



Climate change

It can seem as though human-generated global warming is recent. However, climate science has developed over more than a century, with results identified earlier than many may suspect.

Early experiments

French mathematician Joseph Fourier began investigating Earth's temperature as early as 1807, reporting his findings in the 1824 paper 'General remarks on the temperature of the terrestrial globe and the planetary spaces'. He stated that the atmosphere increases the Earth's temperature by trapping the heat generated by visible light; in other words, the Earth would be cooler if it were not insulated by the atmosphere. By 1836, his compatriot Claude Pouillet had concluded that the atmosphere absorbs radiated heat from the surface more strongly than visible light, explaining this in 'Mémorial on the solar heat, on the radiating and absorbing powers of atmospheric air, and on the temperature of space'.

In 1857, Eunice Foote sealed air in one glass cylinder and carbon dioxide (CO₂) in another; when exposed to sunlight, the CO₂ heated more than air. She commented in 'Circumstances affecting the heat of the sun's rays' that a CO₂ atmosphere would give the Earth a high temperature.

In 1859, unaware of Foote's work, John Tyndall worked on heat radiation through gases, describing his findings in 'Note on the transmission of radiant heat through gaseous bodies'. By 1861, he'd found that water vapour and CO₂ were transparent to light but trapped heat, discussing this in his lecture 'On the absorption and radiation of heat by gases and vapours, and on the physical connexion of radiation, absorption, and conduction'.

OLD NEWS

Quintin Rayer traces the history of our knowledge about global warming, which goes back further than many might expect

Both Tyndall and Foote had identified CO₂ as a greenhouse gas. Tyndall's precise experiments isolated its effect on infrared radiation, and he observed that small changes in CO₂ concentrations would greatly affect terrestrial heating, corresponding to changes in climate.

The theory develops

Swedish scientist Svante Arrhenius explored how increased atmospheric CO₂ concentrations raise surface temperatures for his 1896 paper 'On the influence of carbonic acid in the air on the temperature of the ground', estimating that they would affect global temperatures – and possibly account for long-term climate variations. He even related atmospheric CO₂ concentrations to global coal production. Essentially, he provided the first comprehensive climate change theory

By the 1930s, scientists had noted rising polar temperatures and the retreat of Arctic Sea ice. In his 1938 paper 'The artificial production of carbon dioxide and

its influence on temperature', building on Arrhenius' work, Guy Stewart Callendar concluded: "By fuel combustion man has added about 150,000 million tons of carbon dioxide to the air during the past half century", and estimates that "approximately three quarters of this has remained in the atmosphere". He estimated that "artificial production" of CO₂ was warming the climate by 0.03°C per decade. However, his findings were not widely accepted until further work was completed in 1941.

In his 1956 paper 'The carbon dioxide theory of climatic change', Gilbert Plass calculated the Earth's average surface temperature increase if atmospheric CO₂ concentrations doubled, and commented that CO₂ explained the variations seen during geological history. He observed that recent industrial and other human activities were adding more CO₂ to the atmosphere than natural processes would – large enough to upset the CO₂ balance. He also estimated that human activities were increasing the average temperature by 1.1°C per century. Current rates appear faster, at about 1.6°C per century.

Charles Keeling started collecting data on atmospheric CO₂ concentration in 1957, publishing 'The concentration and isotopic abundances of carbon dioxide in the atmosphere' in 1960. He showed that concentrations were rising at a rate close to that expected from emissions due to global combustion of fossil fuel.

Humanity has thus known about global warming since the 1960s. One must ask why these timely warnings were not acted upon until we were verging on a crisis?

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