

What is Climate Change?

Climate Change is the change in climate over a time period that ranges from decades to centuries. The term refers to both natural and human-induced changes. The term “climate variability” refers to shorter term (years to decades) fluctuations in climate such as those caused by El Niño/Southern Oscillation.

The United Nations Framework Convention on Climate Change defines climate change as: “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods”. In other words, the FCCC uses the term Climate Change to mean only those changes that are brought about by human activities.

Factors affecting global climate

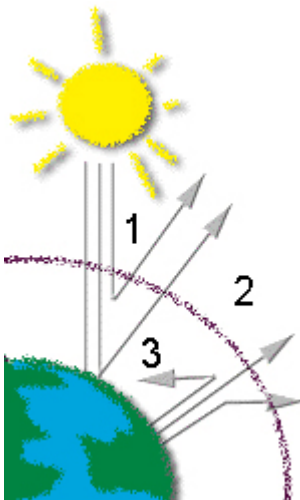
The Earth intercepts the Sun's radiation, which is the energy that drives our weather and climate. About one third of this solar radiation is reflected back into space. The rest is absorbed by different parts of the climate system: the atmosphere, oceans, ice, land and various forms of life.

The Earth then sends its energy out into space, or re-radiates, in the form of long wave radiation. Some of this energy is again absorbed and re-emitted through a process known as the Greenhouse Effect. The rest of the energy is lost to space. There is a delicate long term balance between the outgoing radiation and incoming solar energy. Any change in the factors that affect this process of incoming and outgoing energy, or change the energy distribution itself, will change our climate.

1. Natural Factors

Over the history of the Earth, the climate has changed. The ice ages and intervening warm periods are examples. Some changes are global in scale, while others have been regional or hemispheric. There are a number of natural factors that contribute to changes in the Earth's climate over various time scales. It is important to understand these factors when attempting to detect a human influence on climate:

- **Changes in Solar Output.** The amount of energy radiating from the sun is not constant. There is evidence of an 11-year solar cycle (variation in energy output) in the temperature record of the Earth. Longer period changes may occur as well.
- **Changes in the Earth's Orbit.** Slow variations in the Earth's orbit around the Sun change where and when solar energy is received on Earth. This affects the amount of energy that is reflected and absorbed. These orbital variations are believed to be a factor in initiating the ice ages.
- **The Greenhouse Effect.** When energy from the sun enters the Earth's atmosphere, about a third of it is reflected back to space. Of the rest, the atmosphere absorbs some, but most of it is absorbed by the surface of the Earth. The Earth emits energy at longer wavelengths. Some of this energy escapes to space but some of it is absorbed again and re-emitted by clouds and greenhouse gases such as water vapour, carbon dioxide, methane and nitrous oxide. This helps to warm the surface and the troposphere (lowest layer of the atmosphere), keeping it 33 °C warmer than it would otherwise be. This is the natural Greenhouse Effect, and vital to life as we know it.



Solar energy enters the atmosphere: some is reflected. This energy is absorbed by the Earth and reradiated back to space at longer wavelengths. Greenhouse gases absorb this energy and reradiate much of it back to the surface, much like an insulating blanket.

- **Aerosols.** These are very fine particles and droplets that are small enough to remain suspended in the atmosphere for considerable periods of time. They both reflect and absorb incoming solar radiation. Changing the type and quantity of aerosols in the atmosphere affects the amount of solar energy reflected or absorbed.

2. Human Factors

Enhancing the Greenhouse Effect: Naturally occurring greenhouse gases (e.g. water vapour, carbon dioxide, methane, nitrous oxide) keep the Earth warm enough to support life. Scientific studies show that a variety of human activities release greenhouse gases. These include the burning of fossil fuels for producing electrical energy, heating and transportation. By increasing their concentrations and by adding new greenhouse gases like CFCs, humankind is capable of raising the average global temperature.

Land Use Change: As humans replace forests with agricultural lands, or natural vegetation with asphalt or concrete, they substantially alter the way the Earth's surface reflects sunlight and releases heat. All these changes also affect regional evaporation, runoff and rainfall patterns.

Atmospheric aerosols: Humans are adding large quantities of fine particles (aerosols) to the atmosphere, both from agriculture and industrial activities. Although most of these aerosols are soon removed by gravity and rainfall, they still affect the radiation balance in the atmosphere. Whether this effect adds to or offsets any warming trend depends on the quantity and nature of the particles as well as the nature of the land or ocean surface below. The regional effects, however, can be significant.

Greenhouse Gases

Most greenhouse gases occur naturally. However modern industry and lifestyles have led to new sources of greenhouse gases, as well as to the emission of entirely new greenhouse gases. Among the most important greenhouse gases are:

Water Vapour

Water vapour comes from natural respiration, transpiration, and evaporation. The amount of water vapour stored in the atmosphere increases as the Earth's surface temperature rises.

Carbon dioxide (CO₂)

Carbon dioxide comes from the decay of materials, respiration of plant and animal life and the natural and human-induced combustion of materials and fuels. It is removed from the atmosphere through photosynthesis and ocean absorption.

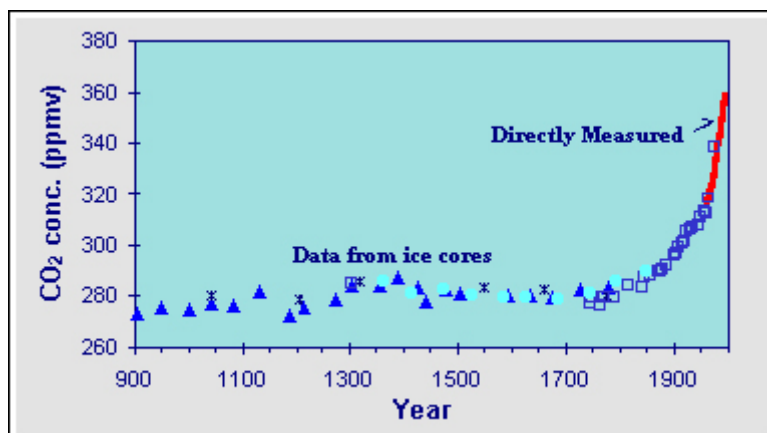


Figure 1: Trends in CO₂ Concentrations (Past 1000 years)

Methane (CH₄)

Although there is less methane than carbon dioxide in the atmosphere, methane is a more effective heat-trapping gas. It comes from the decay of matter without the presence of oxygen. Primary sources include wetlands, rice paddies, animal digestive processes, fossil fuel extraction, and decaying garbage.

Nitrous oxide (N₂O)

Soils and oceans are the primary natural source of nitrous oxide. Humans contribute through soil cultivation and use of nitrogen fertilizers, nylon production, and the burning of organic material and fossil fuels

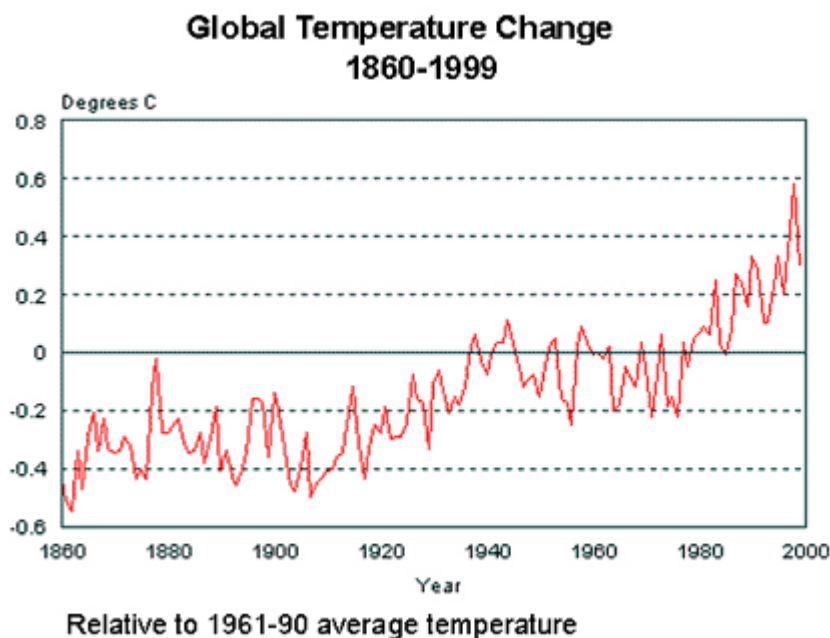
Ozone (O₃)

Ozone exists naturally in the lower atmosphere in minute quantities. It also can be produced in the lower atmosphere from a reaction involving several human-produced pollutants and sunlight.

Climate Trends

An analysis of temperature records shows that the Earth has warmed an average of 0.6°C over the past 100 years. There appears to have been a warming until the early 1940's then a moderate cooling until the mid 1970's, followed by a renewed and pronounced warming continuing through the present. The 1990's was the warmest decade on record. (In fact, ice core and other proxy data indicates that the 1980's and 1990's were the warmest decades of the past millennium).

Night-time temperatures over land have generally increased more than daytime temperatures. Regional changes are also evident. For example, recent warming has been greatest over the mid-latitude continents in winter and spring, with a few areas of cooling such as the North Atlantic Ocean. Precipitation has increased over land in high latitudes of the Northern Hemisphere, especially during the cold season.



This is consistent with predictions of climate change due to an enhanced greenhouse effect and increased aerosols. Yet, it could also be within acceptable limits for natural temperature variation.

Canada has warmed by 1.0°C over the last century. However this warming has not been consistent throughout the entire time span. The 1980's and 1990's were undisputedly the warmest decades on record in Canada. The warming that has

been observed in Canada over the past century is real and significant though its intensity has varied from decade to decade, from region to region, and from season to season.

Modelling the Global Climate

General Circulation Models

A General Circulation Model (GCM) simulates the passage of energy through the climate system. The workings of the climate system are represented by sequences of mathematical equations. Essentially, these describe the earth's radiation budget, its translation into heat and motion, and the operation of the water cycle. Values are specified for the certain quantities such as the amount of solar radiation reaching the top of the atmosphere and the reflectivity of different types of surfaces. Additional equations or sub-models may be added to account for other factors that affect the basic climate processes.

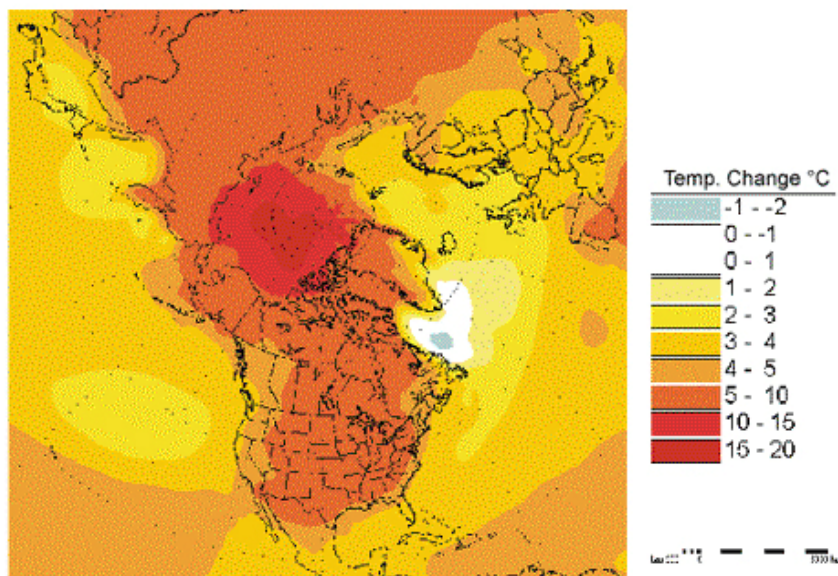
Researchers at Environment Canada have developed one of the most advanced GCMS being used today. Its improvements over previous models include a more accurate simulation of cloud properties, solar heat, ocean temperatures, and ice boundaries.

In spite of its sophistication, a GCM is still only an approximation of reality. Even the most powerful supercomputers available today cannot handle all the detail needed to give a complete description of the climate system. Nor do we fully understand all of the processes that affect climate. Consequently, the world as seen by a GCM bears a strong resemblance to a three-dimensional map made up of Lego pieces. All of the major features are recognizable, but much of the fine detail is missing. The objective as the models evolve is to fill in more of the missing detail and make the models more realistic.

What do the models tell us?

The models project an increase in global mean surface temperature relative to 1990 of about 3-4°C by 2100. Regional temperature changes could differ substantially from the global mean value. Average sea level is expected to rise as a result of thermal expansion of the oceans and melting of glaciers and ice-sheets. Models project an increase in sea level of about 50 cm from the present to 2100. Regional sea-level changes may differ from the global mean value owing to land

Projected Temperature Change Between 1975-1995 and 2080-2100
Combined Effects of Projected Greenhouse Gas and Sulphate Aerosol Increases
Canadian Model



movement and ocean current changes.

All model simulations, whether they were forced with increased concentrations of greenhouse gases and aerosols or with increased concentrations of greenhouse gases alone, show the following features: greater surface warming of the land than of the sea in winter; a maximum surface warming in high northern latitudes in winter; little surface warming over the Arctic in summer; an enhanced global mean hydrologic cycle, and increased precipitation and soil moisture in high latitudes in winter. Warmer temperatures will lead

to a more vigorous hydrologic cycle; this translates into prospects for more severe droughts and/or floods in some places and less severe droughts and floods in other places.

What is the greenhouse effect?

There are two meanings of the term "greenhouse effect". There is a "natural" greenhouse effect that keeps the Earth's climate warm and habitable. There is also the "man-made" greenhouse effect, which is the enhancement of Earth's natural greenhouse effect by the addition of greenhouse gases from the burning of fossil fuels (mainly petroleum, coal, and natural gas). In order to understand how the greenhouse effect operates, we need to first understand "infrared radiation".

Greenhouse gases trap some of the infrared radiation that escapes from the Earth, making the Earth warmer than it would otherwise be. You can think of greenhouse gases as sort of a "blanket" for infrared radiation-- it keeps the lower layers of the atmosphere warmer, and the upper layers colder, than if the greenhouse gases were not there.

About 80-90% of the Earth's natural greenhouse effect is due to water vapour, a strong greenhouse gas. The remainder is due to carbon dioxide, methane, and a few other minor gases.

It is the carbon dioxide concentration that is increasing, due to the burning of fossil fuels (as well as from some rainforest burning). This is the man-made portion of the greenhouse effect, and it is believed by many scientists to be responsible for the global warming of the last 150 years. Also, the concentration of methane, although small, has also increased in recent decades. The reasons for this increase, though, are uncertain.

Note: The main resource of this document is various organizations dedicated to minimise the global warming threats and their websites. Association of Political Science Students has taken it resource document for various activities on Climate Change which is the theme of this year's International Youth Day. The APSS would like to thank them.

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