BWB 2020

3.5

Year 13

Module 1P

Weather & climate

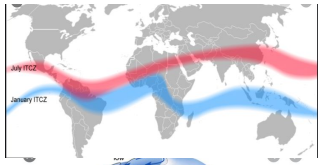
Geography Knowledge Organiser

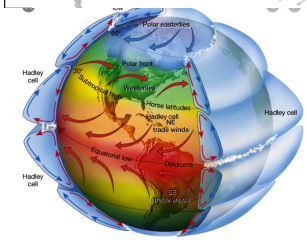
3.5.1 - Global controls

Structure of atmosphere

Troposphere lowest layer, most weather, most of atmospheric mass water vapour and dust. Varies between 8km and 12km in height, the lower layers are heated from below temps drop by 6.5°C approx every 1000m as atmosphere thins, tropopause at top is a isothermal layer.
Stratosphere lacks dust and water vapour largely stable, increase in temperature with height due to absorption of solar radiation (UV wavelengths) by ozone layer 20 - 30km above earth
Mesosphere temps fall again with height as density of atmosphere decreases unable to absorb solar energy
Thermosphere lies above 90km temperature increases with altitude due to absorption of radiation at UV wavelength
Atmospheric heat budget-balance between incoming solar radiation, isolation and outgoing radiation from earth
Sun is the source of energy that drives the atmospheric engine
Amount of energy received varies with latitude
Tropics- energy surplus because they gain more from insolation than is lost by radiation
Higher temperate and polar latitudes have an energy deficit losing more by radiation than is gained by radiation
This imbalance in energy distribution sets up a transfer of heat energy via winds and ocean currents from the tropics to higher latitudes

Global atmospheric circulation - based on global transfer of heat
-This in turn gives low and high pressure belts and the planetary wind systems associated with the 3 main convection cells, Hadley, Ferrel and Polar ie the **tricellular model** that controls atmospheric movements and redistribution of heat.
The basic model has been modified
The troposphere thins towards the poles and is divided into 3 zones
-At the upper junction of the cells jet streams-powerful eastward moving high altitude winds help move weather systems around the globe.
Hadley cell - complication is the subtropical jet stream aids movement along an East West axis called the Walker Cell





High and low pressure belts

Winds blow from high to low pressure, Coriolis effect/force caused by Earth's rotation means winds are deflected to right from their point of origin in northern hemisphere and the left on the southern hemisphere.
Ocean currents - Follow a gyre or largely circular route in each ocean basin except for the Southern Ocean which has a circular polar current around Antarctica. Ocean currents move clockwise in northern hemisphere and anticlockwise in southern hemisphere
Eg warm current North Atlantic Drift or Gulf Stream flows off west coast of UK
Cold current is Labrador Current flows off east coast of Canada and USA in North Atlantic Ocean
Continentality - distance from sea influences regional climates
Solid land surfaces respond quickly to solar radiation as they have a lower specific heat capacity than the sea. Land heats up quickly in the summer but cools rapidly in winter giving these areas a high annual temperature range. Oceans heat up gradually during summer but retain this heat in the early months of winter leading to lower annual temperature ranges and a thermal reservoir effect on coastal areas.
Altitude - temperature decreases with altitude. Globally in troposphere is ELR of 6.5°C per 1000m. If a parcel of dry air is forced to rise over a mountain such as the Rockies the expansion of air causes it to cool at the DALR 1°C per 1000m
If the air cools enough to be saturated it can rise but cools at the SALR which is a slower rate because the condensation process releases latent heat into the surrounding air which slows the rate of cooling

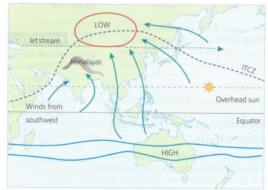
3.5.2 - World's major climates

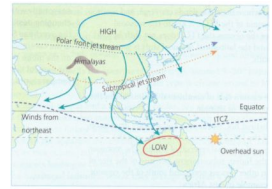
World's major climate types

The main influence on tropical climate regions is
-The overhead or near overhead position of the sun giving high insolation throughout the year
·The position and movement of the ITCZ together with wind systems of the tropical pressure belts
- The path of the upper jet streams affecting the paths of low pressure systems
EG TROPICAL Savanna Located 5-20° latitude N and S of equator
High temperatures 25-35°C all year because of high insolation
Hot wet season and a marginally cooler dry season, Humidity high in hot wet season but evaporation rates high in dry season. Rainfall occurrence is linked with the movement of the ITCZ towards each tropic associated with apparent movement of sun's position overhead.
Hot season low pressure prevails-moist in blowing winds and rising air currents bring convectional rainfall. Rainfall more reliable toward equatorial latitudes where they average 800mm a year but less reliable toward the hot desert margins where they average 300-400mm annually.
Cooler dry season occurs when subtropical high pressure dominates and dry out flowing winds prevail.- when sun and ITCZ move away to extend beyond the equator towards the other tropic. High pressure over outer margins of the savanna may prevent the ITCZ and associated rain moving into these regions leading to drought.

Seasonal variations in the position of the ITCZ, heat equator, wind and pressure

***Combined effects of the earth's axial tilt and its orbit around the sun results in seasons.* Sun's overhead position shifts during the year from over the equator Equinox 21st March to. Tropic of Cancer - Summer solstice 21st June then back over. Equator - Equinox 21st September before moving to. Tropic of Capricorn - winter solstice 21st December** Dates can vary over a few days.
-The relative movement of the sun's overhead position shifts the maximum insolation point seasonally hence the term heat equator and sometimes referred to as the ITD the intertropical discontinuity
-This influences the latitudinal movement of the pressure belts and wind systems notably the ITCZ
-The ITCZ is the point at which the 2 Hadley cells meet and trade winds converge, moist tropical air rises to give convectional rain.
-The movement of the ITCZ is key to seasonal rain in the tropics
-Over oceans the ITCZ, heat equator does not shift beyond 5° either side of the equator and its latitudinal seasonal shift is greater north if the equator due to presence of large land masses which heat up relatively quickly when the sun shifts overhead causing air to rise and pulling in converging trade winds





Monsoon Climate Occurs mainly on Eastern side of continental landmasses in the tropics. Extend across approximately 5-20° of latitude
2 distinct seasons: ***Hot wet season and cooler drier season -Determined by ITCZ annual movement between the tropics and the consequent movement of low and high pressure belts and seasonal reversal of winds* Eg Indian subcontinent.**
Hot wet monsoon season-the landmass heats up -draws in the ITCZ- brings low pressure drawing in hot, moist winds from the Indian Ocean.Rainfall is further increased by relief as the moist air cools and condenses over higher areas like the Western Ghats forming orographic uplift and rainfall -2000mm.Temperatures - high averaging 30° C.Humidity is high but decreases with distance inland.Cyclones and hurricanes are frequent towards the end of the rainy season.
The cooler dry season occurs as the ITCZ shifts south and the sub tropical continental descending high pressure takes precedent. The subsiding air and out blowing winds are dry.Temperatures remain high 25°C in lowland areas and evaporation rates are high. Weather is more severe in mountain areas.

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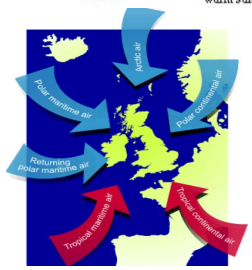
3.5.3 - UK Climate & weather

Characteristics of the UK climate

The UK has a cool temperate maritime margin climate
Characterised by relatively mild temperatures
Average seasonal range 5-20°C
High humidity
High precipitation averaging 600mm annually
Precipitation totals Higher in upland areas in face of prevailing winds and orugraphic rainfall eg Cumbrian mountains of Lake District 1000m
Lowland rain shadow areas like East Anglia 300mm



Main influences

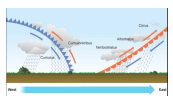
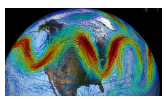
-Mid latitude position in Western edge of landmass
-Mid latitude low pressure belt
-Mild prevailing westerly winds
-Gulf stream and North Atlantic Drift

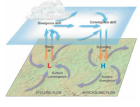
Air masses and their influence

Weather influenced by position of polar front and its jet stream
This determines route of low pressure systems, depressions with intervening spells of anticyclonic conditions.
Weather is linked to position of air masses
Pm (RPM) , Tm, Am, Tc, Pc
Strength of PFJS which flows in a bigger Rossby Wave influences interaction of Pm and Tm air masses and formation of depressions
Continental air masses **Pc and Tc air bring high pressure anticyclonic conditions long spells if dry weather** in summer but sometimes winter 'gloom' low grey stratus cloud days which last up to a few days
In contrast **fast moving depressions bring warm and cold fronts with associated rain and wind changeable weather** in short periods of time.
If the pressure is drops significantly in 24 hours a 'cyclonic bomb' can occur with storm conditions.

The jet stream

The jet stream upper air wind-follows meandering path of the Rossby Waves. Jet streams occur vertically due to temperature contrasts between air masses. Marked pressure gradients lead to extremely strong winds flow in narrow bands which accelerate moving poleward and decelerate moving towards the equator.
-**Rossby Waves vary seasonally a**nd move continuously around the globe
Their amplitude and sinuosity varies between 4, to 6 waves in summer due to insolation setting up marked temperature differences in air masses.
3 in winter as temperature differences less marked
-Rossby Waves determine formation of depressions and anticyclones
Moving west to east on a downward south moving limb the jet stream slows and causes air to converge and pile up. This upper air convergence pushes air down towards earth's surface creating high pressure anticyclones at the surface. On a poleward moving limb of a Rossby wave the jet stream speeds up and there is upper air divergence. Upper air divergence pulls air in at the surface creating low pressure depressions
At times often in winter with fewer waves there is a high zonal index where waves are shallow and there is a high horizontal surface pressure difference between 35° and 55°. This produces strong mid latitude westerlies which bring a succession of depressions and storms.
Often in summer the zonal index is lower as waves increase and become more pronounced causing formation of blocking anticyclones



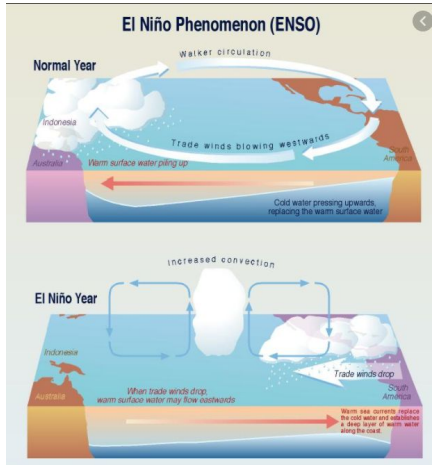
3.5.4 - Extreme weather

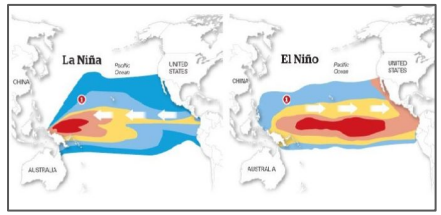
A climatic hazard is an extreme climatic or weather event causing harm or damage to people property infrastructure and land uses

El Nino and La Nina - cyclical climatic events in the tropical Pacific which appear to be increasing in frequency and intensity because of global warming.
-These episodes alternate in an irregular cycle called the **ENSO El Nino Southern**

Oscillation Refer to atmospheric pressure changes between the east and west tropical Pacific reflecting close interactions between atmosphere and oceans.

Associated with widespread changes in climate such as extreme heavy rainfall and flooding in Peru and extreme drought in Eastern Australia. These extremes last several months having significant socio-economic impacts affecting infrastructure, agriculture, health and energy sectors.

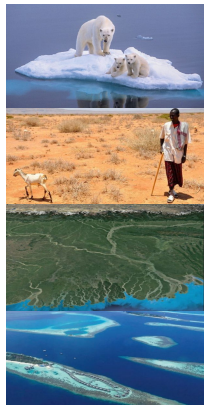




Changing vulnerability of populations to weather and climatic hazards

The vulnerability of populations to climatic variability and to weather and climate hazards varies spatially and temporarily.

The most vulnerable regions are
ARCTIC due to impacts of high rates of projected warming on ecosystems
SUB SAHARAN AFRICAN countries such as Somalia due to low adaptive capacity
DELTA REGIONS IN ASIA eg Ganges Brahmaputra Meghna Delta - Asia's largest and the world's most populated delta because of high population densities and exposure to river flooding, sea level rise and storm surges as well as being subject to stresses imposed by human modifications of catchment areas and delta plain land use
SMALL LOW-LYING ISLANDS like Maldives, Tinbat and Turaka in the Pacific - exposure to sea-level rise and storm surges



The most vulnerable sectors are

- **Health** -in areas of adaptive capacity
- **Agriculture** - because of reduced water availability
- **Water Resources**--in mid latitudes and the dry tropics due to decreases on rainfall and higher evaporation rates
- **Ecosystems** particularly mangrove forests salt marshes coral reefs and tropical rainforests
- **Low lying coastal regions** because of their exposure to sea level rise and extreme weather events with associated storm surges

3.5.5 - Impacts & management

Hazards associated with low pressure systems

In the tropical climates low pressure hazards are tropical storms and cyclones with convectional rain and high winds.
These occur towards the end of the hot season August to November in the northern hemisphere are generated in exceptionally deep fast moving depressions over oceans off the east margins of continents in the tropics and subtropics. These depressions travel westward due to the Coriolis effect and grow in size fed by the oceans heat and water evaporating from the ocean surface They trigger the secondary hazards of flooding, storm surges and sea incursions, landslides, mudflows and wind-bourne debris




During the 2017 hurricane season a succession of hurricanes - Harvey category 4 on the Saffir Simpson scale with winds up to 120 mph affected Texas and Louisiana
Hurricane Irma category 4 with winds 130mph affected Florida, Georgia and South Carolina and damaged 95%of buildings in Barbuda
Hurricane Maria category 4 with 155 mph winds and Hurricane Nate impacted the Caribbean and Gulf Coast of the USA
Saffir Simpson scale 1-5 hurricane scale estimates potential damage to property and loss of life based on sustained wind speed. At category 3 and higher considered major hurricanes.

In the temperate region low pressure hazards include severe storms heavy rainfall or snow and gale force winds
These are generated in week fast moving depressions the worst is a weather bomb or tail end of an Atlantic hurricane on Autumn or sometimes they occur in spring when temperature and pressure gradients are at their steepest along the polar front. They trigger secondary hazards like flooding, sea incursions especially when low pressure coincides with a high tide or spring tide, landslides and wind-bourne debris

Hazards associated with high pressure systems

In **tropical climates** high pressure hazards are low rainfall high evaporation rates and drought.These trigger secondary hazards of falling water tables, loss of vegetation,wildfires, soil erosion and desertification.
Above are due to persistence of continued subtropical high pressure over continental areas This limits the ITCZ zone to lower latitudes closer to the equator than is normal for the time of year.
In **temperate climates** high pressure hazards include drought in summer and frost, ice and fog in winter. Secondary hazards in summer include falling water tables and loss of vegetation and photochemical smogs.
Secondary hazards in winter include temperature inversions with air pollution intensifying fog into smog conditions. These occur with stationary or blocking anticyclones Tc air masses from subtropical high pressure. In winter the conditions are associated with Pc air mass.

Strategies to manage climatic hazards

Monitoring, prediction and warning for future hazards, immediate response to lessen the impact once the hazard has occurred and long term planning
Increasingly strategies involve the use of technology
MODIFY HUMAN VULNERABILITY to hazard risk through prediction and warning, community preparedness and land use planning.

MODIFYING THE HAZARD EVENT through environmental control and hazard resistant design.
MODIFYING THE LOSS through aid and insurance

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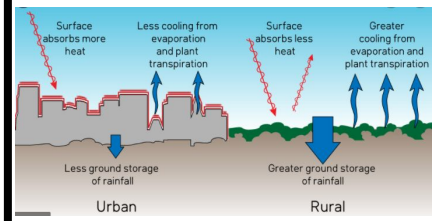
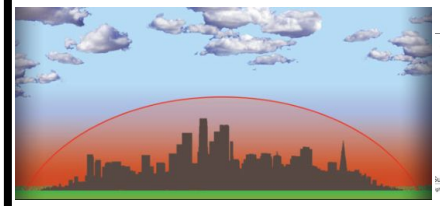
3.5.6 - Human activities

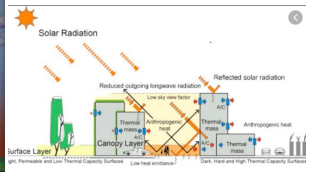
Impacts of urban areas on temperature, wind, precipitation and humidity

-Urban areas replace existing microclimates with modified ones
-Urban heat island refers to distinct climate associated with an urban area in its canopy and boundary layers in particular temperature changes ie warming compared to surrounding rural area
-Barrow, Alaska population grew from 300 in 1990 to 4600 in 2017.
Winter 2001/2002 Barrow was 2.2°C warmer than the surrounding rural area. A maximum difference of 6°C was recorded in January, February reflecting the higher energy usage for the heating of residential and commercial buildings.



Factors that influence the heat island intensity and shape include
1.Anticyclone dominance
2.Structure and density of buildings SVA
3.Population size and density
4.Traffic
5.Economic activity
6.Urban sprawl





Air quality

Impacts of urban area on air quality

Urban areas can create particulate pollution, photochemical smog and acid rain. The dust two are exacerbated by anticyclone conditions

Strategies to reduce the impact of human activity on urban climates and air quality

national regional and local

Political solutions - Clean Air Acts eg London 1956 after the London winter chimney pot smog of 1952 led to 4000 deaths (12 000)
Since then clean air acts have been part of policy making eg **congestion charge** for London and potential ban on diesel vehicles in Birmingham.
One-way systems bus only lanes, cycle lanes increase car parking, suggested toll on bridges over Tyne
Technological solutions - controlling particulates from cars by catalytic converters
Encouraging shift from diesel and petrol to electric
Decreasing harmful emissions from power stations and industrial plants by using scrubbers in chimneys to remove harmful emissions SO2 and NOx
Develop alternative fuels - windiest country on Western Europe so wind farms make sense on and offshore
Attitudinal fixes - include educating people to purchase electric/hybrid fuel cars supported by taxation perks or change household energy use to greener companies or solar panels.

3.5.7 - People, climate & the future

Global impact of anthropogenic climate change ACC

ACC is predicted to affect all climate belts but IPCC reports pronounced changes in Arctic regions North of 65°N
Global mean temperature rise measured at the surface between 1900 and 2005 has increased by 0.74°C but polar warming twice that rate due to positive feedback eg permafrost melt increase in CO2 and impact of lower albedo.

Effects of CC on the Arctic

Boundary between the taiga/ boreal forest and tundra has advanced N in response to higher temperatures
Length of growing season has increased by 3 days per decade in Alaska,
Melting of sea ice puts pressure on polar bear community
Melting of permafrost leads to subsidence of buildings, infrastructure and increase in thermokarst
Destabilisation of the Polar Arctic High pressure (Beaufort High) which will impact on global circulation and cells
Warmer temperatures thinning sea ice and warmer Arctic Ocean water pushes south disrupting NAD affect - possible negative feedback more snow for us and onset of new ice age

The atmospheric tipping point

Effects of CC become irreversible eg research suggests that thermal expansion in oceans due to global warming is set for 100 years so sea level rise unavoidable
2018 IPCC report concluded the world faces environmental catastrophe unless drastic measures are taken to curb global warming
Gaia hypothesis suggests Earth will take it into her own hands
Impacts of 1.5C of global warming will he far greater than expected.
Still possible to limit the temperature rise to 1.5°C target set by 2015 Paris Agreement (International agreements at global CC conferences has varied greatly since 1999 Kyoto Protocol was signed)
Emphasis on reducing fossil fuels significantly (but Arctic sea ice melt gives access to oil reserves on sea bed and USA change in attitude to oil Obama/Trump
To achieve limit on temperature rise anthropogenic emissions of CO2 would need to be reduced to 45% of their 2010 levels by 2030 and to zero by 2050 (think superpower influences and population increases/demand USA, China and India)

Atmospheric tipping point predicted environmental and economic impacts

-Extreme weather events and heat related morbidity and mortality
-Threatened ecosystems - insects vital for pollination of crops and plants are almost twice as likely to lose half their habitat at 2°C higher than 1.5°C higher, at a higher temperature 99% of corals would be lost and the lower temperature target this drops to below 90%
-Coastal flooding sea level rise affect 10 million by 2100 at 2°C than target of 1.5°C
-Marine fishery catches would be 3 million tonnes lower at 2°C due to elevated acidity and lower oxygen levels but only half this at 1.5°C.
-Large scale single events eg ice sheet collapse, river flooding, decreased crop yields, inc. water restrictions highlight how economic & environmental impacts are linked

Strategies to mitigate and adapt to climate change- must operate together.

ADAPTATION refers to people and societies who change their lifestyles to cope with a new environment rather than trying to prevent climate change. Adaptation tends to occur at a local scale because strategies are tailored to specific local impacts and they use all levels of technology Eg:

-**GM technology** to develop drought resistant crops
-**SUSTAINABLE COASTLINE MANAGEMENT** in areas vulnerable to sea level rise by replanting mangroves or managing natural retreat(realignment)
-**SUSTAINABLE WATER STORAGE** in a variety of ways to provide safe and clean water supplies to cope with more frequent droughts

-MITIGATION refers to a reduction in the output of greenhouse gases and or increasing the amount of greenhouse gas storage. Mitigation needs to operate at a variety of scales, individual, local, national and global eg

-**CLIMATE CHANGE INTERNATIONAL CONFERENCES** develop global frameworks on setting greenhouse gas emission reduction targets. Translated into national & local strategies
-**DEVELOPING ALTERNATIVE FUELS** recyclable and renewable. Serious alternatives to fossil fuels eg solar, wind, wave and biomass power.
-**CARBON CAPTURE AND SEQUESTRATION** technology to capture and store emissions in oceans, burying them in rocks and even old oil wells.

Home study questions

DEVELOPING

Outline the global importance of high pressure **[4 marks]**

Explain how urban areas impact on local climates **[4 marks]**

SECURING

Analyse the pattern of low pressure on a global scales **[6 marks]**

Explain how the weather of the UK is affected by different air masses **[6 marks]**

MASTERING

'Low pressure hazards have a greater impact than high pressure hazards'' **To what extent** do you agree with this statement? **[15 marks]**

Evaluate the effectiveness of different scales of mitigation and adaptation used to respond to climate change. **[15 marks]**

CHALLENGE

Create a flow diagram to show the formation and impact of El Nino and La Nina

Summarise the importance of jet streams and atmospheric pressure systems on the monsoon climate and suggest why defining distinct seasons with their causes is often too simple an explanation.