

Statement

The Australian Meteorological and Oceanographic Society Statement on Climate Change

Our climate has changed substantially

Global climate change and global warming are real and observable. Since the start of the 20th century, the global-mean surface temperature of the Earth has increased by around 0.6°C, and the last decade (1996-2005) was the warmest since at least the mid-19th century, when widespread observations first became available. The rate of warming has been largest in the latter part of the 20th century, with the global-mean surface temperature rising by about 0.17°C per decade since 1976. Moreover, 1998 and 2005 were the warmest years on record. Over the last hundred years, the mean surface temperature of Australia has increased by almost 0.9°C, which is more than the global average. It is probable that the mean surface temperature of the Northern Hemisphere is higher now than at any time in the last 1,000 years. Data are too sparse, however, to allow a similar conclusion for the Southern Hemisphere.

Increasing temperatures have been observed both over land and in the oceans, in rural areas and cities, at the surface and in the lower atmosphere by satellites and radiosondes¹. This warming has been accompanied by a decrease in the number of frosts, a rapid contraction of almost all alpine glaciers, a reduction in global sea-ice, a reduction in global snow cover (especially in spring), and a rise in sea-level.

The greenhouse effect is a natural and well-understood phenomenon

About half the sunlight intercepted by the Earth is either absorbed by the atmosphere or reflected to space by clouds, aerosols² and the air itself, the most important of these reflectors being clouds. The other half of the intercepted sunlight is transmitted through the atmosphere, ultimately warming the surface. At the same time, the land, the oceans and the atmosphere continuously absorb and emit infrared radiation, the intensity of which increases very rapidly with temperature. Consequently, the mean surface temperature is determined by the amount of sunlight reaching the surface, the amount of infrared radiation emitted by the atmosphere and subsequently absorbed at the surface, the amount of infrared radiation emitted by the surface, and the transport of moist air or seawater to and from the surface by turbulence, convection³ and other organised circulations. Water vapour, carbon dioxide and other gases that are present in small amounts (often collectively called greenhouse gases) increase the capacity of the atmosphere to absorb and emit infrared radiation. The mean surface temperature increases as the atmospheric concentration of greenhouse gases increases because the atmosphere emits more infrared radiation (both upwards and downwards), some of which is absorbed by the surface. It is for this reason that the mean surface temperature is higher than it would otherwise be without an atmosphere or greenhouse gases. This process, called the natural greenhouse effect, keeps the surface of the Earth and the lower atmosphere warm enough to sustain us.

Without greenhouse gases, clouds or aerosols, the surface of the Earth would have a mean temperature of about 18°C below zero. With greenhouse gases, but no clouds or aerosols, the mean temperature would be 30°C above zero. Clouds and, to a lesser extent, aerosols, reduce the mean surface temperature to its current value of about 15°C above zero. About three-quarters of the natural greenhouse effect is due to water vapour, with the remainder coming from greenhouse gases such as carbon dioxide. While clouds absorb infrared radiation, which increases the greenhouse effect, they reflect sunlight, so that on balance they probably reduce the surface temperature.

Most of the observed warming is highly likely due to human activity

It is highly likely that those human activities that have increased the concentration of greenhouse gases in the atmosphere have been largely responsible for the observed warming since 1950. The warming associated with increases in greenhouse gases originating from human activity is called the enhanced greenhouse effect. The atmospheric concentration of carbon dioxide has increased by more than 30% since the start of the industrial age and is higher now than at any time in at least the past 650,000 years. This increase is a direct result of burning fossil fuels, broad-scale deforestation and other human activity. Concentrations of a range of other potent greenhouse gases, such as CFCs⁴, methane and nitrous oxide, have increased also as a result of human activity, and have contributed to the observed warming. Conversely, some other by-products of human activity, most notably

¹ Measuring devices attached to balloons.

² Small particles suspended in the air such as dust and soot, produced by both natural and man-made processes

³ In the atmosphere, the vertical transport of heat and moisture by circulating eddies.

⁴ CFCs (chlorofluorocarbons), the gases responsible for the ozone hole, are also greenhouse gases.

industrial aerosols, have had a cooling effect on the atmosphere, and have offset some of the warming from the enhanced greenhouse effect.

Why are we confident that the warming is due to human activity rather than natural climate variability?

The observed warming in recent decades is as expected from long-understood physics of the atmosphere. Climate models are close relatives of the computer models used every day around the world to predict daily weather. They correctly simulate the temperature record of the 20th century (including periods of relative cooling) when both natural factors (internal climate variability, volcanic emissions and variations in solar radiation) and human influences (increased greenhouse gases and aerosols, and decreased stratospheric ozone) are included, but fail to simulate accurately the temperature record if human influences are omitted. In fact, some changes in natural influences on the climate during the past 50 years (such as volcanic emissions and variations in solar radiation) are likely to have had a cooling effect on the climate. These same climate models correctly capture the cooling effect of large volcanic events such as the eruption of Mt Pinatubo, which adds to our confidence in their capacity to correctly predict how the climate will respond changes in the concentration of greenhouse gases and aerosols. As mentioned earlier, estimates of past climates indicate that the mean surface temperature of the Northern Hemisphere in the late 20th century probably exceeds the temperature of any time during at least the last 1,000 years, suggesting that the recent warming is larger and more rapid than might be expected from natural processes alone. The widespread warming, in the lower atmosphere, over the icy regions of the planet, over the land surface, and in the oceans is unlike the response to any known natural internal cause of climate variability, but is the pattern expected from an enhanced greenhouse effect.

What are the uncertainties?

Predictions of the Earth's climate are based on numerical models and there are many uncertainties in these models. For example, limits on the speed and memory of today's computers restrict climate models to resolving horizontal scales no smaller than a few hundred kilometres, although some improvement in resolution can be obtained using nested grids⁵. Many of the physical processes that ultimately determine the Earth's climate and its variation, however, operate on scales smaller than the grid size of the models, and are thus not resolved by current models. Such subgrid-scale processes must be approximated, a process known as parameterisation. Almost always, the parameterisations involve ad hoc assumptions about the physical processes and are the most serious weakness in climate models. The interaction between the parameterised processes is another source of uncertainty. For example, while the direct effect of increasing carbon dioxide on atmospheric infrared radiation can be accurately calculated, the resulting changes in the water vapour, clouds and surface reflectance are less certain. The difficulties are especially pronounced for clouds and lead to uncertainties in the predicted temperature changes. It is estimated that the change in the global mean surface temperature for a doubling in carbon dioxide concentration as predicted by current climate models has an uncertainty in the range 1.5 to 5°C. Although the uncertainties are large, they do not change the fact that an increase in temperature is still predicted to accompany an increase in greenhouse gases.

Determining if and why precipitation and extreme weather systems such as tropical cyclones have changed is more challenging still. Nevertheless, there has been a tendency over the 20th century for increased rainfall in higher latitudes and equatorial latitudes, with decreased rainfall in the subtropics, and this pattern has much in common with that predicted by climate models. There is some evidence that the frequency of very intense tropical cyclones has increased, although there are concerns about the reliability of the historical records of tropical cyclones. Our understanding, modelling, and even monitoring of tropical cyclones is inadequate to provide confidence that a human effect on tropical cyclones has been detected as yet.

Our climate is very likely to continue to change as a result of human activity

According to climate modelling carried out by the CSIRO, the mean Australian surface temperature will be between 0.4 and 2°C higher in 2030 than in 1990. By 2030, most of the uncertainty in these projections is due to the uncertainty in the way physical processes are represented by climate models; later in the century, the uncertainty in the economic and population growth and the future level of greenhouse gas emissions and anthropogenic aerosols becomes increasingly dominant. The models predict that by 2030 the warming will be accompanied by a 10-50% increase in the number of summer days over 35°C and a significant decrease in the frequency of frosts in many locations. The models also predict that by 2070, the mean Australian temperature will be 1 to 6°C above its 1990 value.

⁵ Climate models implemented over a small region of the globe, forced at their boundaries by the output of global climate models