

Frequently Asked Question 3.1

How are Temperatures on Earth Changing?

Instrumental observations over the past 157 years show that temperatures at the surface have risen globally, with important regional variations. For the global average, warming in the last century has occurred in two phases, from the 1910s to the 1940s (0.35°C), and more strongly from the 1970s to the present (0.55°C). An increasing rate of warming has taken place over the last 25 years, and 11 of the 12 warmest years on record have occurred in the past 12 years. Above the surface, global observations since the late 1950s show that the troposphere (up to about 10 km) has warmed at a slightly greater rate than the surface, while the stratosphere (about 10–30 km) has cooled markedly since 1979. This is in accord with physical expectations and most model results. Confirmation of global warming comes from warming of the oceans, rising sea levels, glaciers melting, sea ice retreating in the Arctic and diminished snow cover in the Northern Hemisphere.

There is no single thermometer measuring the global temperature. Instead, individual thermometer measurements taken every day at several thousand stations over the land areas of the world are combined with thousands more measurements of sea surface temperature taken from ships moving over the oceans to produce an estimate of global average temperature every month. To obtain consistent changes over time, the main analysis is actually of anomalies (departures from the climatological mean at each site) as these are more robust to changes in data availability. It is now possible to use these measurements from 1850 to the present, although coverage is much less than global in the second half of the 19th century, is much better after 1957 when measurements began in Antarctica, and best after about 1980, when satellite measurements began.

Expressed as a global average, surface temperatures have increased by about 0.74°C over the past hundred years (between 1906 and 2005; see Figure 1). However, the warming has been neither steady nor the same in different seasons or in different locations. There was not much overall change from 1850 to about 1915, aside from ups and downs associated with natural variability but which may have also partly arisen from poor sampling. An increase (0.35°C) occurred in the global average temperature from the 1910s to the 1940s, followed by a slight cooling (0.1°C), and then a rapid warming (0.55°C) up to the end of 2006 (Figure 1). The warmest years of the series are 1998 and 2005 (which are statistically indistinguishable), and 11 of the 12 warmest years have occurred in the last 12 years (1995 to 2006). Warming, particularly since the 1970s, has generally been greater over land than over the oceans. Seasonally, warming has been slightly greater in the winter hemisphere. Additional warming occurs in cities and urban areas (often referred to as the urban heat island effect), but is confined in spatial extent, and its effects are allowed for both by excluding as many of the affected sites as possible from the global temperature data and by increasing the error range (the light grey band in the figure).

A few areas have cooled since 1901, most notably the northern North Atlantic near southern Greenland. Warming during this time has been strongest over the continental interiors of Asia and northern North America. However, as these are areas with large year-to-year variability, the most evident warming signal has occurred in parts of the middle and lower latitudes, particularly the tropical oceans. In the lower left panel of Figure 1, which shows temperature trends since 1979, the pattern in the Pacific Ocean features warming and cooling regions related to El Niño.

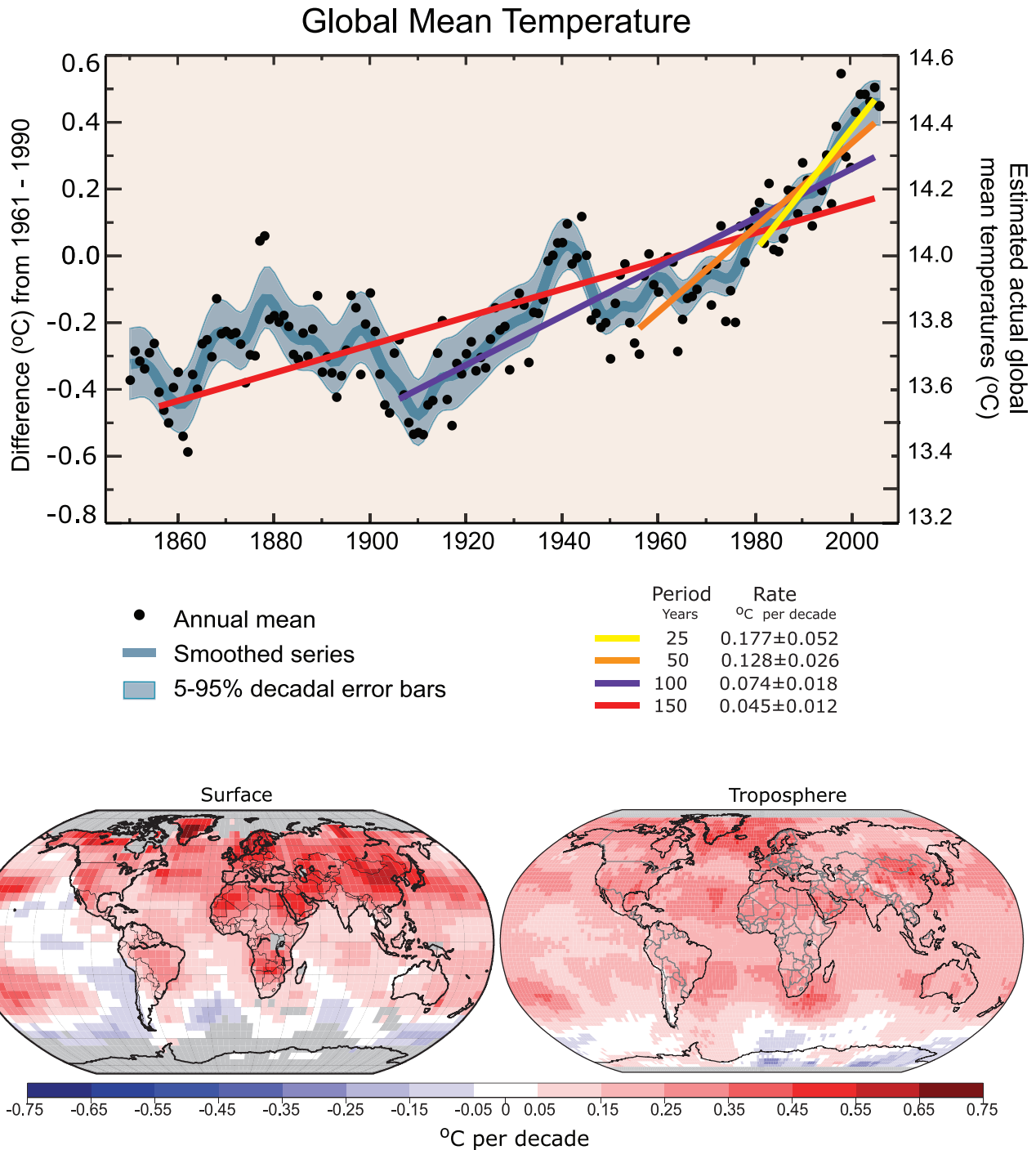
Analysis of long-term changes in daily temperature extremes has recently become possible for many regions of the world (parts of North America and southern South America, Europe, northern and eastern Asia, southern Africa and Australasia). Especially since the 1950s, these records show a decrease in the number of very cold days and nights and an increase in the number of extremely hot days and warm nights (see FAQ 3.3). The length of the frost-free season has increased in most mid- and high-latitude regions of both hemispheres. In the Northern Hemisphere, this is mostly manifest as an earlier start to spring.

In addition to the surface data described above, measurements of temperature above the surface have been made with weather balloons, with reasonable coverage over land since 1958, and from satellite data since 1979. All data are adjusted for changes in instruments and observing practices where necessary. Microwave satellite data have been used to create a 'satellite temperature record' for thick layers of the atmosphere including the troposphere (from the surface up to about 10 km) and the lower stratosphere (about 10 to 30 km). Despite several new analyses with improved cross-calibration of the 13 instruments on different satellites used since 1979 and compensation for changes in observing time and satellite altitude, some uncertainties remain in trends.

For global observations since the late 1950s, the most recent versions of all available data sets show that the troposphere has warmed at a slightly greater rate than the surface, while the stratosphere has cooled markedly since 1979. This is in accord with physical expectations and most model results, which demonstrate the role of increasing greenhouse gases in tropospheric warming and stratospheric cooling; ozone depletion also contributes substantially to stratospheric cooling.

Consistent with observed increases in surface temperature, there have been decreases in the length of river and lake ice seasons. Further, there has been an almost worldwide reduction in glacial mass and extent in the 20th century; melting of the Greenland Ice Sheet has recently become apparent; snow cover has decreased in many Northern Hemisphere regions; sea ice thickness and extent have decreased in the Arctic in all seasons, most dramatically in spring and summer; the oceans are warming; and sea level is rising due to thermal expansion of the oceans and melting of land ice.

(continued)



FAQ 3.1, Figure 1. (Top) Annual global mean observed temperatures¹ (black dots) along with simple fits to the data. The left hand axis shows anomalies relative to the 1961 to 1990 average and the right hand axis shows the estimated actual temperature (°C). Linear trend fits to the last 25 (yellow), 50 (orange), 100 (purple) and 150 years (red) are shown, and correspond to 1981 to 2005, 1956 to 2005, 1906 to 2005, and 1856 to 2005, respectively. Note that for shorter recent periods, the slope is greater, indicating accelerated warming. The blue curve is a smoothed depiction to capture the decadal variations. To give an idea of whether the fluctuations are meaningful, decadal 5% to 95% (light grey) error ranges about that line are given (accordingly, annual values do exceed those limits). Results from climate models driven by estimated radiative forcings for the 20th century (Chapter 9) suggest that there was little change prior to about 1915, and that a substantial fraction of the early 20th-century change was contributed by naturally occurring influences including solar radiation changes, volcanism and natural variability. From about 1940 to 1970 the increasing industrialisation following World War II increased pollution in the Northern Hemisphere, contributing to cooling, and increases in carbon dioxide and other greenhouse gases dominate the observed warming after the mid-1970s. (Bottom) Patterns of linear global temperature trends from 1979 to 2005 estimated at the surface (left), and for the troposphere (right) from the surface to about 10 km altitude, from satellite records. Grey areas indicate incomplete data. Note the more spatially uniform warming in the satellite tropospheric record while the surface temperature changes more clearly relate to land and ocean.

¹ From the HadCRUT3 data set.

**From the report accepted by Working Group I
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but not approved in detail**

Frequently Asked Questions

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