

# Teaching Guide

## Topic 6: Atmospheric systems and societies

### Topic map

Sub-topic number and name	Learning outcome	Number of lessons (suggested) 1 hour per lesson	Relevant material
6.01 Introduction to the atmosphere	The atmosphere is a dynamic system, essential to life on Earth and influenced by variations in all ecosystems.	2	Pages 256–264  Figures 6.01–6.06  Self-assessment questions 6.01.01–6.01.02  Case study 6.01.01  End-of-topic question 1
6.02 Stratospheric ozone	Stratospheric ozone protects living systems from the negative effects of UV radiation from the Sun.  Human activities have disturbed stratospheric ozone formation, and management strategies are now being employed to conserve it.	3	Pages 265–278  Figures 6.07–6.15  Self-assessment questions 6.02.01–6.02.05  Case study 6.02.01  End-of-topic question 2
6.03 Photochemical smog	Burning fossil fuels produces pollutants that may lead to photochemical smog.  Photochemical smog has significant impacts on societies and systems.  Photochemical smog can be reduced by decreasing human reliance on fossil fuels.	3	Pages 279–289  Figures 6.16–6.20  Self-assessment questions 6.03.01–6.03.03  Case study 6.03.01  End-of-topic question 3

6.04 Acid deposition	<p>Acid deposition can impact upon living systems and the built environment.</p> <p>The pollution management of acid deposition often involves cross-border issues.</p>	2	<p>Pages 290–298</p> <p>Figures 6.21–6.26</p> <p>Self-assessment questions 6.04.01–6.04.04</p> <p>Case study 6.04.01</p> <p>End-of-topic question 4</p>
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## Sub-topic 6.01: Introduction to the atmosphere

### Overview

Most students should have some basic knowledge and understanding of the atmosphere from previous study. However, viewing the atmosphere as a dynamic system, changes in the atmosphere throughout geological history, and the impact of living organisms on the composition of the atmosphere are likely to be new ideas.

Students will learn to interpret a thermal stratification diagram, explain the role of the albedo effect and outline the role of the greenhouse effect.

### Suggested activities

#### Possible starters

Ask students to define some key terms such as troposphere, stratosphere, albedo effect, greenhouse effect and clouds. Ask students to explain why the atmosphere is a dynamic system. Provide a diagram of thermal stratification (with axes labelled) for students to complete the labelling.

There are a number of videos and weblinks that provide a good introduction to the atmosphere. Good sources of introductory materials are:

- [www.metlink.org/secondary/a-level](http://www.metlink.org/secondary/a-level) – Royal Meteorological Society (UK) resources on weather and climate for A level/International Baccalaureate (IB). Relevant sections for this sub-topic include atmospheric structure, composition and solar radiation.
- [www.ucar.edu](http://www.ucar.edu) – University Corporation for Atmospheric Research.
- [www.geography.org.uk](http://www.geography.org.uk) – The Geographical Association (UK) – provides a wide range of links and resources for the issues developed in this topic.

#### Main lesson content

- Looking at the Earth–atmosphere system from the school/college grounds can get students to begin to think of the atmosphere as a dynamic system, even when the weather is very stable, although some level of instability in terms of clouds and

precipitation will provide more stimulus. Can they recognise/think of inputs, outputs, flows and storages?

- Another simple outdoor exercise when there is intermittent cloud cover is to record readings of air temperature when (a) the Sun's rays reach the school/college grounds unobstructed, and (b) when cloud cover obstructs the Sun's rays. This is a useful introduction to teaching the albedo effect.

### **Common misunderstandings and misconceptions**

Issues that can trouble students are (a) the changing composition of the atmosphere throughout geological history and (b) the role of the albedo effect from clouds. In terms of the former, stressing the role of plants in taking in carbon dioxide and giving out oxygen, and then posing the question of what happens if there is a big change in the quantity of the Earth's plants, can be useful. For the albedo effect, students sometimes find it difficult to appreciate that clouds can both reflect the Sun's energy back into space and trap and reflect outgoing long-wave radiation. Carefully chosen diagrams and short video sequences are very useful here.

### **Supporting struggling students**

A useful resource for students finding this area difficult is the BBC's GCSE Bitesize website [www.bbc.co.uk/schools/gcsebitesize/science/aqa\\_pre\\_2011/oils/changesact.shtml](http://www.bbc.co.uk/schools/gcsebitesize/science/aqa_pre_2011/oils/changesact.shtml). The objective of the Bitesize series is to break basic knowledge and understanding into manageable sections.

### **Challenging high achievers**

Extension tasks for high achievers might include more detailed study of the way in which the composition of the atmosphere has changed over time, and the ways in which human activities alter inputs and outputs in the atmospheric system.

### **Homework suggestions**

Preparing for a test on the basics of the atmosphere could involve learning Figure 6.03, which illustrates changes in temperature and pressure with altitude. This is central to much of the content in Sub-topics 6.01 and 6.02.

Preparing to draw an annotated diagram of the natural greenhouse effect might also prove to be valuable use of homework time, because students often cannot explain the greenhouse effect well.

### **Cross-references with other sub-topics**

1.02 Systems and models, 2.04 Biomes, zonation and succession, 4.01 Introduction to water systems, 5.01 Introduction to soil systems.

## Sub-topic 6.02: Stratospheric ozone

### Overview

Students may have some very basic knowledge of the topic but are likely to lack any detail, particularly in the area of damage caused by ultraviolet (UV) radiation to human health and biological productivity, and in relation to pollution management.

Students will evaluate the role and importance of national and international organisations in reducing emissions of ozone-depleting substances. They will understand that the depletion of ozone has global implications for ocean productivity and oxygen production. They will also further their ability to interpret graphs/diagrams showing changes in the characteristics of the atmosphere with altitude.

### Suggested activities

#### Possible starters

Ask students about the nature of the ozone 'problem' in the stratosphere. It is also useful for students to study a diagram showing the location of ozone in the atmosphere, noting the different altitudes of 'good' ozone (the stratosphere) and 'bad' ozone (the troposphere). The latter is a key element of Sub-topic 6.03. Students could also be asked to list ozone-depleting substances.

[www.unep.org/ozoneaction](http://www.unep.org/ozoneaction) – United Nations Environment Programme 'Twenty Questions and Answers About the Ozone Layer' (2014) could profitably be used as starters and for main lesson content.

#### Main lesson content

- This sub-topic provides the opportunity to discuss a range of interesting and relevant issues, including the role of stratospheric ozone in the atmospheric system, the action of ozone-depleting substances, the damage caused to human health and biological productivity by UV radiation, and the effectiveness of pollution management. The illegal market in ozone-depleting substances is a particularly controversial issue that can spark substantial debate. Useful resources include:
  - [www.theozonehole.com](http://www.theozonehole.com) – a well-illustrated resource covering all the expected aspects of the topic
  - [www.ozonelayer.noaa.gov/science/basics.htm](http://www.ozonelayer.noaa.gov/science/basics.htm) – National Oceanic and Atmospheric Administration
  - [www.curriculum-press.co.uk](http://www.curriculum-press.co.uk) – geography factsheet no. 188: 'The ozone problem'.

### Common misunderstandings and misconceptions

The contrast between the 'good' ozone of the stratosphere and the 'bad' ozone of the troposphere can be difficult for some students to grasp. Ozone destruction and reformation as

an example of dynamic equilibrium is also a difficult concept for some students. Some may struggle with the detail of the science of pollution management – recycling refrigerants, alternatives to gas-blown plastics, and developing non-propellant alternatives.

### **Supporting struggling students**

A useful resource for students finding this area difficult is the BBC's GCSE Bitesize website – [www.bbc.co.uk/schools/gcsebitesize/science/aqa\\_pre\\_2011/oils/changesact.shtml](http://www.bbc.co.uk/schools/gcsebitesize/science/aqa_pre_2011/oils/changesact.shtml). The objective of the Bitesize series is to break basic knowledge and understanding down into manageable sections.

### **Challenging high achievers**

There is plenty for high achievers here. The relative success of individual countries in implementing the Montreal Protocol is interesting to investigate. Research into the science of pollution management is another area that might attract high achievers.

### **Homework suggestions**

Figures 6.08 (The location of ozone in the atmosphere) and 6.09 (How the ozone layer intercepts ultraviolet radiation) are central to the content of this sub-topic. A homework task to prepare for a test on these diagrams would be timely early on in this sub-topic. The self-assessment questions in the textbook can provide regular homework tasks throughout this sub-topic.

### **Cross-references with other sub-topics**

1.03 Energy and equilibria, 1.05 Humans and pollution, 8.02 Resource use in society.

## **Sub-topic 6.03: Photochemical smog**

### **Overview**

Most students are likely to have only limited prior knowledge of this sub-topic. They will probably have a number of general ideas but lack the detailed knowledge and understanding to produce the logical sequence of argument required.

Students will evaluate pollution management strategies for reducing photochemical smog.

### **Suggested activities**

#### Possible starters

A video clip showing a dense photochemical smog and the reactions of the people affected should engender a lively debate. YouTube is likely to provide the most recent examples. <http://education.nationalgeographic.com/encyclopedia/smog/> is another useful resource. If students or teachers have personal experience of photochemical smog, this will add substantially to the initial debate.

### Main lesson content

- Students might research the correlation between increasing global urbanisation and industrialisation and the increase in urban air pollution. They could present the formation of secondary pollutants from primary pollutants in diagrammatic form.
- Maps and data on the extent and impact of smog should be an essential part of main lesson content. Useful information and resources can be found at the following websites:
  - <http://environment.nationalgeographic.com/environment/global-warming/pollution-overview> – the causes and effects of air pollution
  - [www.conserve-energy-future.com](http://www.conserve-energy-future.com) – Conserve Energy Future – the causes, effects and solutions of air pollution
  - [www.who.int/ceh/risks/cehair/en](http://www.who.int/ceh/risks/cehair/en) – World Health Organization – the impacts of air pollution on human health
  - [www.sciencedaily.com](http://www.sciencedaily.com) – a good source of articles and videos on air pollution
  - <http://energydesk.greenpeace.org/2014/03/10/beyond-beijing-interactive-map-chinas-cities-affected-emergency-levels-air-pollution> – interactive map of China's cities affected by emergency levels of air pollution.

### **Common misunderstandings and misconceptions**

The concept of temperature inversion is difficult for some students. It is easier for students if the term is introduced in Sub-topic 6.01 when thermal stratification of the atmosphere is explained (temperature lapse, isothermal layer, temperature inversion). Diagrams showing typical data for temperature inversions would be particularly useful.

### **Supporting struggling students**

Using case studies to reinforce the knowledge and understanding requirements of this sub-topic can be reassuring for students struggling with the content of the syllabus.

### **Challenging high achievers**

Extension tasks for the most able could include attempting to compare the role of the contributory factors in the formation of smog in different large areas (local topography, climate, population density, fossil fuel use). Comparing the relative success of pollution management strategies in different cities and countries could also prove to be a rewarding task.

### **Homework suggestions**

The case study on 'Transboundary pollution' in the Elevate materials provides text and illustrations that could be the basis for a range of homework assignments. Students could look on the internet for information on the most recent forest fires and the extent of their impact. The Royal Meteorological Society website ([www.metlink.org/secondary/a-level](http://www.metlink.org/secondary/a-level)) provides a wealth of material that could be used for homework.

### **Cross-references with other sub-topics**

1.05 Humans and pollution, 7.02 Climate change – causes and impacts, 6.04 Acid deposition.

## Sub-topic 6.04: Acid deposition

### Overview

Students will probably have some basic knowledge of this issue, depending on the science course they followed in previous years and the country in which they live. However, many will not have encountered the detail regarding the formation of acid deposition, its effects on living systems, and related pollution management strategies.

Students will assess the impact of acid deposition on living systems and the built environment, and evaluate management strategies for acid deposition. They will become aware that this is a major example of transboundary pollution requiring international discussion and cooperation.

### Suggested activities

#### Possible starters

Discuss any personal experience of acid deposition or examples students have come across in the mass media. A series of key images of the impact of acid deposition on living systems and the built environment should stimulate discussion.

#### Main lesson content

- An interesting exercise would be for students to produce a fact file on acid deposition for the country in which they live or an alternative country. The fact file could be structured around causes, consequences and management strategies. The transboundary nature of acid deposition might also warrant more detailed investigation.
- Useful sources of information are:
  - [www.epa.gov/acidrain/what](http://www.epa.gov/acidrain/what) – US Environmental Protection Agency. Explains various aspects of acid deposition
  - [www.esa.org/esa/science/reports/acid-deposition](http://www.esa.org/esa/science/reports/acid-deposition) – Ecological Society of America
  - [www.curriculum-press.co.uk](http://www.curriculum-press.co.uk) – geography factsheet no. 181: 'Acid rain'.

### Common misunderstandings and misconceptions

Distinguishing between the direct effect and indirect toxic effect of acid deposition can sometimes be a challenge for students.

### Supporting struggling students

The careful use of case studies can do much to clarify the knowledge and understanding requirements of this sub-topic. Helpful websites include:

- [www.clean-air-kids.org.uk/acidrain](http://www.clean-air-kids.org.uk/acidrain)
- <http://science-howstuffworks.com>
- [www.bbc.co.uk/education](http://www.bbc.co.uk/education) – BBC Bitesize.



### **Challenging high achievers**

The most able students could investigate the relative success of pollution management strategies and present their findings to the class. They could also access the extent of international cooperation with regard to acid deposition.

### **Homework suggestions**

The websites listed above provide a range of materials that can be used for homework tasks to augment the self-assessment questions that appear at regular intervals in this sub-topic. Depending on where students live, they could be asked to identify a building or natural environment that has deteriorated due to acid deposition and describe what has happened. Students can be encouraged to provide a photograph.

### **Cross-references with other sub-topics**

1.05 Humans and pollution, 2.05 Investigating ecosystems, 6.03 Photochemical smog.