

## Climate change science

### Introduction

This session is intended to develop your students' understanding of the greenhouse effect. They will have met this topic before but the chief examiner's report for the last couple of years of AS Science for Public Understanding (which included this topic) suggests that many students have a very confused notion of the topic despite the coverage of the ideas in GCSE Science, Geography and other subjects.

### The activity

The notes for each slide in the PowerPoint presentation provide further background information to complement the textbook. You can use the presentation to introduce key terms and ideas, using the discussion questions below, then ask students to study the related section of the textbook and answer the questions.

Two of the slides in the presentation have links to a web site with animations that can enhance the treatment of the topic.

Answers to the questions in the textbook are provided in the A2 section of the Nuffield Science in Society web site.

You may wish to revise students' understanding and recall of electromagnetic radiation before starting the presentation. Possible resources include the AS textbook, page 98, or this short animation from NASA which explains the differences between solar and terrestrial emitted radiation.  
[http://earthobservatory.nasa.gov/Experiments/PlanetEarthScience/Glob alWarming/GW\\_Movie1.php](http://earthobservatory.nasa.gov/Experiments/PlanetEarthScience/Glob alWarming/GW_Movie1.php)

### Questions for discussion

#### Slide 2

- What keeps the carbon dioxide in the atmosphere?  
*gravity*  
*Masses of planets are: Venus:  $4.87 \times 10^{24}$  kg, Earth:  $5.98 \times 10^{24}$  kg, Mars:  $0.65 \times 10^{24}$  kg*
- Describe the relationship between carbon dioxide in the atmosphere and mean temperature as shown in these planets.  
*High temperature when there is high percentage of CO<sub>2</sub> in atmosphere*

### Science explanations

**Na** Visible light is part of a whole spectrum of electromagnetic radiation. Other types of electromagnetic radiation are:

**Nb** radio - microwaves - infrared - visible light - ultraviolet - X-rays - gamma.

**Nc** These are all similar in type (electromagnetic waves). They can all travel through empty space (a vacuum). The differences between them are due to their different wavelengths. In the list above, they are placed in order, from longest to shortest wavelength. The names of the types are a convenience only; each merges into the next.

**Nd** All objects emit radiation; the hotter they are the more radiation they emit and the shorter the wavelength at which they emit most radiation.

**Ne** When radiation strikes another object it can be reflected, transmitted or absorbed (or a combination of these). Reflected or transmitted radiation is similar to the original radiation. When radiation is absorbed, however, it ceases to exist as radiation, instead causing heating and perhaps also changes to molecules or other effects.

**Nf** Some gases, such as carbon dioxide, methane, nitrogen oxides and water vapour absorb infrared radiation; other gases such as nitrogen, oxygen do not.

**Ob** The temperature of an object changes if the energy it absorbs and the energy it radiates from its surface are not in balance.

- What is the other major factor determining temperature?  
*Distance from Sun*

### Slide 3

- What is the difference between the radiation emitted from the surface of the Sun and that emitted from the surface of the Earth?  
*Sun: Short wavelength, high energy, UV and visible.*  
*Earth: Long wavelength, less energy, IR.*
- Why are they different?  
*Wavelength depends on temperature of emitting body.*
- Roughly what proportion of the incoming radiation from the Sun is actually absorbed by the Earth's surface?  
*About half, 343Watt per m<sup>2</sup> from Sun, 168 absorbed*
- What has happened to the rest?  
*reflected from atmosphere, mainly clouds, and surface*
- What is the effect of radiation when it is absorbed?  
*Heating*
- The Earth keeps receiving radiation from the Sun but it does not get hotter and hotter. Why?  
*Because the energy of the outgoing radiation equals the energy of the incoming radiation.*

### Slide 4

- Why is the energy reflected by aerosols or glaciers and snow not absorbed by greenhouse gases?  
*It is short wave solar radiation. Greenhouse gases only absorb long wave IR radiation.*
- Explain why an increase in the Earth's albedo would reduce the IR radiation being emitted.  
*The Earth would absorb less solar energy so would be cooler. Therefore it would emit less energy.*
- Explain why major volcanic eruptions usually lead to reduction in average global temperatures for a year or two.  
*Some of the dust and sulphates they release stay in the atmosphere as aerosols which increases albedo. Aerosols may also help cloud formation leading to more clouds that reflect more sunlight.*
- Water is found in the atmosphere both as clouds and as water vapour, an important greenhouse gas. Explain how these two different forms of water have opposite effects on the emission of energy back into space.  
*Clouds increase the reflection of incoming radiation, cooling the Earth. (The textbook at the bottom of page 102 suggest further complexity.)*  
*Water vapour absorbs outgoing IR radiation, reducing emission and warming the Earth.*

**Textbook** Pages 100 – 104

Questions 4 - 11

### Check on understanding

At the end of the session it would be well worth reinforcing the basic ideas by asking students to shut up their notes and books and then getting each of them to draw and annotate a diagram of the greenhouse effect from memory. Then ask them, in groups, to criticise each other's diagrams.

August 2009



## Climate change science

### Introduction

This session is intended to help your understanding of the greenhouse effect. You will watch a short power point presentation and discuss questions about the slides.

You may need to start with a review of your understanding of electromagnetic radiation, using the AS textbook page 98 or this web site

[http://earthobservatory.nasa.gov/Experiments/PlanetEarthScience/GlobalWarming/GW\\_Movie1.php](http://earthobservatory.nasa.gov/Experiments/PlanetEarthScience/GlobalWarming/GW_Movie1.php)

### Questions for discussion

#### Slide 2

- What keeps the carbon dioxide in the atmosphere?
- Describe the relationship between carbon dioxide in the atmosphere and mean temperature as shown in these planets.
- What is the other major factor determining temperature?

#### Slide 3

- What is the difference between the radiation emitted from the surface of the Sun and that emitted from the surface of the Earth?
- Why are they different?
- Roughly what proportion of the incoming radiation from the Sun is actually absorbed by the Earth's surface?
- What has happened to the rest?
- What is the effect of radiation when it is absorbed?
- The Earth keeps receiving radiation from the Sun but it does not get hotter and hotter. Why?

#### Slide 4

- Why is the energy reflected by aerosols or glaciers and snow not absorbed by greenhouse gases?
- Explain why an increase in the Earth's albedo would reduce the IR radiation being emitted.
- Explain why major volcanic eruptions usually lead to reduction in average global temperatures for a year or two.
- Water is found in the atmosphere both as clouds and as water vapour, an important greenhouse gas. Explain how these two different forms of water have opposite effects on the emission of energy back into space.

**Now read the Textbook** Pages 100 – 104 and answer questions 4 - 11

**Check on understanding** Shut your notes and books and draw and annotate a diagram explaining the greenhouse effect from memory. Then in groups, criticise each other's diagrams.