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全球变暖

Global Warming

Sally Morgan

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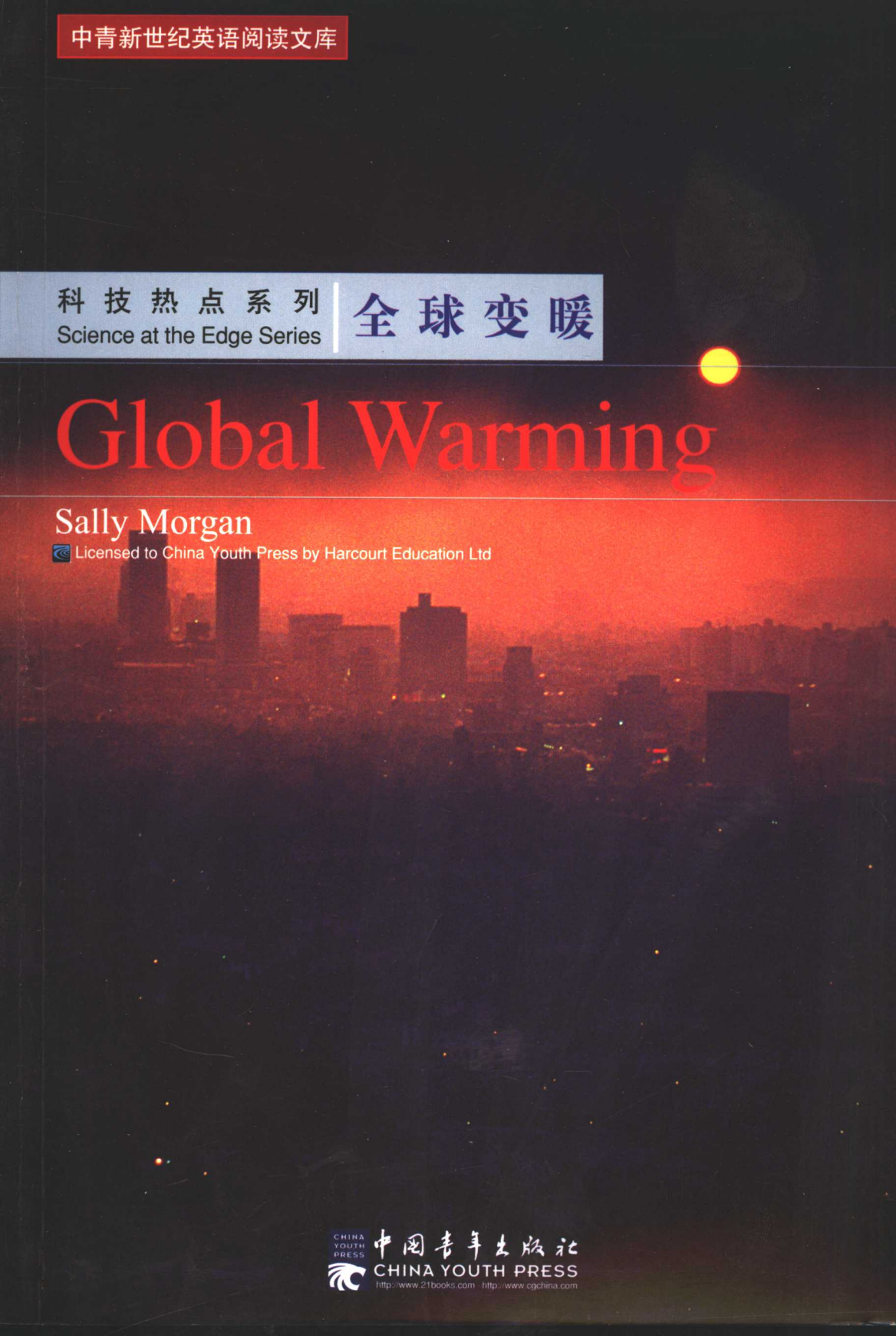

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Contents

Global warming

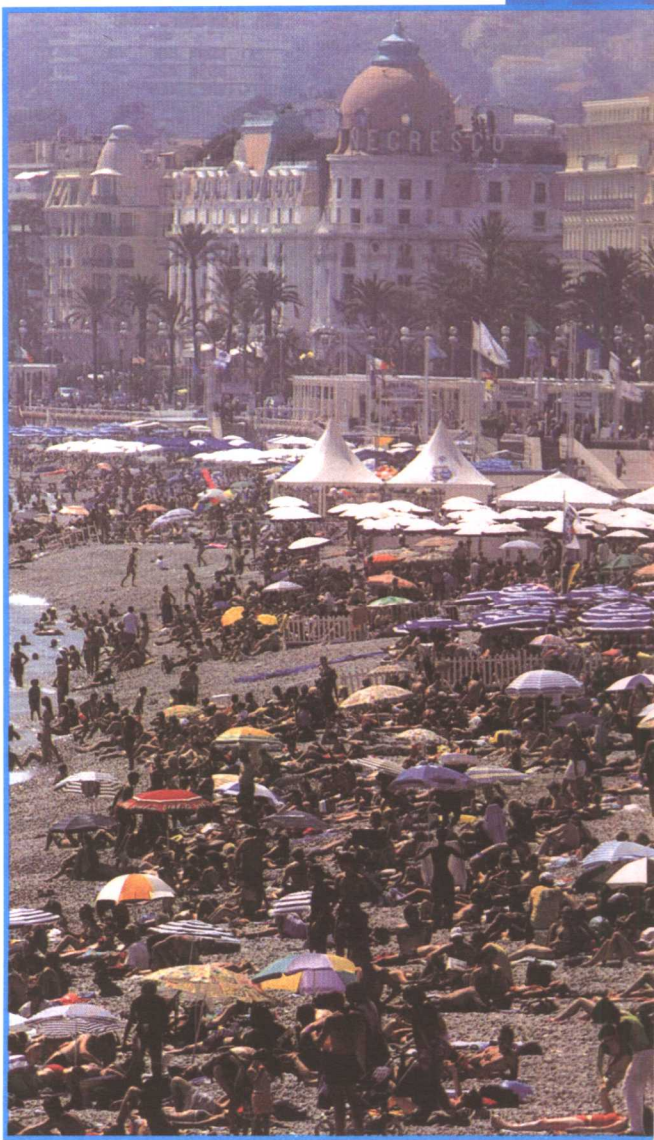
The first year of the new millennium witnessed several unusual weather events. The worst floods in hundreds of years struck Madagascar, Mozambique and southern Africa. Heavy rains also occurred in other places, too. Western Australia experienced record rainfall. The extra-heavy **monsoon** in South and South-East Asia brought floods in which more than 650 people died, and 10 million people were affected in India alone. **Torrential rains** and deadly mudslides **wreaked havoc** in Central and South America in May and June. Later in the year it was no better. There was severe flooding in the Alps, the United Kingdom and France. In contrast, a **scorching** heatwave gripped much of southern Europe during June and July of that year, breaking many records and claiming numerous lives as temperatures soared to 43°C in Greece, Italy, Romania and Turkey.

During 2000 there was extensive flooding in much of Mozambique, including Xai-Xai province shown here, as rivers and streams burst their banks.

The 20th century ended with an average global temperature that was 0.6 degrees Celsius higher than the start of the century. This increase in average global temperature was the largest of any century over the last 1000 years. The year 2000 was the sixth warmest year of a 140-year period dating back to 1860. The warmer years were 1998, 1997, 1995, 1990 and 1999.

Many people believe that the changes in the weather are due to global warming. Global warming is the term used to describe the increase in the average global temperature. The Earth is warming up because certain gases in the atmosphere are on the increase, including **carbon dioxide** and **methane**. Global warming is an issue that affects everybody in the world and it has to be tackled by all countries.

In this book you can learn about the greenhouse effect, the role of the greenhouse gases and why these gases are on the increase. You can find out how the world climate could change as global temperatures increase and what effects these changes may have on plant and animal life, crops and people. In the latter part of the book you can read about how individuals and governments could reduce greenhouse gas **emissions** and start to combat these changes.



The beaches of the Mediterranean are popular with tourists, but in recent years temperatures during the summer have risen above 40°C, threatening the health of visitors.

Is the climate changing?

Climate change is not new. During the last Ice Age that ended about 10,000 years ago, average global temperatures were five or so degrees Celsius below those of today. The end of the Ice Age was marked by a period of relatively rapid warming, bringing the world's average temperature to a level similar to that of today, that is 15°C. For the last 10,000 years, average global temperatures have not varied by much more than a degree either side of 15°C.

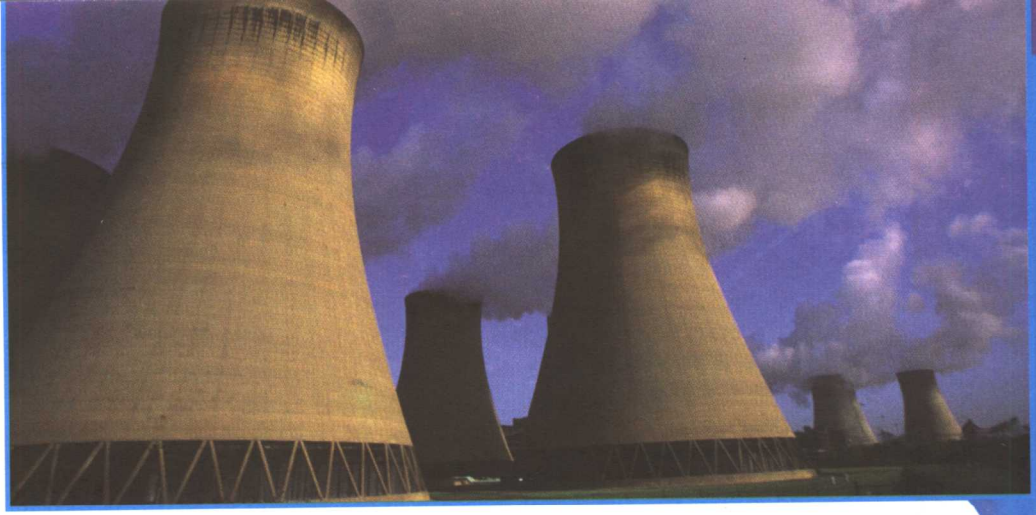
Two thousand years ago, Greenland was much warmer than today and it was covered by lush vegetation, giving the area its name. Then the climate became cooler, the vegetation was lost and the ice sheet extended over the land. Between 1430 and 1850, northern Europe experienced a 'Little Ice Age'. During this time, the climate was much colder and crops failed. There were widespread food shortages and starvation.

Britain experienced some of its coldest winters during the 1810s and 1820s. The River Thames froze regularly and Frost Fairs were held on its icy surface. The year 1816 was described as the year without summer, with frosts in June and disastrous crop failures.

Rising temperatures

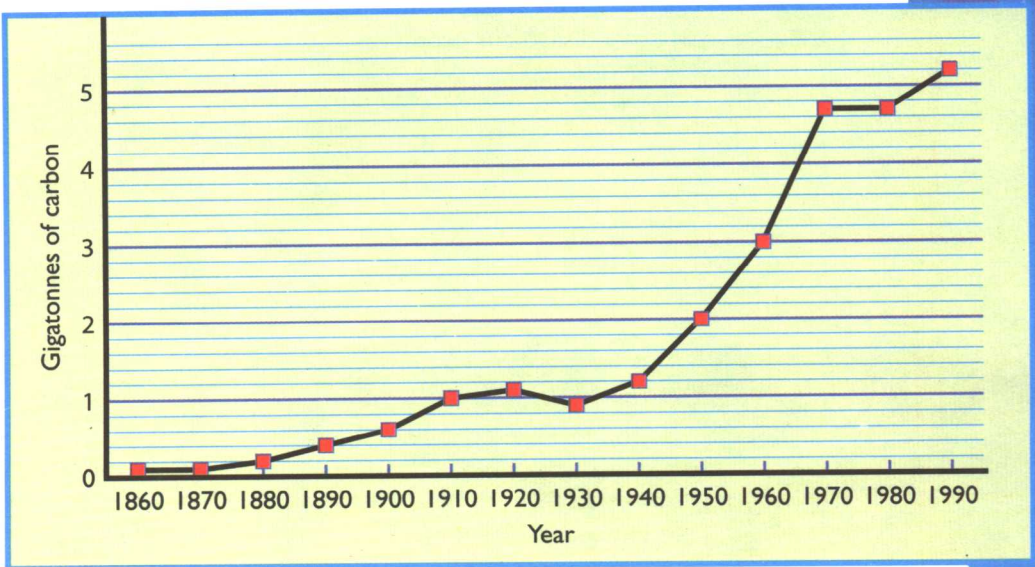
Although there have been temperature **fluctuations** in the past, a definite upward trend is emerging. Continuous records dating back 140 years show that the 1990s was the warmest decade on record. The warmest years on record are, in descending order, 1998, 1997, 1995, 1990, 1999 and 2000.

This rise in global temperatures has led scientists to believe that something is causing the climate to change. The most likely cause is an increase in the quantities of greenhouse gases in the atmosphere. These gases trap heat in the atmosphere, and as they increase in concentration they cause the global temperatures to increase. This increase is called global warming.



Modern power stations can burn coal, gas or oil to generate electricity. A network of **pylons** and cables carry the electricity to the consumer.

Since the beginning of the Industrial Revolution, about 250 years ago, increasing quantities of fossil fuels have been burnt. When these fuels burn they release carbon dioxide, a greenhouse gas. The rise in the use of fossil fuels has been accompanied by an overall increase in global temperatures.



This graph shows the global increase in fossil fuel use from 1860 to 1990. The trend is still rising.

Looking for evidence

Just over ten years ago, the idea of global warming was mostly theoretical – the evidence for it was still unclear. Many governments decided not to take any action until there was real evidence. In 2001 the Intergovernmental Panel on Climate Change (IPCC), which had been set up by the United Nations, published its latest report. This stated that the trend towards a warmer world had begun. Its scientists had analysed data going back hundreds of years on everything from air and water temperatures to the distribution of plants and animals. They found that this warming had an impact on more than 400 different processes, both physical and biological, on all continents. The panel concluded that the significant increase in the temperature of the world was linked to human activity.

The ice sheet of the Arctic is breaking up earlier than normal in spring every year. This affects the shelters used by polar bears and **hampers** their hunting activities.

Today there is a wealth of evidence for global warming:

- measured increases in average temperatures
- changing rainfall patterns
- rising sea levels
- **glaciers** thinning and **retreating**
- **coral reefs** dying as the oceans become warmer
- more frequent droughts in Africa and Asia
- **permafrost** (the permanent frozen ground) melting in the Arctic
- lakes and rivers that freeze in winter **thawing** earlier each year
- plants and animals shifting their ranges towards the poles and to higher altitudes
- disrupted migration patterns for animals, such as whales and polar bears.

These observations are undeniably pointing to a changing climate. One drought or **freak** weather event may not be caused by global warming, but the sheer number of events suggests that it is real – it is happening.

The Kyoto Protocol

In recent years, the word 'Kyoto' has been linked with global warming and international climate negotiations. It refers to an international meeting in the Japanese city of Kyoto in 1997, when governments agreed to make cuts in their greenhouse gas emissions. **The Kyoto Protocol** affects those developed industrial countries that are responsible for creating most of the greenhouse gas emissions. These industrial countries have been asked to limit or reduce their greenhouse gas emissions.

Intergovernmental Panel on Climate Change (IPCC)

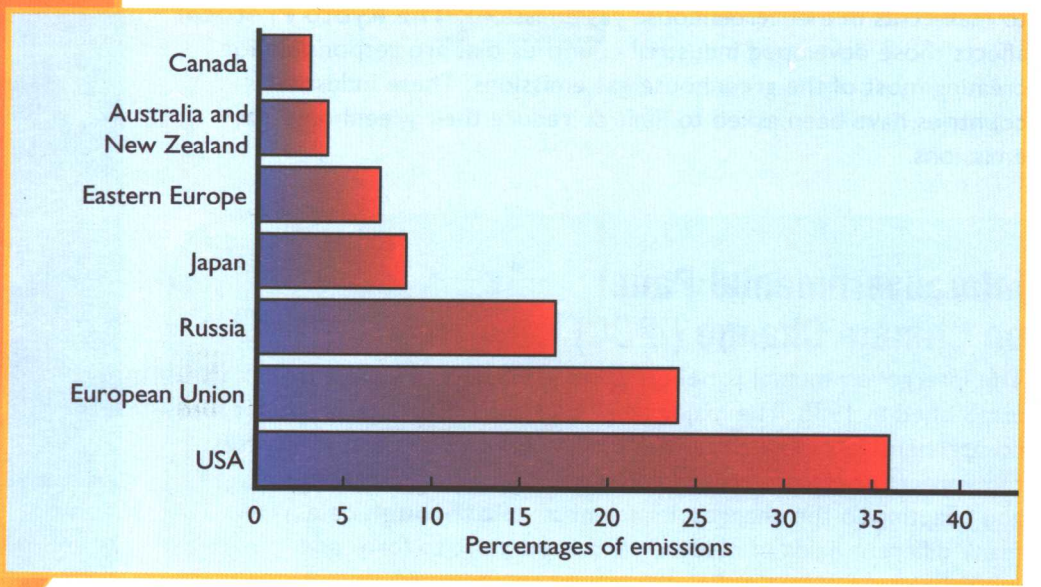
The Intergovernmental Panel on Climate Change (IPCC) was established in 1988. The major activity of the IPCC is to prepare a comprehensive report of climate change every five years. It assesses the impacts of climate change and works out ways of combatting and adapting to the changes. Its scientists **sift through** data from many different fields of research and combine it to form one overall picture. What makes the report so authoritative is that it combines the work of many experts from a wide range of backgrounds and countries.

Overall, this would require a total cut of at least five per cent from 1990 levels by the year 2012. The individual targets range from eight per cent for the European Union and seven per cent for the USA, to a ten per cent increase for Iceland. (This means that emissions in Iceland can increase by ten per cent and still be within the agreed limits.) Although the terms were drafted in 1997, the targets do not have to be met until 2012. However, US emissions are predicted to increase by more than 20 per cent by then, which means a real cut of 27 per cent is needed to meet the US target.

Negotiations continued until 2001, when 180 governments (with the exception of the USA) finally agreed to bring the Protocol into force. Unfortunately, the rules for implementing the targets were relaxed. Many organizations, such as the World Wide Fund for Nature, feel that the Protocol is too weak to have any noticeable effect and will be difficult to police. However, it is a step in the right direction and shows that governments can reach agreement on this international problem.

'The US, the country with the greatest output of emissions that cause global warming, would bear a heavy responsibility for casting doubt on an accord unanimously approved by the international community.'

Dominique Voynet, French Environment Minister



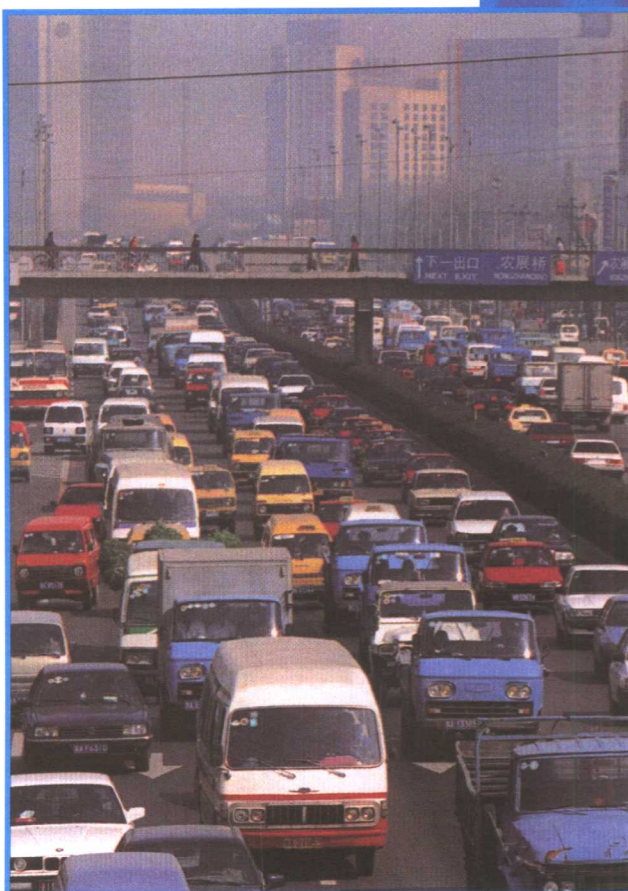
This bar chart shows the percentages of global carbon dioxide emissions from industrialized countries in 1990. The rest of the world combined contributes only two per cent of the total emissions.

Just a fluctuation?

There is a body of scientists who do not believe that global warming is happening, or who believe that if it is happening, then it is happening at a much slower rate than people think, or is not due to humans. These scientists have interpreted the evidence in a different way. Their evidence against global warming is presented on pages 50–51.

Problems ahead

There are now more than six billion people living in the world and each person has the potential to consume natural resources and energy, and to produce waste and pollution. However, not everybody uses up resources at the same rate. About 800 million people live in economically developed regions, such as Canada, the USA, Europe, Australia and Japan. They consume most of the world's resources and produce the bulk of the pollution and waste. However, there are more people who could be classed as aspiring consumers. These are the people living in fast-developing countries such as China, India, South Korea, Taiwan, Brazil, Mexico and the countries of eastern Europe. Today China has fewer cars than the US city of Los Angeles. If China's car ownership, together with oil consumption, were to match that of the USA, it would need 80 million barrels of oil per day. This is more than the world's 1996 oil output of 64 million barrels of oil per day. When the people of these developing countries increase their purchase of consumer items, such as cars, computers and other electrical goods, there will be a surge in carbon dioxide emissions.



In the recent past, bicycles were the main form of transport in China. Today, traffic jams are commonplace as the Chinese replace their bicycles with cars.

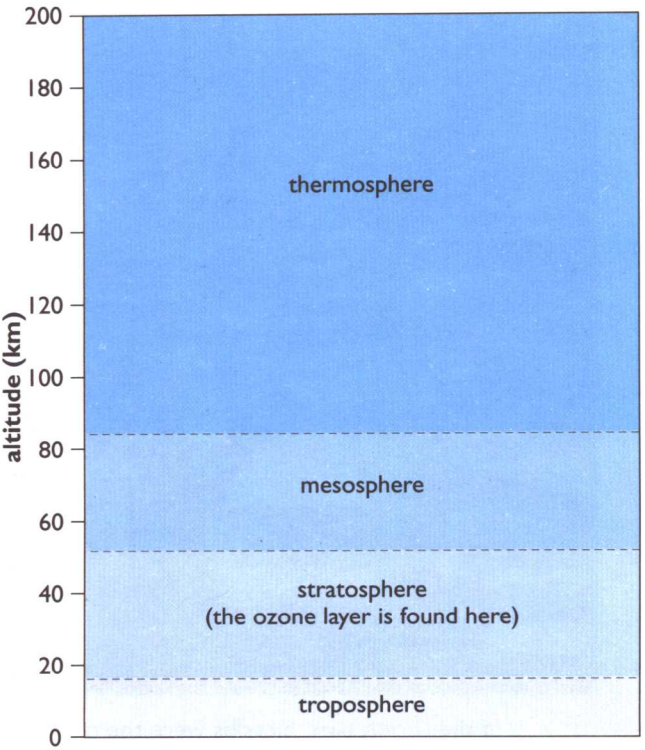
A greenhouse world

The greenhouse effect

The greenhouse effect is a natural process that keeps the Earth at a temperature that is suitable for life. It is created by gases in the atmosphere that absorb heat. Without the greenhouse effect, the surface of the Earth would be about 30 degrees Celsius cooler than it is today. The problem is that the greenhouse effect is getting stronger.

The atmosphere

The atmosphere is a relatively thin layer of gases and tiny particles surrounding the Earth. The lower atmosphere, up to an altitude of about 80 km, is made up of mostly **nitrogen** and oxygen with smaller quantities of ten other gases. Above 80 km the quantities of the gases other than oxygen decrease, and by 150 km the atmosphere is mainly oxygen.



Closest to the ground is the troposphere, which extends to about 18 km. This is the layer that contains all the weather. Above this layer is the stratosphere, which is a calm, sunny layer. The **ozone** layer is found here. The ozone absorbs **ultraviolet radiation** from the sun. The next layer, the mesosphere, starts at about 55 km and extends to about 80 km. The outermost layer is called the thermosphere.

Source of energy

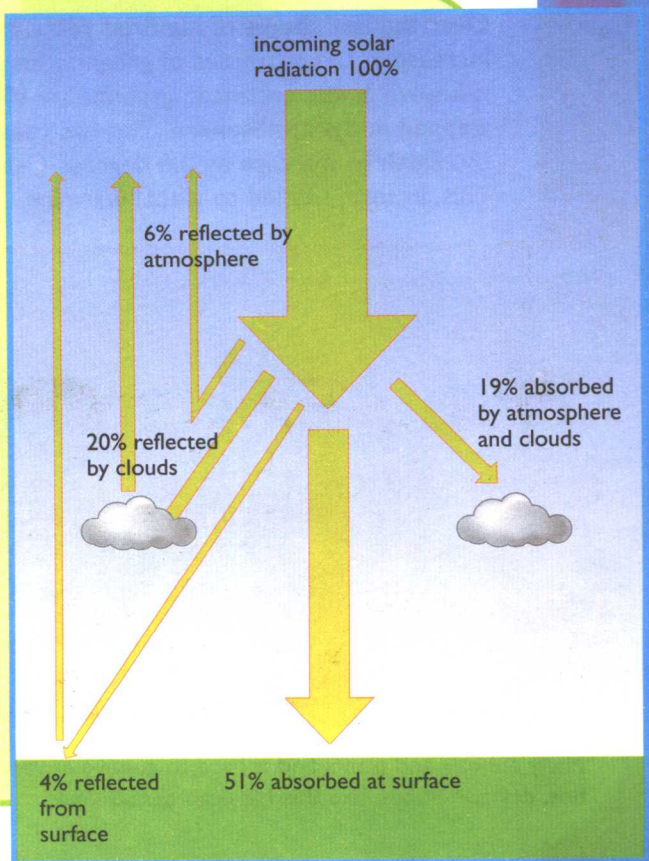
The Sun has been radiating energy for billions of years. Its energy, in the form of radiation, travels as waves through space. Travelling at the **phenomenal** speed of 300,000 kilometres every second, the radiation reaches the upper part of the Earth's atmosphere in eight minutes. Some of this radiation is reflected back into space by clouds and by particles in the atmosphere or is absorbed by gases in the atmosphere. Some is reflected from the Earth's surface, while the rest, about half the total incoming radiation, is absorbed by the Earth's surface. This has the effect of warming the atmosphere and the ground.

As the ground gets warmer, it radiates heat back into the atmosphere. Some of it is absorbed, scattered and reflected by clouds and gases in the atmosphere and this slows down the rate at which heat is lost from the atmosphere. The rest is lost to space. The warming of the atmosphere in this way is called the greenhouse effect and the gases that absorb the radiation are called greenhouse gases.

Radiation

Almost everything and everybody, including the Sun, radiates energy. The Sun emits mostly ultraviolet and visible light. Hot objects on the Earth emit mostly **infrared radiation** and some visible light. For example, when an electric fire is switched on it is possible to feel the infrared heat before you see the elements glowing (visible light). As the elements get hotter, they emit more light and become redder.

The diagram on the right shows how the incoming radiation from the Sun is absorbed and reflected.



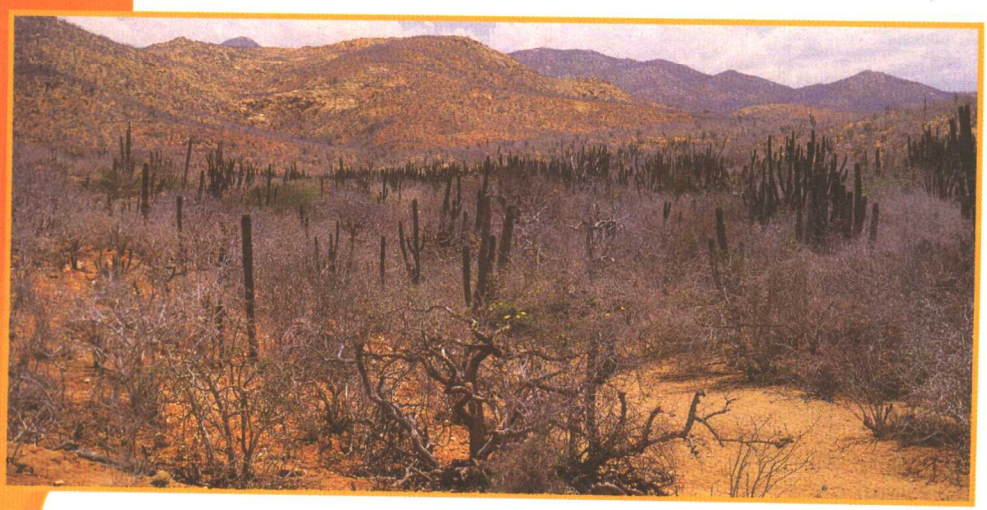
Essential for life

The greenhouse effect is essential, for without the heat-absorbing capabilities of the greenhouse gases the Earth's temperature would be about -17°C. This is far too low to sustain life as we know it – most plants and animals would be unable to survive. Fortunately, however, the presence of gases, such as carbon dioxide, methane and water vapour, in the atmosphere means that the Earth's average temperature is about 15°C.

The ability of the atmosphere to retain heat means that the temperature range between day and night and over the year is small. The narrow range is important for living things as they cannot tolerate big changes in temperature. For example, plants stop **photosynthesizing** when the temperature rises above 40°C and when it falls to freezing. Mammals, too, although they can regulate their body temperature, find it difficult to live in the extremes of temperature experienced in the polar regions and in hot deserts.

Getting warmer

Over the last couple of hundred years, human activities have led to an increase in the quantities of greenhouse gases in the atmosphere. This is known as the enhanced greenhouse effect. More heat has been trapped in the atmosphere. This has caused the average temperature of the Earth to increase by 0.6 degrees Celsius over the last 100 years. This, in turn, has led to global warming.



Many animals and plants find it hard to survive in very hot, dry conditions, like this Mexican **scrub** land.

The greenhouse gases

There are a number of different greenhouses gases in the atmosphere, including water vapour, carbon dioxide, methane, **nitrous oxide** and **chlorofluorocarbons** (CFCs – see page 19). These gases differ in their concentration, in their effectiveness at trapping heat and in the length of their lifetime. Water vapour is present in huge quantities in the atmosphere and is the most effective greenhouse gas of all. However, its concentration in the atmosphere is not directly affected by human activities.

Global warming potential

The gases differ in their effectiveness or global warming potential (GWP). Carbon dioxide is given a GWP of 1, making it easy to compare its effect with other gases. For example, a molecule of CFC-11 has a GWP of 3400. This shows that it is thousands of times more effective at absorbing heat than a molecule of carbon dioxide. So, scientists need to know both the concentration of a gas in the atmosphere and its GWP. The concentration of CFCs in the atmosphere is very small compared with carbon dioxide. But each CFC molecule is thousands of times more effective in absorbing heat.

Greenhouse gas	Atmospheric concentration (parts per million by volume)	Rate of increase (% per year)	Global warming potential (GWP)	Lifetime (years)
carbon dioxide	355	0.5	1	120
methane	1.72	0.6–0.75	21	10
nitrous oxides	0.31	0.2–0.3	206	132
CFC-11	0.000255	4	3400	55
CFC-12	0.000453	4	7100	116

This table lists the main greenhouse gases, their concentration in the atmosphere, the rate at which they are increasing and their global warming potential.

*'There is at the moment no obvious mechanism that will slow, stop or otherwise **deflect** the warming, short of stabilization of the composition of the atmosphere by human action.'*

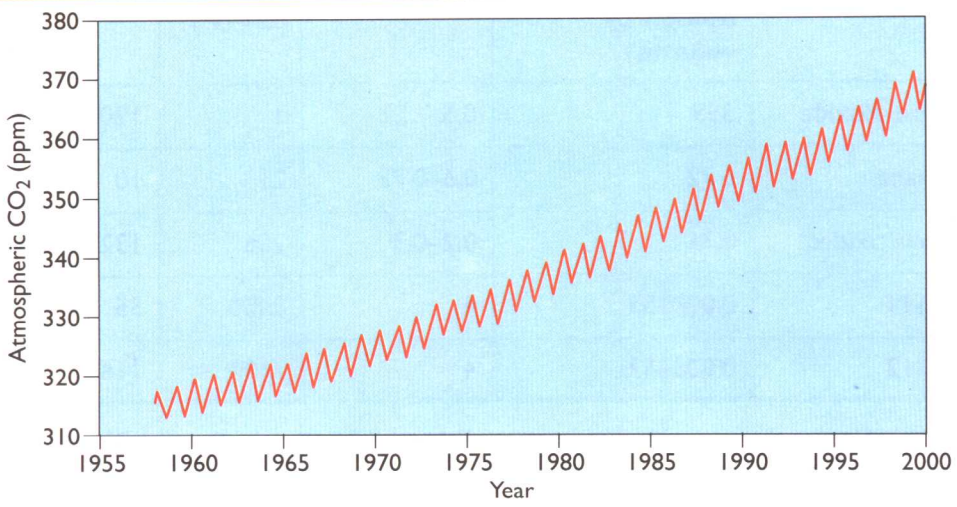
George M. Woodwell, Director of the Woods Hole Research Center, USA

Carbon dioxide

Carbon dioxide is probably the most important greenhouse gas. Before 1750 its concentration in the atmosphere was 280 parts per million (ppm). Today, that figure has risen to 355 ppm. The present carbon dioxide concentration has not been exceeded during the past 420,000 years. The current rate of increase is **unprecedented** during at least the past 20,000 years.

About three-quarters of the emissions of carbon dioxide due to human activities over the past 20 years comes from the burning of fossil fuels. Fossil fuels – coal, gas and oil – are the ancient remains of plants and animals, and they take millions of years to form. When they are burnt, they release heat together with carbon dioxide and water vapour. Fossil fuels have many uses, for example to power vehicles, heat homes and businesses and power factories. Since 1990, nearly half the total increase in global carbon dioxide emissions has come from the USA, exceeding the combined growth in emissions from China, India, Africa and Latin America. By 1997, the USA was responsible for about one-fifth of total global greenhouse gas emissions.

The remaining emissions of carbon dioxide come from changes in land use, especially **deforestation**. Over the last 30 years, deforestation has steadily increased. The burning of forests, especially rainforests, adds carbon dioxide to the atmosphere, as does the burning of firewood.



This graph shows the rise in atmospheric carbon dioxide levels over the last forty years, recorded at a scientific monitoring station in Hawaii, in the Pacific.