Climate Change: The Science

Global warming is a result of the 'greenhouse effect', caused mainly by the emission of carbon dioxide into the atmosphere. By ***Allan Abraham***

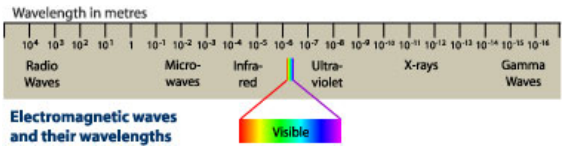
The science involved in climate change centres on the greenhouse effect. Current scientific opinion holds that global warming is caused by the greenhouse effect. Ozone depletion in the stratosphere is believed to play no role, or at most a negligible role, in global warming (see companion article, The Ozone Factor). Since the greenhouse effect is thought to be the main contributor to global warming, this article discusses the science concerning the greenhouse effect.

- It explains the greenhouse effect and the role in it of greenhouse gases.
- It explains the significance of carbon dioxide and fossil fuel combustion in the greenhouse effect and for global warming.

Common sources of human-generated carbon dioxide are discussed in Sources of Carbon Dioxide . Issues related to controlling carbon dioxide concentration in the atmosphere are described in Atmospheric Carbon Dioxide .

The Greenhouse Effect and Greenhouse Gases

The sun radiates primarily visible light and some ultraviolet radiation. Since the atmosphere is largely transparent to radiation in these wavelengths, the sun's radiation easily penetrates to earth. The earth's atmosphere is however, not transparent to infrared radiation, which is what the earth's surface radiates back. [Footnote 1] So the temperature of the earth rises because of the infrared radiation trapped by the atmosphere. This is similar to what happens in a greenhouse or a car parked in sunlight. The glass of the greenhouse or car allows in visible light and ultraviolet radiation but traps the infrared radiation emitted by the objects within the greenhouse or car. In the case of the earth, it is the atmosphere that behaves like the glass of the greenhouse.



Electromagnetic waves and their wavelengths

Infrared radiation emitted by the earth is trapped by the atmosphere because the radiation is absorbed by certain kinds of molecules in the atmosphere, mostly carbon dioxide and water. Methane, nitrous oxide, and hydrofluorocarbons are other molecules that absorb infrared radiation. These gases in the atmosphere are therefore referred to as greenhouse gases.

The earth has always had a greenhouse effect. Without it, the temperature of the planet would be –20°C to –30°C. The oceans would have frozen and life would not have survived. Today, however, the greenhouse effect has become more marked because of the increased concentrations of greenhouse gases, especially carbon dioxide, in the atmosphere. Scientists have shown that there is a correlation between the parallel increase in concentrations of greenhouse gases and average global temperatures. See the companion article Climate Change: The Evidence .

Concentrations and Sources of Greenhouse Gases

Globally, carbon dioxide is responsible for more than two-thirds of the absorption of infrared radiation in the atmosphere. Carbon dioxide is produced by the burning of fossil fuels, which are carbon-based. Depending upon the chemical composition of the fuel, different amounts of carbon dioxide are produced per tonne burned and per unit of energy produced. Coal releases the most carbon dioxide per unit of energy produced (0.08kgC/kWh), followed by oil (0.07kgC/kWh), and then gas (0.05kgC/kWh). [Footnote 2] The world uses fossil fuels for its energy requirements. Energy use is discussed in World Energy Use , carbon emissions in

Atmospheric Carbon Dioxide .

Methane is the next most important greenhouse gas. It is released from agriculture, waste, coal mining, and natural gas distribution. In some agricultural economies, methane can account for a significant proportion of total greenhouse gas emissions. For example, methane accounts for 40% of New Zealand's greenhouse gas emissions, and 90% of the methane emissions are produced by the country's sheep and cattle as a byproduct of their digestion.

The other greenhouse gases, produced by a small range of industrial processes and products, are easier to control with technological change than is carbon dioxide. The human influence on water vapour—which is a significant greenhouse gas because it absorbs infrared radiation—is negligible.

It is, therefore, towards the control of carbon dioxide emissions that any strategy to limit global warming must turn.

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24 July 2004.[1] Objects at a temperature of about 15°C, the average temperature of the earth's surface, radiate energy in the infrared range of wavelengths. According to the Stefan–Boltzmann Law, every object above a temperature of absolute zero emits energy.[2] kgC=kg of Carbon; kWh=kilowatt-hours.

SIDEBARS

A Note on Light

Light has both wave and particle nature. In the context of the greenhouse effect, it is the wavelength aspect that is of interest. Three ranges of wavelength are distinguished: the ultra-violet range, the visible range, and the infrared range. The earth's atmosphere is transparent to the first two, but blocks infrared radiation.

SIDEBARS

Water Vapour as a Greenhouse Gas

Water vapour is also a greenhouse gas. The radiation water vapour absorbs, however, is considerably less than that absorbed by carbon dioxide. Furthermore, most of the water vapour in the atmosphere is due to natural cycles that are outside human control. This amount is thought not to have changed significantly over time.

Climate Change at NewScientist.com

NewScientist.com has a good collection of articles on climate change. The FAQ section addresses basic questions. The articles cover current issues in the field.

Climate Change at Guardian.co.uk

The Guardian has an excellent archive of stories on climate change as well as good explanations of the basic science.

IPCC Website

The IPCC website is the most authoritative source of scientific and economic information about global warming. The IPCC is an international group of scientists, economists, and other experts investigating climate change.