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Global warming – Fact, Fiction and Myth

The islanders of Kiribati in the Pacific Ocean were televised watching the first dawn of the new millennium, and a world linked by satellite technology saw a unique sight. For it is predicted that by the start of the next century the small, low-lying islands of this Pacific nation will have all but disappeared, so there will be no 22nd-century celebration in 2099.

Kiribati belongs to the Alliance of Small Island States (ASOIS), which was formed to highlight the plight of developing nations prone to inundation by the sea over the next 100 years. Some 50 million people world-wide could be affected by rising sea levels.

Data show that the last 10 years were the hottest of the 20th century, with 1999 1.25°C warmer than the long-term average. What new changes will the 21st century hold?

Global warming, or the greenhouse effect

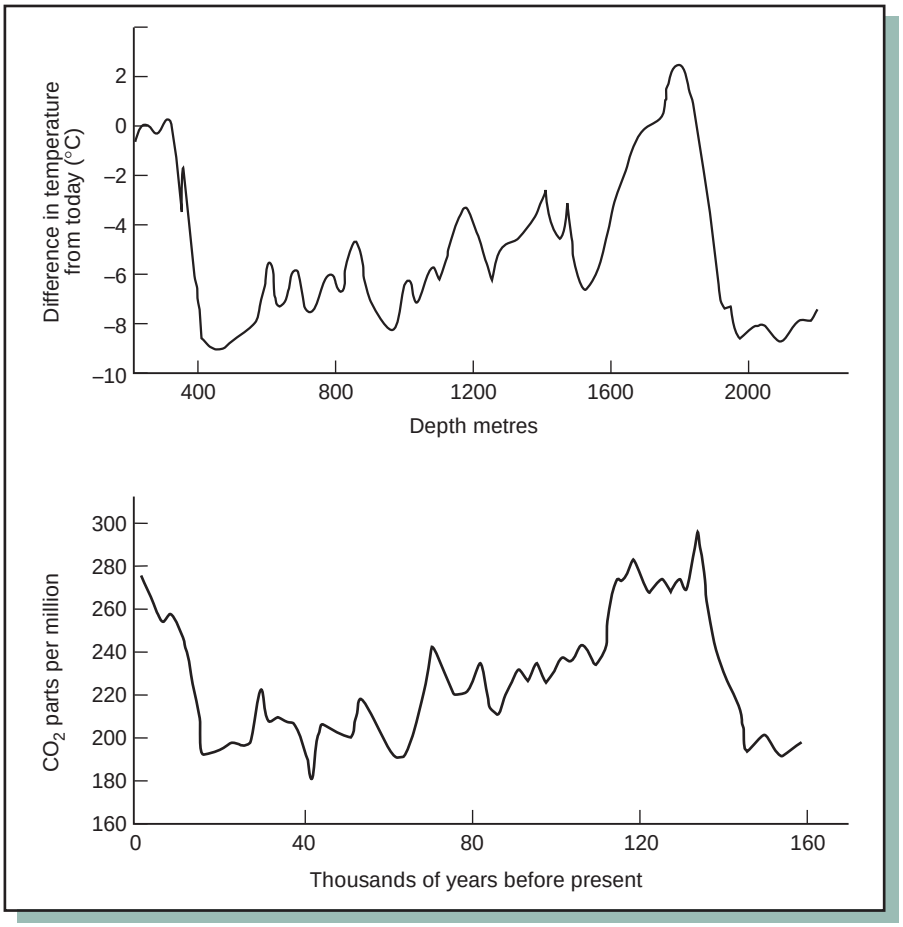
'Global warming' and the 'greenhouse effect' are terms which the media interchange freely.

The greenhouse effect is a natural phenomenon that facilitates a life-sustaining average temperature of 15°C for the earth's lower atmosphere. Scientists looking at the atmospheric composition of the other planets have deduced that a group of gases are responsible for trapping heat. These 'greenhouse gases' – water vapour, carbon dioxide, methane, ozone – constitute a small but important percentage of the gases in the earth's atmosphere.

How the greenhouse effect works

About 30% of the sun's radiation is reflected back into space by surfaces which are highly reflective or have a high albedo, e.g. ice, snow, clouds. Short-wave radiation is absorbed by the earth's surface. Longer-wave infrared radiation is then emitted and is absorbed and re-emitted by greenhouse gases. This re-emission of heat warms the lower layers of the atmosphere and the earth's surface.

Figure 1: Comparison of surface air temperatures and CO_2 levels over the past 160,000 years from Vostok Antarctic ice core



Source: adapted from *Geography Review*, May 1995, p.6

Without greenhouse gases in the atmosphere, the earth would be a hostile, cold and lifeless world.

Until the 19th century the rates of photosynthesis from plants consuming carbon dioxide and producing oxygen, and respiration by animals burning oxygen in their bodies and producing carbon dioxide, had been in balance, maintaining carbon dioxide levels at around 0.03%. Over the past 150 years this balance has began to change, and carbon dioxide levels are predicted to rise to 0.09% by 2100. Methane (CH_4) has also increased as rice production and cattle numbers have risen. It is this disruption of the carbon cycle or budget that is largely responsible for the 'enhanced greenhouse effect', or global warming. Figure1 shows the close correlation between global temperatures and carbon dioxide levels in the atmosphere.

Past climatic changes

During the earth's warmer periods the heavier oxygen 18 isotope was more prevalent in precipitation than the lighter oxygen 16. Under the right conditions, this precipitation has become part of ice caps such as those in Greenland and Antarctica. The balance of the two oxygen isotopes in the ice is therefore an indicator of the general temperature at the time of precipitation.

Ice cores and sediment cores can also provide data on the quantities of carbon dioxide, nitrous oxides and volcanic dust, present in the atmosphere. Analysis of these cores has linked the oscillations in the earth's climate to 20,000, 40,000 and 100,000-year cycles of the earth's orbit around the sun, called Milankovich cycles. Milankovich cycles are thought to have been the main cause of the ice ages over the

past two million years. Figure 2 shows fluctuations in temperature from the global average over the past 8,000 years, including the 'Little Ice Age'.

A rapid rise in temperature just 10,000 years ago ended the last glacial stage, and at present around 10% of the earth's surface is ice-covered. At the peak of the last glacial stage temperatures over land were 8–15°C lower than at present, but the rise to interglacial temperatures took only a few hundred years, proving that dramatic temperature changes can occur in relatively short periods of time.

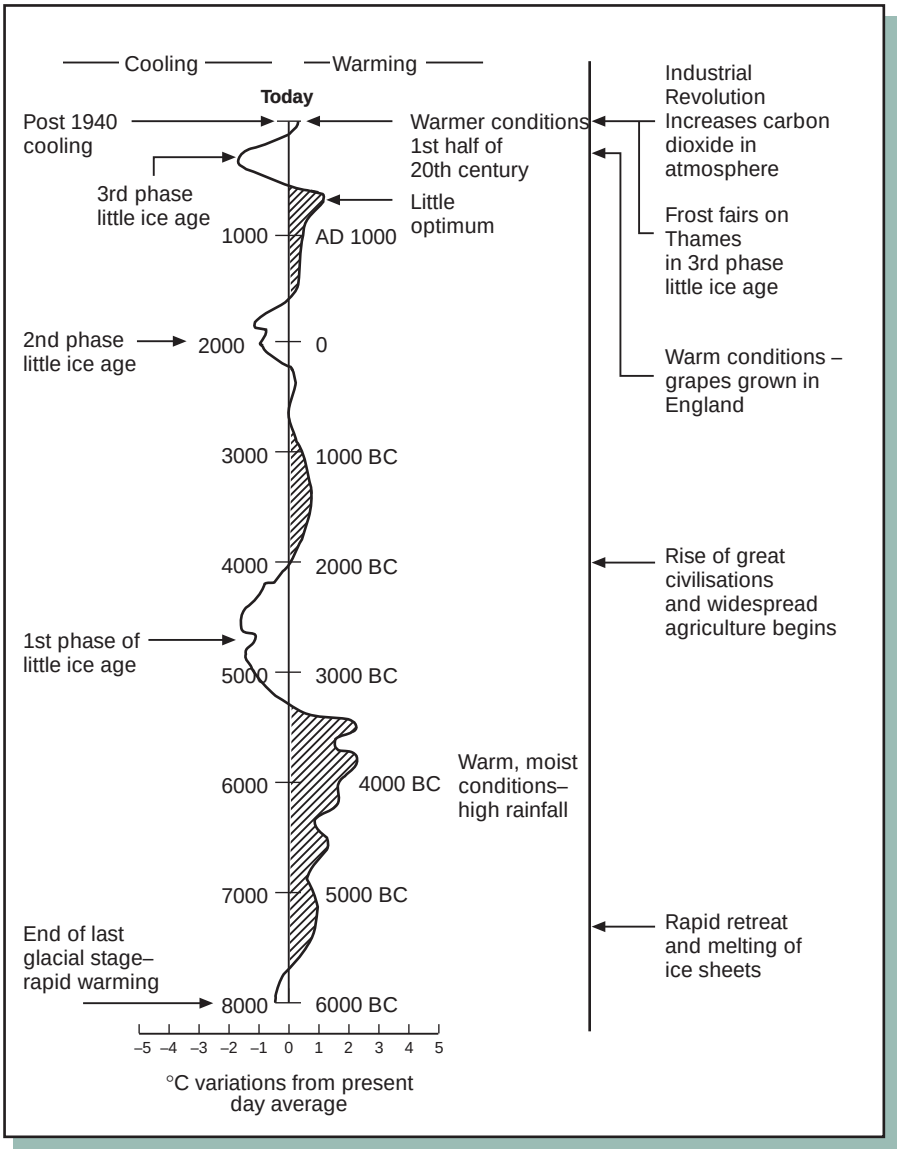
Temperatures over the past 1000 years in Europe have seen alternating periods of warmer and colder temperatures. The 'Little Ice Age' from 1430 to 1850 was a sustained period of cooler weather – on average, 2°C cooler than today. There is a school of thought that says that if industrial carbon dioxide had not been released into the atmosphere, then the world could have been due for its next big freeze (Figure 2).

Human activity and emissions

At the 1992 Rio Earth Summit, developed countries including the United Kingdom made a voluntary agreement to reduce carbon dioxide emissions to 1990 levels by 2000. The 1997 Kyoto Protocol, which was ratified by 174 parties, invokes a binding commitment on the part of developed counties to reduce their six principal greenhouse gas emissions to 5.2% below their 1990 levels over the period 2008–2012. The six named gases are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorcarbons and sulphur hexafluoride; these are in order of GWP (global warming potential).

In Britain, for example, some 28 million tonnes of carbon dioxide is released every year by road transport, and a further 1 million tonnes is generated by rail transport.
The Kyoto Protocol does not apply to countries classed as developing, although some of these are trying to reduce emissions. The USA produces 25% of the world's greenhouse gases, and has previously been reluctant to commit to any targets. However, the

Figure 2: Temperature trends over the past 8,000 years



Source: adapted from *Environment and People*, Stanley Thornes, p.150

Figure 3: The principal greenhouse gases

Gas	Increase % annum	Years in Air	% of Greenhouse effect
CO_2	0.5	7	50
Methane	1	10	18

American government has now agreed to a cut of 7%.

> 'This treaty will have a devastating impact on the American economy. This treaty will do nothing to help the environment because it lets developing nations that will be the world's largest emitters of greenhouse gases ... completely off the hook.'
>
> US Senator Chuck Hagel

EU countries are also committed to a 7% cut, but some countries have been allowed an increase, to sustain their economic development (Australia, for instance, is permitted a 10% increase). It is unlikely that many developed countries will achieve the targets of the Protocol. The Inter-Government Panel on Climate Change says that even to just keep Greenhouse gas emissions at double their pre-industrial levels will require a world-wide reduction of 60–70% by 2100.

Evidence for global warming

- 10–25cm rise in sea levels during the 20th century.
- 0.3–0.6°C rise in global temperatures since late 19th century.
- 0.2–0.3°C rise in past 40 years.
- Diurnal temperature range has reduced over 40% of the land's

surface, due to increased insolation caused by increased cloud cover.

Figure 4 shows changes in average global temperatures over the past 130 years, including the post-1940 cooling, when a new ice age was predicted, and also the warmest era this century, from the late 1980s.

Evidence from the poles

- NASA has measured shrinkage of Arctic pack ice at 2.9% per decade.
- It has thinned from 3.1m to 1.8m in a decade.
- A 2.5°C rise in temperature since the 1940s has lengthened the annual melt season in Antarctica by 2–3 weeks.

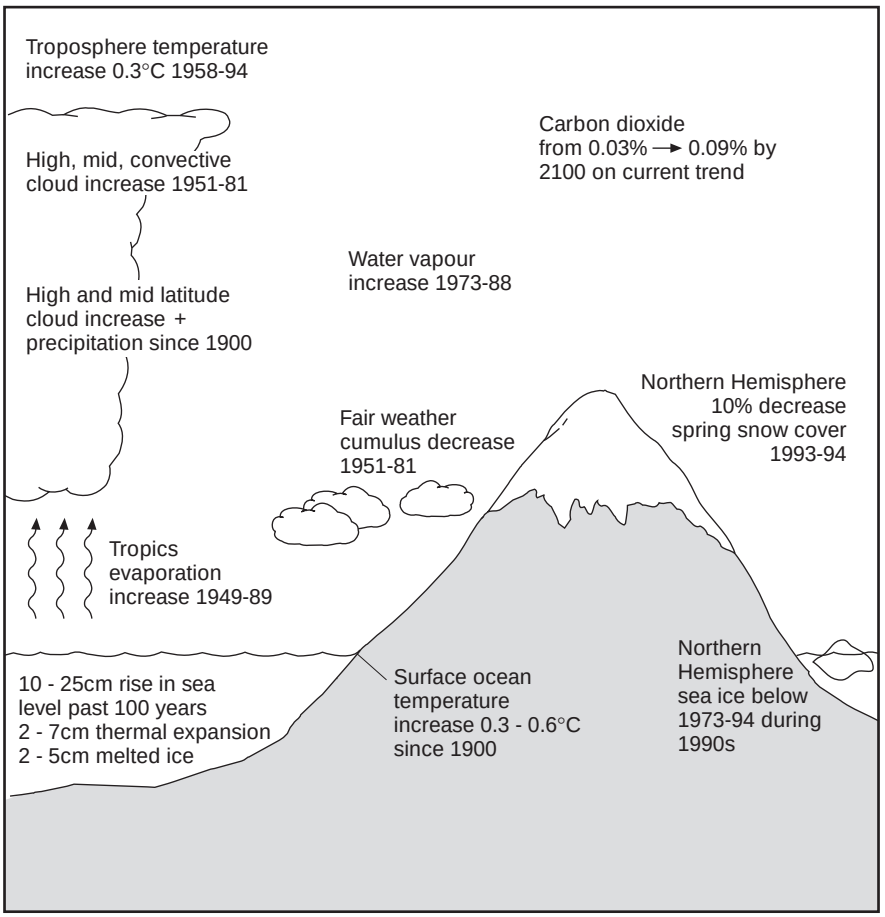
Predictions and myths

It is difficult to make accurate predictions as to the consequences of global warming; scientific data and research are often misinterpreted by the media and public, which causes wide-ranging viewpoints. Extensive research is being undertaken by organisations such as the Climatic Change Unit at the University of East Anglia, the British Antarctic Survey and the United Nations Intergovernmental Panel on Climatic Change (IPCC) to firm up predictions, dispel myths and prepare for the changes that will happen.

Predictions

- Average global temperature rise of 1.5–4°C over the next century.
- By 2050, carbon dioxide levels will have doubled from pre-industrial times.
- 50 cm rise in average sea levels by 2100.
- Extra 50–80 million cases of malaria/year worldwide.

Figure 5: Identified changes in atmospheric and hydrological characteristics



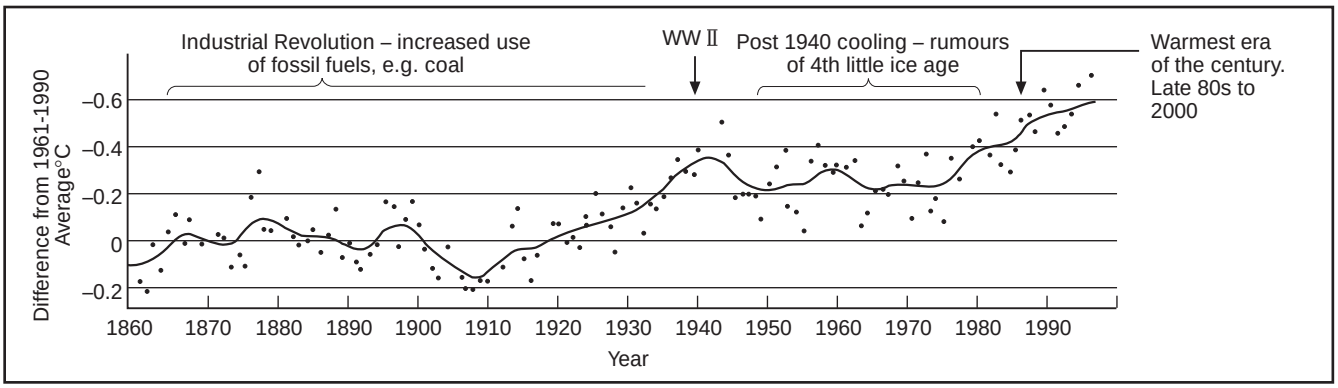
Source: Adapted from IPCC *Climate Change* (1995)

- World vegetation zones will change, affecting agriculture. African yields of millet, the main staple food, will decline by 63–79%, leading to famine.
- Millions of people will be displaced by coastal flooding, erosion and drought. Major coastal cities, including New York and London, will be at higher risk from flooding.
- Rainfall will become more unpredictable and more uneven.
- Britain may receive 20% more rain, but also higher sun hours as the weather patterns change to give more downpours. 2000 miles of Britain's rivers will be become flood risk areas.
- More severe weather events and extremes of climate will occur, as there will be more energy in the atmosphere, creating more violent convection, winds and pressure differences.

Dispelling myths

- **Myth: The warming will be uniform; everywhere will be warmer.**
  Some places may be cooler; e.g. the south-eastern states of the USA have cooled, and the UK could become

Figure 4: Annual average global temperature anomalies



Source: adapted from Environment Agency material; University of East Anglia

cooler if the Gulf Stream is diverted by cool polar water from melted pack ice.

- **Myth: Sea level rises due to melted polar ice.**
  When it melts, pack or sea ice only takes up the volume of water it displaced previously. Land ice adds volume to sea, but it is principally thermal expansion due to higher temperatures which causes the sea level to rise.
- **Myth: 80m sea level rise is inevitable.**
  Unlikely; this would only happen if all the Antarctic ice sheets melted. At present they are still protected from the warming affects of the sea by sea ice. It would take up to 4,000 years for the Antarctic ice sheets to melt totally.
- **Myth: Global warming is caused by the hole in the ozone layer.**
  Global warming is caused by the trapping of re-radiated energy by greenhouse gases such as carbon dioxide. No direct evidence has been found that suggests that the hole in the polar ozone layer is causing global warming, although there will be a greater amount of the sun's radiation entering through the hole into the earth's atmosphere.
- **Myth: The world has never been warmer.**
  During past interglacials the climate has been warm enough for hippos to live in Southern Britain. During the time of the dinosaurs, fossil evidence suggests it was significantly warmer globally than it is now.
- **Myth: Burning forests is leading to a situation of more carbon dioxide in the atmosphere in the atmosphere than oxygen.**
  There is around 20% oxygen in the earth's atmosphere, and currently less than 1% carbon dioxide.

Feedback mechanisms

There are feedback mechanisms within the atmosphere which might possibly either counteract the effects of global warming by natural processes, or enhance the effect further.

- An increase in cloud cover would reflect more of the sun's energy, causing a drop in temperature. Alternatively, it could cause temperatures to rise, by increasing insolation (Figure 5).
- Warming of the atmosphere will increase its capacity to hold water vapour, a principal greenhouse gas, thereby increasing the global warming.
- The circulation of the oceans controls the climate. Significantly, they carry heat from the equator to the poles and act as vast stores of carbon dioxide. They react slowly to changes in atmospheric temperature but have a high heat capacity, acting like a long-term global radiator.
- Increase in snowfall due to increased evaporation may increase the area of ice with a high albedo, therefore reflecting more of the sun's energy.
- Growth of microscopic marine organisms, such as phytoplankton, will accelerate due to increased carbon dioxide levels that will be incorporated into their shells, thereby taking carbon dioxide out of the atmosphere.
- Mountain chains such as the Himalayas create weather systems such as the monsoon; the rain washes the atmosphere of carbon dioxide.
- Volcanic eruptions eject vast quantities of sulphur dioxide, which has a cooling effect on the atmosphere by reflecting the sun's radiation. In 1991, when Mount Pinatubo erupted, the dust cloud cooled the planet by 1°C for several years.

Other influences

Other factors affecting global atmospheric temperature include:

- natural cycles varying the earth's orbit around the sun
- changes in the sun's radiation
- variations in the relative global proportions of land, sea and ice
- tectonic uplift of mountains
- oceanic circulation patterns, e.g. more frequent El Niño events
- variations in sea level

Conclusion

There is little doubt that the earth's atmosphere has warmed dramatically over the past 150 years. There are numerous theories as to how this will affect the global environment. Global warming would seem to be an issue that one can confidently predict will be affecting people's lives long after the 2099 New Year celebrations and Kiribati have been forgotten.

Bibliography

Geography Review, May 1995
Environment and People (Stanley Thornes)
IPCC, *Climate Change* (1995)
Websites of the *Guardian*, *New Scientist*, IPCC and the Environment Agency.

Focus Questions

1. (a) Explain the difference between the greenhouse effect and global warming.
(b) Using Figure 5, summarise the hydrological and atmospheric evidence for global warming.
(c) Discuss the evidence and arguments for and against global warming.

2. (a) Explain what is meant by the term 'feedback mechanism'.
(b) How might feedback mechanisms offset the effects of global warming?

3. (a) How has climatic change effected the natural and human environments in the past?
(b) How will climatic change effect the world in the future?
(c) Assess the likely future effectiveness of the world's nations in tackling the possible problems of global warming.

4. Research task: use the Internet, newspapers and other resources to create a report on the world's environment and climate in 2100.
Useful websites:
www.globalwarming.org
www.ncdc.noaa.gov/ol/climate/globalwarming
www.ipcc.ch/
www.edf.org/pubs/Factsheet/e_GWFact2.html
www.newscientist.com/nsplus/insight/global/faq.html