes the storm to spin faster and generate higher wind speeds. At **39 mph** the storm can be classed as a **tropical storm**.
5. The **eye** of the storm is in the centre. This is an area spanning around **30 miles wide** that is of **extremely low pressure** (can be 15% lower pressure than areas outside of the storm). Cool, dry air (cool from the higher altitudes and the moisture has been transferred into the system) descends in the eye, causing the weather to be relatively **calm and cloud free**. The more intense the storm, the clearer the eye.
6. Surrounding the eye is the **eyewall**, the most **intense and powerful** area of the storm. **Warm, moist air rapidly rises** here, with extremely **high winds and torrential rain**. When winds reach **74 mph**, it becomes a hurricane/cyclone/typhoon.



7. When the tropical storm reaches a coast, the **low pressure and high winds** will cause a large amount of sea water to be **taken into the system** and then released as a high wave called a **storm surge**.
8. When the storm reaches **land**, it no longer has a **supply of energy** (warm, moist air from the sea) and the eye eventually **collapses**. Heavy rain can persist for days.

Due to the **Bernoulli Principle**, which states that as there is an increase in the difference between pressures of two areas the movement of air increases, the big difference in pressures within the cyclone cause the wind speeds to be very high.

Seasonality of regional-scale hazards

As the conditions for tropical cyclones are so specific, they can only occur in certain times of the year when all the conditions have been met. This is usually just after summer when the sea surface temperatures are at their warmest and the difference between wind speeds with an increase in altitude is very low.

Droughts and floods rely on the extremes of levels of precipitation. In most places, **precipitation levels vary seasonally** along with temperatures which, if high, can decrease the levels of available water.

The changing nature of tropical cyclones

Tropical cyclones are getting stronger and lasting longer mainly due to the fact that the level of energy in the oceans is increasing due to **global warming**. In 2017, once the conditions were reached for tropical cyclones to form, they formed faster than any other year. They are also **moving more slowly along the ground** which means that they can cause more damage.

Due to global warming and the melting of the polar ice, **sea levels are rising**. This will make storm surges caused by tropical cyclones more dangerous. Each year there are similar numbers of tropical storms, however, more of these tropical storms are reaching cyclone status. **US models predict that there will be a 45-87% increase in the frequency of CAT 4 and 5** (Saffir-Simpson measure for the wind speed in hurricanes is divided into 5 categories with 5 having the highest wind speed and causing the most damage) hurricanes. There will also be an **increase in hurricane rainfall by a third** while **wind speeds could be increased by as much as 25 knots**.

The changing nature of droughts

In **1950 1% of the land was affected by droughts, in 2000 this increased to 3%**. An increase in the global surface temperatures due to climate change is increasing the levels of evapotranspiration and so there is less surface water. In **2012 in the USA, 81% of the country was living in abnormally dry conditions which cost $30 billion**.

The changing nature of flooding

Deforestation means that the levels of **infiltration are decreasing**. **Rising sea levels** are causing increased levels of flooding in coastal areas. Increasing **urbanisation** means that there are fewer areas of land for infiltration to occur and people are also building on land which is **prone to flooding** as flood plains are flat and therefore ideal to build on. In addition to this, land may be at a premium and other areas have already been built on. European rivers have experienced a **44% increase in extreme flooding events since 1995**. An increase in atmospheric temperatures will mean that the atmosphere can hold more water, leading to more intense downpours. **Eastern USA is seeing a 50% increase in extreme rainfall events**.

Local-scale hazards and their explanation and causes

Tornadoes

Tornadoes are **vertical funnels of rapidly spinning air**. Their winds can be up to **250 miles per hour**. Tornadoes form when a **change in wind direction or speed creates a horizontal spinning effect** within a storm cell. This horizontal spinning is then **tipped vertically by strong updrafts** rising up through the storm clouds. They occur more in spring and summer and usually occur in the late afternoon. Tornadoes only become visible when the storm picks up water droplets are condensed from warm moist air or when debris or dust from the ground is picked up. Tornado Alley in the USA is a major hotspot for tornadoes. There are roughly **80 deaths and 1,500 injuries each year in Tornado Alley as a result of tornadoes**.

Supercells are storms that contain updrafts that rotate about a vertical axis. They are formed when a moisture-rich, warm air mass collides with a cooler, drier air mass. Watch this video on the formation of tornadoes.

Hail

When **water freezes together in the upper regions of a thunderstorm cloud**. A droplet of water will freeze at a certain height in the storm cloud. It will then begin to fall but is pushed back upwards by strong updrafts. Another water droplet will then freeze onto it and it will begin to fall. This process repeats until it is too heavy to be lifted back up by the updrafts and it falls as hail. **In India in 1888, a hail storm killed 250 people**. Watch this video on the formation of hail.

Blizzards

A blizzard is when there is a **large amount of snowfall, with winds greater than 56km/hr and less than a quarter of a mile visibility**. It must also last for more than **three hours**. Blizzards usually form when cold polar air meets warm moist air. The cold air at ground level and the moisture-rich clouds above with warm rising air create the conditions needed for a blizzard.

Fog

Fog is a **thick cloud of tiny water droplets suspended near or at the Earth's surface**. These water droplets obscure visibility. There are two types of ways that fog can form: by advection or by infrared cooling. **Advection** formed fog is a wind-driven fog formation. Warm air is pushed by winds along a cool surface. The moisture in the warm air condenses to form fog. Fog formed by **infrared cooling** occurs due to changes in seasons and the absorption of heat by the land. In the summer the ground absorbs solar radiation. When the seasons change a cooler air mass collides with the warm moist air mass prevalent over the warm ground. This causes the water vapour to condense quickly and so forms fog.

Photochemical smog

Photochemical smog is formed when **ultraviolet light from the sun reacts with nitrogen oxides** in the atmosphere. It mainly occurs in densely populated, warm cities such as Beijing and Sydney.

Consequences and impacts

Primary hazards

- Storm surge which is a tsunami like event caused by where the water level rises above its normal level due to strong winds.
- Strong winds
- Collapse of buildings
- Flooding
- Injury and death
- Roads blocked due to fallen infrastructure and trees.
- Hospitals/schools damaged
- Hypothermia due to extreme cold weather.
- Transport disrupted as a result of damaged and blocked rails and roads.
- Increase in road accidents due to decreased visability or blocked and damaged roads.
- Roof collapse due to large amounts of snow fall or strong winds.
- Reduced visibility due to fog or blizzards.
- Respiratory problems due to air pollution.
- Crops damaged.

Secondary hazards

- Increase in the spread of diseases due to stagnant water containing debris and bodies, and compromised sanitation.
- Landslides.
- Increase in food prices as crops are damaged.
- Famine due to damaged crops.
- Increase in water-borne diseases as a result of stagnant water containing debris and bodies, and compromised sanitation.
- Communications damaged.
- Transport and trade disrupted due to damaged rails and roads.
- Pollution of water sources from debris and bodies.
- No school as a result of damaged buildings or inaccessibility.
- Decrease in productivity.
- The strain on the health service as a result of increased numbers of injured and ill people as well as damage to hospital buildings and the potential decrease in the number of doctors and nurses.

Consequences

Economic consequences for HICs:

- Job losses as companies cannot afford to employ more people due to the cost of repairs or loss of business.
- Businesses collapse due to high amounts of damage and debt.
- Lower productivity as a result of damaged equipment and people unable to work.
- Cost to the insurance industry.

Economic consequences for LICs:

- Reliance on aid which could stop the country from developing in the future.
- Aid could undercut local prices and put local businesses out of business.

Social consequences for HICs:

- Unable to go to work due to injury, illness or inaccesibility.
- Homelessness.
- Death and injury.

Social consequences for LICs:

- Death and injury.
- Spread of diseases as a result of stagnant water containing debris and bodies, and compromised sanitation.
- Displacement/migration as people are forced to leave their homes. This could also put a strain on the recipient country.

Environmental consequences:

- Damage to habitats from landslides, strong winds and storm surges.
- Water pollution from debris and bodies as well as damaged sewage systems.
- Debris from damaged infrastructure which can pollute water sources.
- Agriculture affected.

Political consequences for HICs:

- Criticism of government as a result of the perception of them not doing enough to help.
- Prioritisation needed which could be difficult and promote controversy.
- Media influence which can cause increased criticism of government and affect decisions made about how the government should help.

Political consequences for LICs:

- Corruption from aid
- Instability

Management and mitigation

Mitigation vs adaptation

Mitigation is attempting to **stop the effects** of the hazard by trying to plan beforehand whereas adaptation is attempting to **live with a hazard** by altering lifestyles.

Modifying the risk

This involves **monitoring, prediction and prevention**.

- **Forecasting and warning**: This is more likely to occur in HICs who have the necessary equipment and in countries who are prone to the hazard. Measuring temperature, humidity, wind speed and storm paths using ocean buoys, satellites and ships can all be used to predict and track a hurricane.

- **Land-use planning**: Not building infrastructure at high-risk areas such as on the coast in areas that are frequently affected by tropical cyclones.
- **Global warming**: Reducing global warming might be able to reduce the frequency and intensity of meteorological hazards.

Modifying the hazard

This involves **preparation, protection and reduction of impacts**.

- **Community preparedness**: Evacuation drills, websites containing information and gritting road surfaces all help to prepare people. Emergency services also need to undergo regular drills to make sure they are prepared if a hazard were to occur.
- **Environmental control**: Vegetation to reduce impacts of soil erosion and landslides. Planting mangrove trees along the coast to reduce the waves energy.
- **Design**: Wind and water-resistant buildings. Community shelters, hail cannons, protective roofing, avalanche breaks and flood embankments can all help to reduce the impacts of the hazard and protect people against its effects.

Modifying the loss

This involves **rescue, relief and recovery**.

- **Accept loss**: If the hazard is of low impact and occurs infrequently then accepting the damage might be the best option rather than spending lots of money and resources trying to protect or mitigate against it.
- **Aid**: This is especially needed in LICs to help them recover. Short-term aid usually comes from both foreign governments and NGOs whereas long-term aid after a hazard mainly comes from NGOs. Aid is needed to rescue people and for the country to be able to recover and improve so that the effects of the hazard in the future is not as devastating.
- **Insurance**: Mainly occurs in HICs. How individuals recover from hazards. However, insurance can cost a lot of money, especially in areas which are prone to meteorological hazards. The payment of insurance also helps to stimulate the economy again as people will use it to buy new items.
- **Emergency services and disaster relief teams**: Help to rescue people, distribute food and clean water and provide medical care.