UNIT 2 Atmosphere and Weather

Recommended Prior Knowledge: Students require little prior knowledge although some fundamental principles of systems and processes such as condensation etc may have been covered at key Stage 3 and/or IGCSE and in the hydrology unit.

Context: It is a discrete unit but atmospheric processes are fundamental to all the other natural systems. For instance, weathering processes are directly affected by atmospheric processes.
Outline: This unit covers global, meso and micro scale atmospheric processes

Content	Objectives	Terminology	Teaching Strategies (TS) and Activities (A)	Resources
Energy Budgets 2.1	• A basic appreciation of the vertical structure of the atmosphere • An appreciation of the atmosphere as a heat engine • An understanding that incoming solar radiation must be balanced by outgoing radiation. • Diurnal spatial and temporal variations in energy budgets	**Troposphere** **Tropopause** **Stratosphere** **Energy budget** **Evaporation** **Condensation**	**TS** Introduce by a temp/height diagram to show vertical structure of the atmosphere. **A** Annotate with troposphere, tropopause, stratosphere. Emphasise the troposphere as the region of the weather. Temperature inversion acting as a cap on rising air at the tropopause. Nearly all atmospheric moisture is contained in the Troposphere. **TS.** • Idea that the atmosphere is an engine powered by the sun. **Inputs** must be balanced by **outputs or overall heating/cooling may result** • **Global scale energy budgets**. Briefly introduce atmosphere-earth energy budget with figures. (Not essential to the syllabus but illustrates the system concept) • Local energy budgets. Input-output analysis via day-night time energy models.	. The Atmospheric Systems chapter in Hart's textbook is tailored to this unit and provides good simple straightforward visual material, which is appropriate at this level. Warburton P.25 Waugh P.207 Guinness and Nagle p387 Hart p.59 Hart p.62. Fig 3.7 and p.63 fig 3.8 **Ross p.179. This is a simplified diagram and by far the most useful of the earth-atmosphere system**

	• Methods of heating • Knowledge and understanding of local diurnal energy budgets	**Albedo** **Reflection** **Scattering** **Conduction** **Convection** **Radiation-long and short wave** **Sensible heat transfer** **Latent heat transfer**	**The six factor 'day model' and four factor 'night model'** form the basis of 2.1 and need full discussion and explanation of albedo, the role of clouds as reflectors, scatterers and absorbers of light/heat. Different clouds perform different functions. **Six Factor day model** Transfers of heat: Evaporation, sensible heat transfer, incoming solar radiation, longwave radiation, surface absorption **Four factor night model** Transfers of heat: Longwave radiation, sensible heat transfer, heat supply to the surface, condensation Methods of heating. Radiation conduction convection. Use analogies with which the students can readily identify. Radiators, air con, Bunsen burner flame under a beaker of water which they may have used in the physics lab or pan of boiling water. See Hart. P.61 • Distinguish between latent heat and sensible heat transfers. **Latent Heat-** involves phase change e.g. gas to liquid. Energy is "stored" or "released" **Sensible heat-**energy gain or loss without a phase change. Water vapour does not undergo a phase change This section of work can be kept fairly straightforward if the day-time and night-time budgets are used. Need not occupy too many lessons. **A.** Consolidate by asking questions based on one or both of the diagrams. **1**. Draw a fully labelled diagram to show the 'day	**Six factor day model** Hart p.74 fig. 3.25 and **Four factor night model** p.76 fig. 3.32 Hart p.75 Includes a good table of albedos p.61 Effects of cloud cover on energy transfers Hart p.61 Prosser p.114 **Very good diagram on phase change** Witherick p.118 Hart P.76 and 77 **There are other useful sources of information for Unit 2.1** Waugh Chapter 9 p.206 Nagle Chapter 8 p.148 Prosser p.149 Garrett and Nagle AS Geog Concepts and Cases Ch.3 p.62 David Money Ch.1 • Waugh p.208 Ross p.180

			model' of radiation balance in the earth's energy budget. **2**. Describe and explain the effect of cloud cover on the earth's heat energy budget. **3.** Six factor day model. Some energy transfers are left blank. They have to fill them in and then describe two ways on which the local energy budget might be different at night. **These questions test knowledge and understanding.**	
Earth-atmosphere Energy budget 2.2	• Understanding of the global energy budget. • Reasons for differential heating on a global scale. i.e. Why is it hot at the equator and cold at the poles? • Global pattern of pressure and winds • Understanding that temperature variations produce pressure and winds	**Hadley cell** **Ferrel cell** **Atmospheric circulation** **ITCZ** **High pressure** **Low pressure**	**TS.** Introduce the simple idea of energy surplus and deficit. High temps at the equator and low temps at the poles. Can be demonstrated by giving students a map of average annual distribution of insolation received. By shading areas of less than 150W/m2 in one colour and 225+ in another, it raises several points for discussion e.g. low values over equator due to high amounts of cloud cover. Differing temperature patterns produce differential atmospheric pressure. How are the differences balanced? Air movement-winds (and ocean currents). Leads into discussion of the general circulation of the atmosphere. • **Tri-cellular model of the General Circulation of the atmosphere** • Details of the model. • They should know and understand something of the three cells, know which are thermally direct and which thermally indirect and why.	O'Hare and Sweeney "The Atmospheric System" p18, fig 2.5 Hart p.67 Fig 3.15 Money p.26 (Simplified Version) Guinness and Nagle P.71-3 is very good on air motion Nagle p.154 Ross P.189

		Coriolis force **pressure gradient force** **Geostrophic force** **Ferrel's Law** **Trade winds** **Doldrums** **Polar front**	• Understand how the model helps to explain the pattern of winds. Therefore it is necessary to know about the forces which act on the air, Coriolis and pressure gradient forces and the resolution of those forces. Influence of the rotation of the earth and deflection of air. Relationship between temperature and vertical and horizontal air movement i.e. High pressure is subsiding air and low pressure is rising air.	
		Jet stream **Rossby waves** **Upper westerlies**	• General circulation involves upper air movement as well as surface wind. **Some explanation and clarification of these upper air movements in simple terms.**	Nagle p.155-6 is very good on upper air movement
	• Manifestation of the general circulation in the form of world maps of sea level temperature and pressure maps		**A.** General circulation diagram can be drawn and annotated. Testing of understanding can be done via questions, partly complete diagrams for the student to fill in. • Introduce idea of effect of circulation on global distribution of surface temperature and pressure probably via maps. • World map showing distribution of isotherms for summer and winter i.e. Jan and July	Money p.25
			• World map showing distribution of isobars for summer and winter i.e. Jan and July	Money p.27 Ross p.194
	• Knowledge and understanding of the factors that influence local variation within the		• **Description** emphasising **Patterns** and **anomalies.** Students can pick out similarities and differences across the globe. • **Explanation** of pattern. Factors:	Nagle p.151 is good on anomalies Ross p.187

	global pattern • Appreciation of air masses, their source regions and modifications	**Air mass** **Source region** **Fohn wind** **Orographic**	latitude/seasons and day and night. Highlight anomalies by relating back to the general circulation. Some of the reasons may not be accounted for on a global scale therefore this is the link into the next section of work on micro/local variations. **A.** A useful exercise to consolidate- satellite photograph analysis. **TS.** Explanation of models as simplifications of reality. Leads into local variations. Factors influencing these local changes. • **Ocean Currents**-influence of cold and warm currents on temps and winds patterns in coastal locations across the globe. Students will need a map of ocean currents with names, direction of flow and characteristics. • **Proximity to the sea**-specific heat capacity of water compared with land surfaces. Relate to temp and pressure patterns and anomalies • **Altitude** • **Aspect** • **Length of day and night and seasons** • **Cloud cover** • **Prevailing winds** Definition of an air mass, major source regions- tropical, temperate and arctic. Maritime and continental. Modifications. **Meso-scale Winds** • **Fohn/Chinook winds** link to orographic	Guinness and Nagle p.66-7 is very good on the factors affecting temperature www.met-office.gov.uk has useful satellite photographs **Map of ocean currents** Waugh P.212 Ross p.184 Nagle p.150 is excellent Guinness and Nagle p.417 Very good illustrations of modification of lapse rates by ocean currents Warburton p.123-4 Witherick p.135-6 Waugh p.229-30 Guinness and Nagle p.415-6 Very good source Global Map Fig. 12.40 Waugh p.241

		rainfall **Rain shadow**	rainfall and rain shadow areas	
			Micro-scale winds • **Land and Sea breezes**.	Ross p.190 Fig 6.16 very easy to use diagrams Waugh p.240
		Katabatic wind **Anabatic wind**	• Valley winds-**katabatic** and **anabatic** winds. **TS.** Well annotated diagrams may suffice or diagrams with paragraphs of explanation of processes responsible for formation	Ross P.192 Fig.6.18 Waugh p.241
Weather Processes And phenomena 2.3	• Understand phase change	**Water vapour** **Humidity** **Evaporation** **Condensation** **Sublimation** **Deposition**	**TS**. Introduce diagram to show phase changes of water in the atmosphere-description/definitions. Explanation of ways in which phase changes can occur • Temp change • Increase amount of water vapour Introduce idea of relative humidity and absolute humidity	Prosser p.114 Hart p.64 Fig.3.9 Ross P.197 Waugh p.213-224 Money p.11
		Adiabatic cooling	Ways in which cooling can occur-radiation/adiabatic, conduction, convection	Ross p 198 has a useful diagram
	• Understanding of adiabatic temperature change and relationship between actual air temp and that of rising air.	**Adiabatic lapse rate** **Environmental lapse rate** **Dew point temp.** **Condensation level**	Explanation of adiabatic changes as a fundamental principle.	Waugh p216-7 Nagle p.161/2 is particularly clear
	• The link between air mass stability and weather conditions	**DALR** **SALR** **Stability** **Instability** **conditional instability**	Air mass stability-introduced via diagrams Well annotated, fully labelled is a good way of describing the conditions and a springboard for explanation. Fig 3 Explain DALR AND SALR- Rates and reasons for different rates. Relationship	Fig 3 Temperature:Height diagrams Warburton p.100-4 Money p.12-13

			between ELR AND ALRs **A. Give 2 or 3 different ELRs** to be plotted on graph paper and then ask the students to plot the adiabatic lapse rates. Need to give dew point temp/condensation level. They can then draw conclusions about the stability of each air mass. Fig 4 and 5 Exercise on Atmospheric stability Once stability and instability is secure include conditional instability. **A. One exercise which can be used to test understanding is to give a diagram of an orographic uplift situation, with labels to be attached at appropriate points to explain why differences in temperature and humidity occur on opposite sides of a hill/mountain. This is also a useful reinforcement/revision exercise for explaining orographic uplift mechanisms.**	**Fig 4 and 5 exercise on atmospheric stability**
	• How these changes produce weather phenomena like dew etc	**Condensation/hygroscopic nuclei**	**TS. Some general thoughts on points to include for comprehensive coverage of this unit:** Introduce weather phenomena. This can be done by association with each air mass type or by dealing with forms of precipitation and including cloud formation en route. The way in which this is approached is largely personal preference. Description, explanation-should be linked to conditions in which they can be found. Diagrams where possible. Include as much detail as is realistic in time	Warburton p.113 Table 8.2 Good table of types of ppt. Nagle p. 156, 158,163-4 Hart p.82-4 Waugh p.218-220 Guinness and Nagle p.69-70 Ross P.199-201 Warburton 106-9 Good cloud photographs can be found on www.regolith.com

			available. E.g. Distinction between advection and radiation fog. (This is important-often examined) **Rainfall-Explanation**-brief coverage of Bergeron-Findeisen and coalescence theories. **Types**-Frontal/orographic and convectional rainfall is easily incorporated with air mass stability.	Also www.met-office.gov.uk/ for satellite photos of all areas of the world as well as local and regional weather information. Ross p.207
		Anticyclonic conditions **Hoar frost** **Rime etc** **Dew** **Advection/radiation fog** **Rain** **Hail** **Snow** **Clouds** **Temperature inversions**	Distinguish between winter and summer stability and weather conditions associated. Cloud type related to air mass stability. Anticyclones **TS.** This unit could be introduced via energy budgets-global and local to link the two parts together and to link back to other parts of the unit and the atmosphere as a system.	
The Human Impact 2.4	Wider context of the whole unit-concerns local and global energy budgets. Is divided into two sections 1. Greenhouse effect-local and global 2. Urban Microclimates • Understand the 'greenhouse effect' both natural and man-made	**Greenhouse effect** **Greenhouse gases** **Climatic change-global warming/cooling** **Atlantic conveyor** **El-Nino/La Nina**	**Greenhouse effect**- causes-natural gases in the atmosphere. Identify these, consequence of their presence-emphasise that **it is a natural process**. What would happen without it. Discuss how and why human activity has had an impact. Diagrams can help. It may be necessary/essential to put the ozone layer in context here because so often there is confusion between the greenhouse effect and ozone depletion. Relate the greenhouse effect to possible global warming/cooling. A section on	Money Chapter 4 **Causes and Effects of Climatic change -** very good source Guinness and Nagle p.87 Effects of greenhouse effect Guinness and Nagle P.89 Greenhouse effect-Waugh 254-5 Global Climatic change-Waugh 248 Bowen and Palliser p.82-95 Ozone layer – Nagle p.179

	• Causes and Consequences of the greenhouse effect • Urban microclimates-knowledge of characteristics, understanding of causes and consequences. Relationships between the individual weather conditions e.g. Temp. Wind speed and humidity.	**Specific heat capacity** **Albedo** **Urban heat island** **Anomalies**	climatic change is necessary. **A** Consequences of global warming should be **discussed-**it is important that students appreciate that the issue is a matter of conjecture and that the consequences may be far-reaching but not certain **TS.** Introduce general principles-starting with the concept of the heat island and using this as a springboard for the other phenomena. Inter-relationships between temp. - Wind speed – humidity - precipitation - pollution should be emphasised. **A case study** would be ideal e.g. London, Los Angeles, which are well documented in the textbooks. However, it is worth noting that urban microclimates vary according to size, shape and location. These factors can be built into study. E.g. Tokyo, Mexico City and Chicago may exhibit different characteristics because of their particular sites. Distortions of pattern within the urban area are also worthy of consideration. E.g. Thames and Lea Valley in London	Nagle p.180-1 very good El-Nino- Bowen and Palliser p80-1 Waugh p.250-3 Nagle p.178 Nagle p.176-177- very good Waugh p.242-3 Guinness and Nagle p.82-4 Ross p.211-213 Bowen and Palliser p.72-79-very good Money p.96-101 O'Hare and Sweeney 30-32