



Australian Government

Department of the Environment

Earth System Warming

FACT SHEET

Key points

- Global temperatures have risen since 1880.
- Natural variability influences the rate at which temperature is rising from decade to decade by either reinforcing or opposing the warming trend.
- It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century.
- The last decade (2001-10) was the warmest on record.
- In Australia, the past 12 months between September 2012 and August 2013 were the warmest on record.
- Most of the extra heat has been absorbed by the oceans.
- Sea levels are rising.
- Glaciers and ice sheets are losing mass.

Why is the earth warming?

The main reason the earth has been warming over the past century is because humans have been releasing greenhouse gases into the atmosphere. These greenhouse gases trap outgoing radiation, leading to a warming earth.

While human activities – such as burning coal, petroleum and gas – have increased atmospheric carbon dioxide and other greenhouse gas concentrations, industrialisation has also caused an increase in particulate matter, known as “aerosols”, in the atmosphere. The impact of increased carbon dioxide is warming, while increased aerosols have partially offset this with a cooling effect.

Large volcanic eruptions like Mount Pinatubo in the Philippines in the 1990s also eject aerosols into the stratosphere, resulting in a rapid and short-term cooling of the earth. Volcanic aerosols drop out of the atmosphere after two to three years – so they do not counteract the warming effect of greenhouse gases in the long-term.

Natural climate variations also have an impact on the rate at which the earth warms. For example, El Niño cycles tend to bring warmer conditions globally, while La Niña patterns tend to bring cooler conditions.

What is the human influence?

The IPCC *Fifth Assessment Report* (AR5) concludes that evidence strongly indicates human behaviour is the greatest influence on the warming of the earth's climate system since 1950.

Human activities have caused carbon dioxide to increase by 40 per cent since the pre-industrial period. Along with carbon dioxide, a number of other greenhouse gases produced by humans include methane, nitrous oxide and refrigerant gases.

The earth's climate system takes decades or even centuries to respond to greenhouse gases. So even if we stabilised carbon dioxide concentrations tomorrow, the earth would still continue to warm into the next millennium.

However, the magnitude of warming projected at the end of this century will depend strongly on projected emissions. The AR5 projects warming at the end of this century of 3.2 - 5.4°C (1850 - 1900 baseline) (2.6 - 4.8°C (relative to the 1986 - 2005 baseline)) for a high emissions scenario, and 0.9 - 2.3°C for much lower emissions (0.3 - 1.7°C).

What are some of the signs that the earth is warming?

Average global temperatures have increased by 0.85°C since 1880. Since the 1950s, each decade has been warmer than the previous one.

Temperatures during the 21st century have been the warmest on record. The world's 13 warmest years have all occurred in the past 15 years. The long-term trend is undoubtedly a warming trend.

In the past decade, there have been extreme heatwaves in Europe, North America and Asia that have killed thousands of people. Australia experienced its hottest summer on record and hottest heatwave on record in 2013. Studies have now shown that climate change has contributed to the severity or likelihood of many of these events, including the record summer in Australia.

Most of the extra heat from the enhanced greenhouse effect is stored in the oceans. This contributes to sea-level rise. Sea levels are rising by around 3.2mm per year (2.8 - 3.6mm per year) between 1993 and 2010.

The world's two major ice sheets in Greenland and Antarctica are losing mass, and this is also contributing to sea-level rise. Sea levels have been rising at a faster rate over the past 20 years than at any time during the 20th century.

The absorption of carbon dioxide by the oceans is also causing ocean acidification. The pH of seawater has decreased by 0.1 since the beginning of the industrial era.

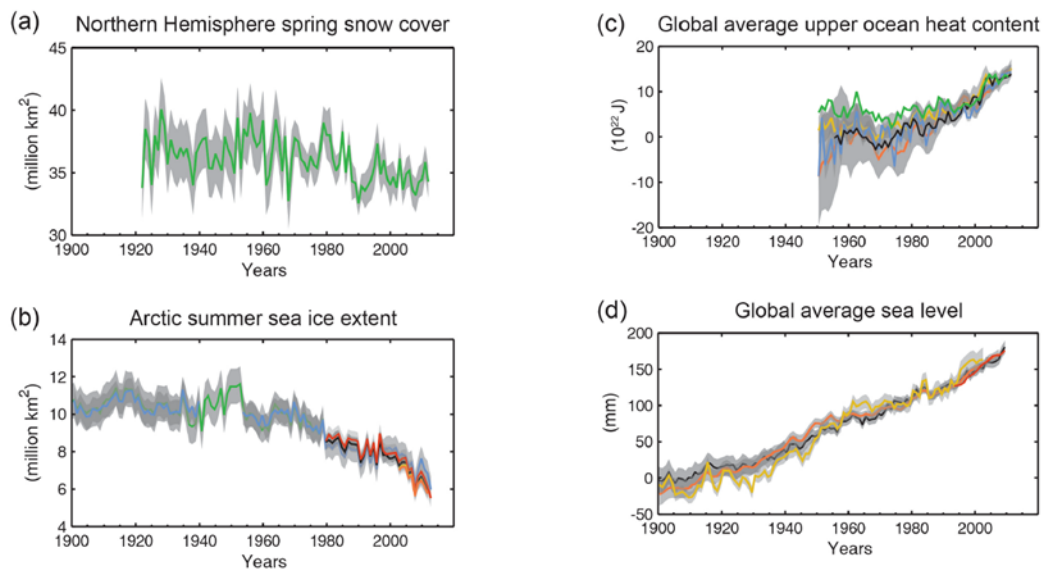


Figure 2: Multiple observed indicators of a changing global climate:

- (a) Northern Hemisphere March–April average snow cover extent
- (b) Arctic July–August–September average sea ice extent
- (c) Change in global mean upper ocean heat content normalized to 2006–2010, and relative to the mean of all datasets for 1971
- (d) Global mean sea level relative to the 1900–1905 mean of the longest running dataset, and with all datasets aligned to have the same value in 1993, the first year of altimetry data. All time-series (coloured lines) show annual values, and where assessed, uncertainties are indicated by different shades of grey.

How has the earth warmed in recent years?

The rate at which global-mean surface temperature has warmed in the past decade is less than the previous decade, and this is not unusual. Over the past 120 years, there have been decades where global-mean temperature has warmed more rapidly, and decades where relative cooling has occurred.

These changing rates of warming occur despite the continuing rise in greenhouse gas emissions and are due to a number of factors.

One of the main reasons is short-term natural variability. In the climate system, global surface temperatures do not instantly warm in response to increasing greenhouse gases. Oceanic warming occurs over a long period of time, through a complex exchange of heat between the atmosphere and ocean. This exchange of heat also causes short-term changes in global-mean temperature, both relative warming and cooling. This cycle is apparent as large year-to-year variability, and can result in decadal timescale fluctuations. Over the past decade it is very likely that the ocean has drawn down more heat from the atmosphere than the previous decade, resulting in less warming in global surface temperature. The pattern of decadal changes in surface temperature can be seen throughout the 20th century, and is an expression of natural variability superimposed on a clear background warming trend.

The Earth's climate is also influenced by other factors that partially offset or reinforce greenhouse warming. Some of these other influences, such as increased aerosols in the atmosphere or reductions in solar radiation, have a temporary relative cooling effect on the climate system. As with the ocean-atmosphere heat exchange, these changes are also superimposed on the longer-term, underlying warming trend.

The IPCC AR5 concludes that the observed reduction in the warming trend from 1998–2012, compared with the trend since 1951, is due in roughly equal measures to a reduced trend in radiative forcing and a cooling contribution from internal variability, which includes a possible redistribution of heat within the ocean. A decade is too short a period to draw any conclusion about how climate is changing in the long-term. It is more accurate to record several decades or more to be confident of a trend.

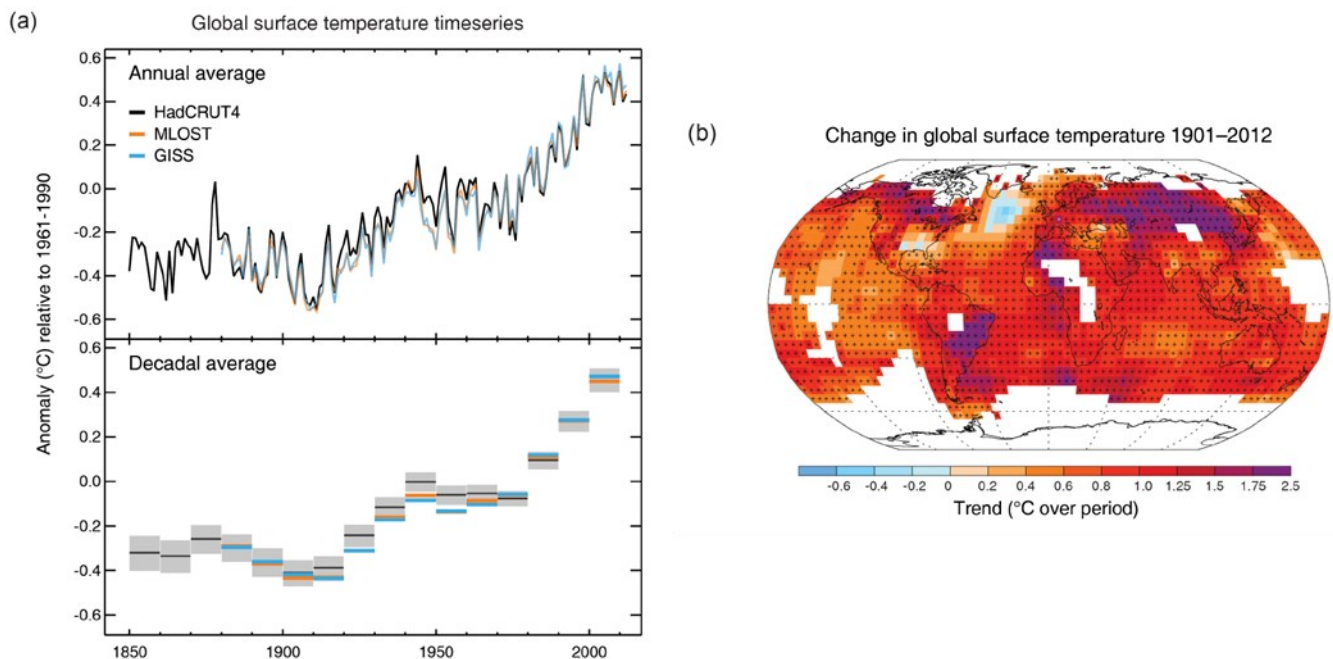


Figure 1: (a) Observed global mean combined land and ocean temperature anomalies from three surface temperature datasets. Top panel: annual mean values, bottom panel: decadal mean values including the estimate of uncertainty for HadCRUT4. Anomalies are relative to the mean of 1961–1990.

(b) Map of the observed temperature change from 1901–2012 derived from temperature trends determined by linear regression of the MLOST time series. Trends have been calculated only for grid boxes with greater than 70% complete records and more than 20% data availability in the first and last 10% of the time period. Grid boxes where the trend is significant at the 10% level are indicated by a + sign.

How are scientists monitoring global warming?

More than 90 per cent of the extra heat that has been stored by the earth between 1971 and 2010 is found in the ocean, so it is vital that we assess the impacts of warming oceans.

Scientists at CSIRO and the Australian Bureau of Meteorology are among those around the world using Argo robotic buoys to measure ocean temperature and salinity. The floats drift with the ocean currents and every 10 days they drop down to a depth of two kilometres and then rise up to the surface – collecting data as they do so. The information they collect is transferred by satellite, and then they sink back down into the ocean to repeat the process.

About 3600 of these floats are drifting around the world's oceans. One of the important results found from analysing the data from these floats is that not only is the ocean warming, its salinity is changing.

Satellites are used to provide the first truly global measurements of sea level. Ice sheets and glaciers are being measured to assess how they are responding to changes in sea level and ocean warming.

Changes in the ocean are also measured using ships, from which instruments are lowered into the sea and kept anchored to the sea floor for a year or two.

How can we predict future warming?

To predict climate changes, we need to understand what has happened in the past. Scientists use climate modelling to simulate these past events and ensure the model simulations adequately represent the observed climate. Multiple scenarios of how humans might behave in the future are used to provide the information needed to simulate future climates.

These computer models represent the principal physics and chemistry of the climate system – the atmosphere, the ocean, the land surface, the ice and the biosphere. They also take into account changes in atmospheric composition due to burning fossil fuels, and changes in land use. As with weather prediction models, computer models that simulate the climate are based on the physics that governs the behaviour of the earth's weather and climate systems.