

## Paper 1 Physical Core

### 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 for IGCSE and in the hydrology unit (Unit 1).

**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 scale and micro scale atmospheric processes.

Content	Objectives	Terminology	Teaching Strategies (TS) and Activities (A)	Resources
<b>2.1 Local energy budgets</b>	<ul style="list-style-type: none"> <li>A basic appreciation of the vertical structure of the atmosphere</li> <li>An appreciation of the atmosphere as a heat engine</li> <li>An understanding that incoming solar radiation must be balanced by outgoing radiation</li> </ul>	<p><b>Troposphere</b> <b>Tropopause</b> <b>Stratosphere</b></p> <p><b>Energy budget</b> <b>Evaporation</b> <b>Condensation</b></p>	<p><b>TS</b> Introduce by a temperature/height diagram to show vertical structure of the atmosphere. <b>A</b> 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.</p> <p><b>TS</b></p> <ul style="list-style-type: none"> <li>Idea that the atmosphere is an engine powered by the sun. <b>Inputs</b> must be balanced by <b>outputs</b> or <b>overall heating/cooling may result</b></li> </ul>	<p>The Atmospheric Systems chapter in Hart's textbook is suitable for this unit and provides good simple straightforward visual material, which is appropriate at this level.</p> <p>Warburton p.25 Waugh p.207 Guinness and Nagle p.387 Hart p.59</p> <p>Hart p.62 fig 3.7 and p.63 fig 3.8</p> <p>Ross p.179. This is a simplified diagram and by far the most useful of the earth -atmosphere system.</p>

	<ul style="list-style-type: none"> <li>• Diurnal spatial and temporal variations in energy budgets</li> <li>• Methods of heating</li> <li>• Knowledge and understanding of local diurnal energy budgets</li> </ul>	<p><b>Albedo Reflection Scattering</b></p> <p><b>Conduction Convection Radiation - long wave and short wave</b></p> <p><b>Latent heat transfer Sensible heat transfer</b></p>	<p>Local energy budgets. Input-output analysis using daytime and night-time energy models</p> <p><b>The 'day model' and 'night model' energy budget</b> 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.</p> <p><b>Day model</b> Transfers of heat: evaporation, sensible heat transfer, incoming solar radiation, long wave radiation, surface absorption</p> <p><b>Night model</b> Transfers of heat: long wave radiation, sensible heat transfer, heat supply to the surface, condensation, production of dew. Methods of heating. Radiation, conduction, convection. Use analogies with which the students can readily identify. Radiators, air conditioning, a 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.</p> <ul style="list-style-type: none"> <li>• Distinguish between latent heat and sensible heat transfers.</li> </ul> <p><b>Latent heat</b> - involves phase change e.g. gas to liquid. Energy is "stored" or "released"</p> <p><b>Sensible heat</b> - energy gain or loss without a phase change. Water vapour does not undergo a phase change</p> <p>This section of work can be kept fairly straightforward if the daytime and night-time budgets are used. Need not occupy too many lessons.</p>	<p>Geofactsheet 167 A simple guide to Energy Budgets</p> <p><b>Six factor day model</b> Hart p.74 fig. 3.25 and <b>Four factor night model</b> p.76 fig. 3.32</p> <p>Hart p.75 Includes a good table of albedos p.61 Effects of cloud cover on energy transfers</p> <p><b>June 2007 Fig. 2</b> very good diagram of day-night budgets which could be used as a teaching tool. <b>Nov 2005 Q. 7(b)</b> 'night model'</p> <p>Hart p.61</p> <p>Prosser p.114 Very good diagram on phase change Witherick p.118</p> <p>Hart p.76 and p.77 <b>Nov 2007 Q. 7(b)</b> Latent heat transfer</p> <p>There are other useful sources of information for Unit 2.1 Waugh Chapter 9 p.206</p>
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<p><b>2.2 The global energy budget</b></p>	<p>Weather phenomena associated with local energy budgets</p> <ul style="list-style-type: none"> <li>• Understanding of the global energy budget</li> <li>• Reasons for differential heating on a global scale, i.e. why is it hot at the equator and cold at the poles?</li> <li>• Global pattern of pressure and winds</li> </ul>	<p><b>Mist, fog, dew, temperature inversions</b></p> <p><b>Hadley cell</b> <b>Ferrel cell</b></p>	<p><b>A</b> Consolidate by asking questions based on one or both of the diagrams.</p> <ol style="list-style-type: none"> <li>1. Draw a fully labelled diagram to show the 'day model' of radiation balance in the earth's energy budget.</li> <li>2. Describe and explain the effect of cloud cover on the earth's heat energy budget.</li> <li>3. Leave some energy transfers blank. Students have to fill them in and then describe two ways in which the local energy budget might be different at night.</li> </ol> <p><b>These questions test knowledge and understanding.</b></p> <p><b>TS</b> Introduce the simple idea of energy surplus and deficit. High temperatures at the equator and low temperatures 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/m<sup>2</sup> in one colour and over 225W/m<sup>2</sup> in another, it raises several points for discussion, e.g. low values over equator due to high amounts of cloud cover.</p> <p>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.</p> <ul style="list-style-type: none"> <li>• <b>Tri-cellular model of the general circulation of the atmosphere</b></li> <li>• Details of the model.</li> <li>• They should know and understand something of the three cells, know which are thermally direct and which thermally</li> </ul>	<p>Nagle Chapter 8 p.148 Prosser p.149 Garrett and Nagle AS Geography Concepts and Cases Chapter 3 p.62 Money Chapter 1 Waugh p.208 Ross p.180</p> <p>Geofile 543 April 2007 Albedo and Energy Budgets</p> <p>O'Hare and Sweeney, The Atmospheric System, p18, fig 2.5</p>
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	<ul style="list-style-type: none"> <li>Understanding that temperature variations produce pressure and winds</li> <li>Manifestation of the general circulation in the form of world maps of sea level temperature and pressure</li> </ul>	<p><b>Atmospheric circulation</b>  <b>ITCZ</b>  <b>High pressure</b>  <b>Low pressure</b></p> <p><b>Coriolis force</b>  <b>Pressure gradient force</b>  <b>Geostrophic force</b>  <b>Ferrel's Law</b>  <b>Trade winds</b>  <b>Doldrums</b>  <b>Polar front</b></p> <p><b>Jet stream</b>  <b>Rossby waves</b>  <b>Upper westerlies</b></p>	<p>indirect and why.</p> <ul style="list-style-type: none"> <li>Be able to map the world wind belts (which will include the pressure belts too, probably)</li> <li>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, the 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.</li> <li>General circulation involves upper air movement as well as surface wind. <b>Some explanation and clarification of these upper air movements in simple terms.</b></li> </ul> <p><b>A</b> General circulation diagram can be drawn and annotated. Testing of understanding can be done using questions and partly completed diagrams for the student to fill in.</p> <ul style="list-style-type: none"> <li>Introduce idea of effect of circulation on global distribution of surface temperature and pressure probably using maps.</li> <li>World map showing distribution of isotherms for summer and winter, i.e. January and July</li> <li>World map showing distribution of isobars for summer and winter, i.e. January and July</li> </ul>	<p><b>June 2007 Q. 7(b)</b>  <b>Nov 2004 Fig. 2</b> World surface temperatures - useful resource.</p> <p>Hart p.67 Fig 3.15  Money p.26 (simplified version)  Guinness and Nagle pp.71-3 is very good on air motion  Nagle p.154  Ross p.189</p> <p>Nagle pp.155-6 is very good on upper air movement</p>
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	<ul style="list-style-type: none"> <li>• Knowledge and understanding of the factors that influence local variation within the global pattern</li> </ul>		<ul style="list-style-type: none"> <li>• <b>Description</b> emphasising <b>patterns</b> and <b>anomalies</b>. Students can pick out similarities and differences across the globe.</li> <li>• <b>Explanation</b> of pattern. Factors: 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 scale variations.</li> </ul> <p><b>A</b> A useful exercise to consolidate – analysis of satellite photographs.</p> <p><b>TS</b> Explanation of models as simplifications of reality. Leads into local variations. Factors influencing these local changes.</p> <ul style="list-style-type: none"> <li>• <b>Ocean currents</b> - influence of cold and warm currents on temperatures and wind patterns in coastal locations across the globe. Students will need a map of ocean currents with names, direction of flow and characteristics.</li> <li>• <b>Proximity to the sea</b> - specific heat capacity of water compared with land surfaces. Relate to temperature and pressure patterns and anomalies</li> <li>• <b>Altitude</b></li> <li>• <b>Aspect</b></li> <li>• <b>Length of day and night and seasons</b></li> <li>• <b>Cloud cover</b></li> <li>• <b>Prevailing winds</b></li> </ul>	<p>Money p.25</p> <p>Money p.27 Ross p.194</p> <p>Nagle p.151 is good on anomalies Ross p.187</p> <p>Guinness and Nagle pp.66-7 is very good on the factors affecting temperature</p> <p><a href="http://www.met-office.gov.uk">www.met-office.gov.uk</a> has useful satellite photographs</p> <p><b>Map of ocean currents</b> 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 <b>June 2008 Fig. 2</b> is an excellent map of ocean</p>
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<p><b>2.3 Weather processes and phenomena</b></p>	<ul style="list-style-type: none"> <li>• Understand phase change</li> <li>• Understanding of adiabatic temperature change and relationship between actual air temperature and that of rising air</li> <li>• The link between air mass stability and weather conditions</li> </ul>	<p><b>Fohn wind Orographic rainfall Rain shadow</b></p> <p><b>Katabatic wind Anabatic wind</b></p> <p><b>Water vapour Humidity Evaporation Condensation Sublimation Deposition</b></p> <p><b>Adiabatic cooling</b></p>	<p><b>Meso scale winds</b></p> <ul style="list-style-type: none"> <li>• <b>Fohn/Chinook winds</b> link to orographic rainfall and rain shadow areas</li> </ul> <p><b>Micro scale winds</b></p> <ul style="list-style-type: none"> <li>• <b>Land and sea breezes</b></li> </ul> <p><b>TS</b> Well annotated diagrams may suffice or diagrams with paragraphs of explanation of processes responsible for formation.</p> <p><b>TS</b> Introduce diagram to show phase changes of water in the atmosphere – description and definitions.</p> <p>Explanation of ways in which phase changes can occur</p> <ul style="list-style-type: none"> <li>• Temperature change</li> <li>• Increase amount of water vapour</li> </ul> <p>Introduce idea of relative humidity and absolute humidity</p> <p>Ways in which cooling can occur - radiation/adiabatic, conduction, convection</p> <p>Explanation of adiabatic changes as a fundamental principle.</p>	<p>currents, a useful teaching resource. Warburton pp.123-4 Witherick pp.135-6 Waugh pp.229-30 Guinness and Nagle pp.415-6 Very good source Global Map Fig. 12.40</p> <p>Waugh p.241</p> <p>Geofile 552 Anticyclones</p> <p><b>June 2004 Q. 7(b) June 2005 Fig. 2</b> very useful simple diagrams of land and sea breezes - excellent teaching resource.</p> <p>Ross p.190 Fig 6.16 very easy to use diagrams Waugh p.240</p> <p>Ross p.192 Fig.6.18 Waugh p.241</p> <p>Prosser p.114</p>
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	<ul style="list-style-type: none"> <li>How these changes produce weather phenomena like dew, etc.</li> </ul>	<p><b>Adiabatic lapse rate (ALR)</b>  <b>Environmental lapse rate (ELR)</b>  <b>Dew point temperature</b>  <b>Condensation level</b>  <b>DALR</b>  <b>SALR</b>  <b>Stability</b>  <b>Instability</b>  <b>Conditional instability</b></p>	<p>Air mass stability - introduced using diagrams. Well annotated, fully labelled diagrams are a good way of describing the conditions and a springboard for explanation. Fig 3 Explain DALR and SALR – the rates and reasons for the different rates. Relationship between ELR and ALRs</p> <p><b>A Give 2 or 3 different ELRs</b> to be plotted on graph paper and then ask the students to plot the adiabatic lapse rates. Need to give dew point temperature /condensation level. They can then draw conclusions about the stability of each air mass. Figs 4 and 5 Exercise on Atmospheric stability.</p> <p>Once understanding of stability and instability is secure, include conditional instability.</p> <p><b>A</b> One exercise which can be used to test understanding is to give a diagram of a situation of <b>orographic uplift</b>, 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.</p>	<p>Hart p.64 Fig.3.9  Ross p.197  Waugh pp.213-224  Money p.11</p> <p>Ross p.198 has a useful diagram</p> <p><b>June 2004 Q. 2</b> lapse rates, instability - good graph to show instability - useful resource. Could be annotated.</p> <p>Waugh pp.216-7  Nagle pp.161-2 is particularly clear</p> <p>Fig 3 temperature/height diagrams  Warburton pp.100-4  Money pp.12-13</p> <p><b>June 2006 Q. 7(b)</b> Weather associated with stability and instability</p>
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<p><b>2.4 The human impact</b></p>	<p>Wider context of the whole unit - concerns local and global energy budgets. It is divided into two sections</p> <ol style="list-style-type: none"> <li>Greenhouse effect - local and global</li> <li>Urban microclimates</li> </ol> <ul style="list-style-type: none"> <li>Understand the greenhouse effect both natural and man-made</li> <li>Causes and consequences of the greenhouse effect</li> <li>Urban microclimates - knowledge of characteristics, understanding of causes and consequences. Relationships between the individual weather conditions, e.g. temperature, wind speed and humidity.</li> </ul>	<p><b>Greenhouse effect</b>  <b>Greenhouse gases</b>  <b>Climatic change - global warming /cooling</b>  <b>Atlantic conveyor</b>  <b>El Nino/La Nina</b></p> <p><b>Specific heat capacity</b>  <b>Albedo</b>  <b>Urban heat island</b>  <b>Anomalies</b></p>	<p><b>Greenhouse effect</b> – causes: natural gases in the atmosphere. Identify these, consequence of their presence- emphasise that <b>it is a natural process</b>. 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 climatic change is necessary. <b>A</b> Consequences of global warming should be <b>discussed</b> - 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.</p> <p><b>TS</b> Introduce general principles - starting with the concept of the heat island and using this as a springboard for the other phenomena. Inter-relationships between temperature,,wind speed, humidity, precipitation and pollution should be emphasised.</p> <p><b>A</b> A <b>case study</b> 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 urban areas' size, shape and location. These factors can be built into study, e.g. Tokyo, Mexico City</p>	<p>Money Chapter 4 Causes and Effects of Climatic change - very good source</p> <p>Guinness and Nagle p.87  Effects of greenhouse effect  Guinness and Nagle p.89  Greenhouse effect - Waugh pp.254-5  <b>June 2006 Q.7(c)</b> Global warming  Global Climatic change-  Waugh p.248  Bowen and Pallister pp.82-95  Ozone layer, Nagle p.179  <b>Nov 2006 Q. 2</b> CO<sub>2</sub> emissions linked to global warming Nagle pp.180-1 very good</p>
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			<p>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. effects of the River Thames and Lea Valley in London</p> <p><b>Note</b> It is important to appreciate the comparison between rural and urban microclimates. Questions set demand knowledge of both. Therefore specific knowledge is needed and comments like “rural areas are not as warm as urban areas” are insufficient for a Level 3 mark. Relative climatic data and an assessment and comparison between day and night would be especially pertinent.  <b>Nov 2006 Q. 2(c)</b> and <b>June 2007 Q. 7(c)</b></p>	<p>El Nino, Bowen and Pallister pp.80-1  Waugh pp.250-3  Nagle p.178</p> <p><b>Nov 2006 Q. 2(c)</b> <b>June 2005 Q. 1 Fig. 1</b> useful diagram/graph of the urban heat island.  <b>June 2004 Q. 7(c)</b>  <b>June 2008 Q. 7(c)</b> urban heat island. This is a popular subject area for questions.</p> <p>Nagle pp.176-177 very good  Waugh pp.242-3  Guinness and Nagle pp. 82-4  Ross pp.211-213  Bowen and Pallister pp.72-79 very good  Money pp.96-101</p> <p>O’Hare and Sweeney pp.30-32</p> <p>Geofile 567 January 2008  Forest microclimates</p>
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