

HOT TOPICS

Has global warming stopped?

Summary

Variations in global-average temperature over the past century have been measured in the near-surface air, in the lowest 10 km of the atmosphere (the troposphere), and in the ocean. All measurements indicate a long-term warming.

The surface of the Earth has warmed by about 0.74°C since the start of the 20th century. This long-term warming trend is overlaid on short-term fluctuations due to such factors as El Niño and La Niña. Data over the past decade provide little insight into long-term trends; the period is simply too short. Nevertheless, the past decade has been the warmest in the instrumental record.

Sea surface temperatures and ocean heat content for the upper 300m and 700m of the ocean show long-term warming. Global average sea level has risen by 17 cm during the 20th century.

Near-surface air temperatures

There are a number of agencies which measure global surface temperature. Foremost among these are NASA, NCDC and the Hadley Centre which have each produced global near-surface temperature records (Figure 1). These all show a warming from 1910 to 1940, followed by a slight cooling in the 1940s, a levelling off in the 1950s and 1960s, then another warming from the 1970s onward. Two of the three temperature records have 2005 as the warmest year, while the third has 1998 slightly warmer than 2005. The differences between the data reflect slightly different data coverage and underlying variability; the Hadley Centre data shows slightly greater variation associated with El Niño and does not include temperatures from the Arctic.

The surface of the Earth has warmed by 0.74°C (uncertainty range 0.56 to 0.92°C) from 1906–2005 (IPCC, 2007). When the annual data are adjusted for short-term fluctuations due to El Niño and La Niña, the warming trend is even more obvious (Fawcett, 2008). This is a statistically significant climatic change and it is very unusual in the context of the past 1700 years.¹

¹ For more information see Hot Topic ‘Can the warming of the 20th century be explained by natural processes?’ available online at www.climatechange.gov.au



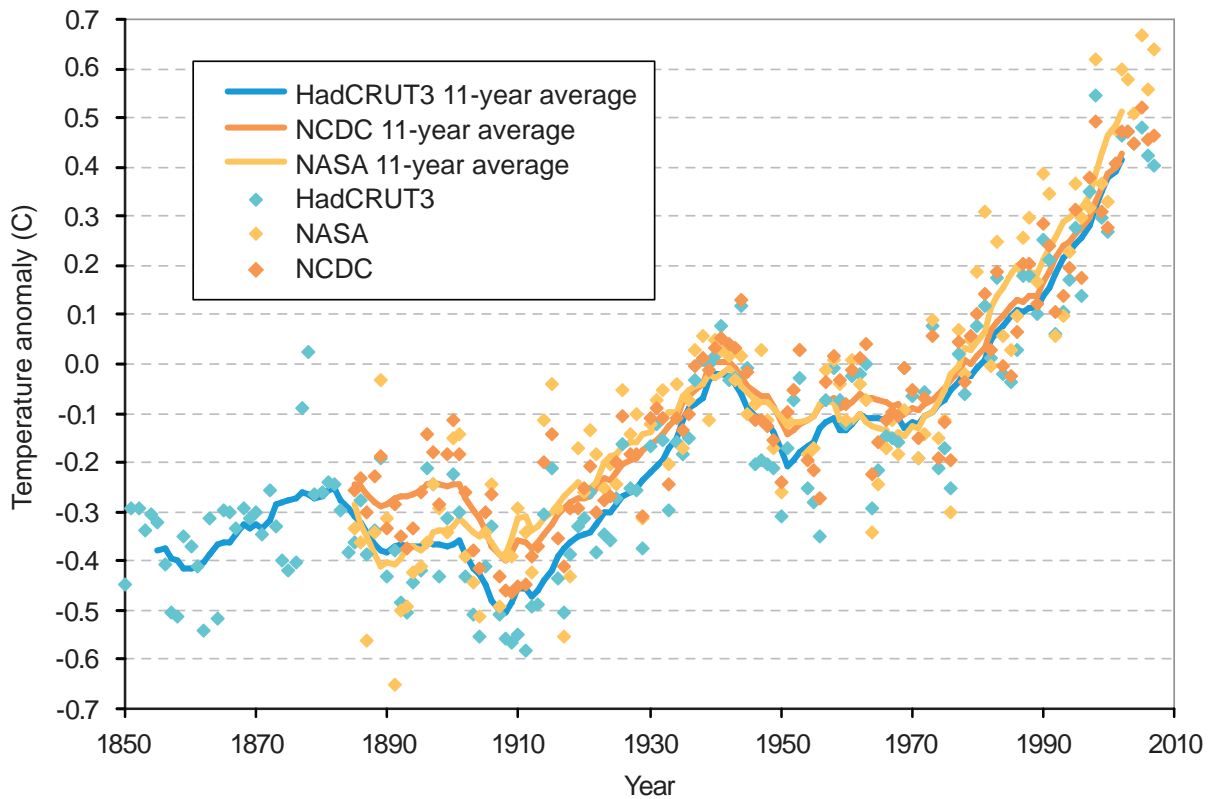


Figure 1: Global-average temperature anomalies (°C), relative to the period 1961–1990, from the UK Hadley Centre (HadCRUT3), NASA, and the US National Climate Data Centre (NCDC). Annual values are shown (dots), along with 11 year running averages (lines).

Data over the past decade provide little insight into long-term trends; the period is simply too short, so trend magnitudes are highly sensitive to the choice of start and end years. For example, there has been an insignificant warming trend over the period 1998–2008 (due largely to the strong El Niño in 1997–98), but a statistically significant warming from 1999–2008 (Easterling and Wehner, 2009). Nevertheless, the past decade has been the warmest in the instrumental record (WMO, 2009). Easterling and Wehner (2009) state:

‘Numerous websites, blogs and articles in the media have claimed that the climate is no longer warming, and is now cooling. Here we show that periods of no trend or even cooling of the globally averaged surface air temperature are found in the last 34 years of the observed record, and in climate model simulations of the 20th and 21st century forced with increasing greenhouse gases. We show that the climate over the 21st century can and likely will produce periods of a decade or two where the globally averaged surface air temperature shows no trend or even slight cooling in the presence of longer-term warming’.

Cities tend to be warmer than surrounding rural areas due to the heat-storage capacity of roads and buildings. This urban-rural temperature difference is often called the heat island effect. Population growth and urbanisation can lead to increases in the heat island effect, and some people have suggested that this affects global temperature trends. The IPCC (2007) notes that:

‘Urban heat island effects are real but local, and have not biased the large-scale trends. A number of recent studies indicate that effects of urbanisation and land use change on the land-based temperature record are negligible (0.006°C per decade) as far as hemispheric – and continental – scale averages are concerned because the very real but local effects are avoided or accounted for in the data sets used. In any case, they are not present in the sea surface temperature component of the record’.



Tropospheric temperatures

Satellites and radiosondes measure temperature in a slab of the lower atmosphere, called the troposphere.² The data should be treated with caution. The IPCC (2007) states:

Lower-tropospheric temperatures have slightly greater warming rates than those at the surface over the period 1958 to 2005. The radiosonde record is markedly less spatially complete than the surface record and increasing evidence suggests that it is very likely that a number of records have a cooling bias, especially in the tropics. While there remain disparities among different tropospheric temperature trends estimated from satellite Microwave Sounding Unit (MSU and advanced MSU) measurements since 1979, and all likely still contain residual errors, estimates have been substantially improved (and data set differences reduced) through adjustments for issues of changing satellites, orbit decay and drift in local crossing time (i.e., diurnal cycle effects). It appears that the satellite tropospheric temperature record is broadly consistent with surface temperature trends provided that the stratospheric influence on MSU channel 2 is accounted for. The range (due to different data sets) of global surface warming since 1979 is 0.16°C to 0.18°C per decade compared to 0.12°C to 0.19°C per decade for MSU estimates of tropospheric temperatures. It is likely, however, that there is slightly greater warming in the troposphere than at the surface, and a higher tropopause, with the latter due also to pronounced cooling in the stratosphere.

Ocean temperatures and sea level

Most of the heating caused by the enhanced greenhouse effect is stored in the world's oceans. This warming is clearly seen in changes in sea surface temperature, ocean heat content and sea-level rise due to thermal expansion of water (Domingues *et al.*, 2008). Figure 2 shows estimates of near-global ocean heat content for the upper 300m and 700m of the ocean for 1950–2003, along with sea surface temperatures. Warming of the oceans is clearly evident.

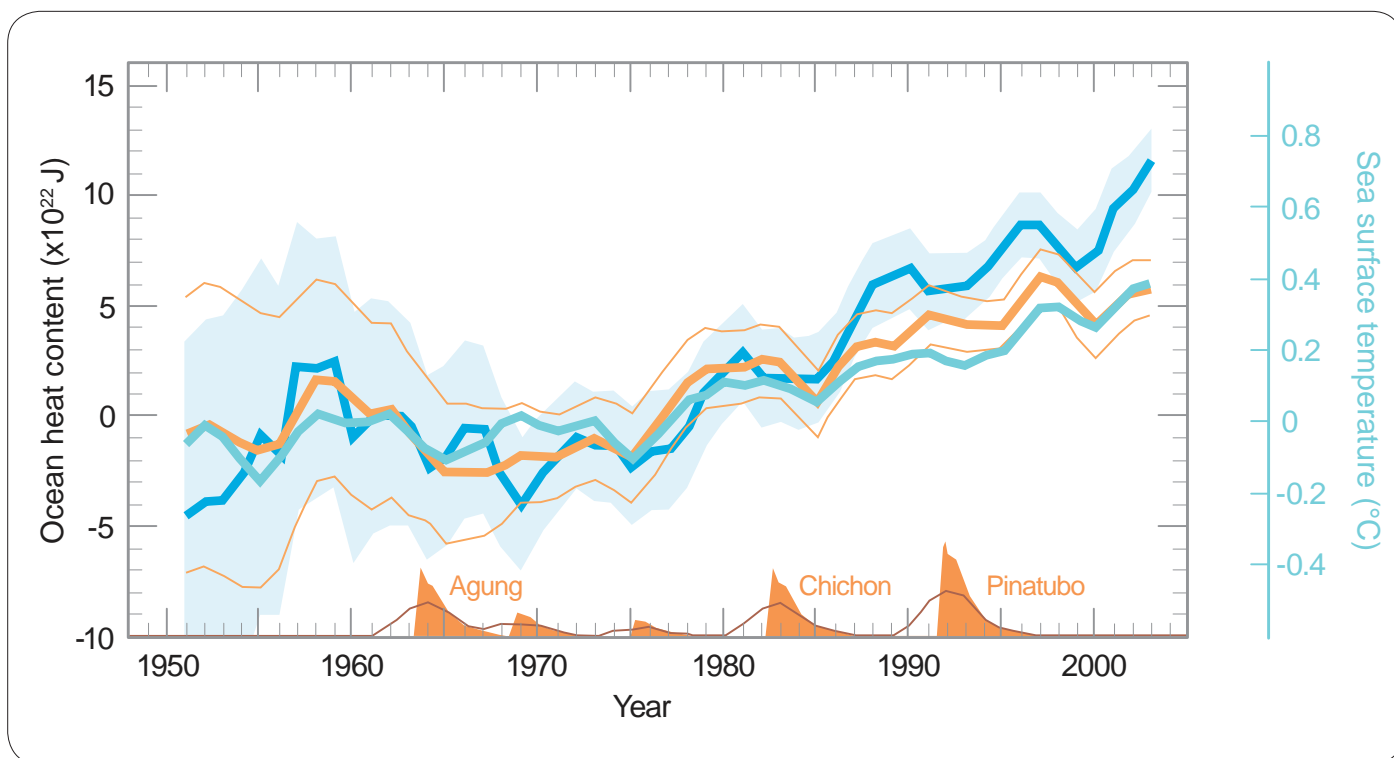


Figure 2: Comparison of near global ocean heat content for the upper 700-m (thick blue line, light blue shading indicates an estimate of one standard deviation error) and upper 100-m (thick orange line; thin orange lines indicate estimates of one standard deviation error). Sea surface temperatures (aqua; right-hand scale) are also shown. All time series are smoothed with a three-year running average and are relative to 1961. The global mean stratospheric optical depth (brown, arbitrary scale) at the bottom indicates the timing of major volcanic eruptions. The brown curve is a three-year running average of these values, included for comparison with the smoothed observations. (Domingues *et al.*, 2008).

² For more information see Hot Topic 'Is there an inconsistency between observed and modelled patterns of warming in the lower atmosphere?' available online at www.climatechange.gov.au



Warming leads to melting of ice and thermal expansion of the oceans, both of which contribute to higher sea level. Global average sea-level has risen by 17 cm during the 20th century, and the rate of increase from 1961–2003 was 1.3–2.3 mm/yr (IPCC, 2007). From 1993–2003, the rate was 2.4–3.8 mm/yr, but this may simply reflect decadal variability rather than an increase in the long-term trend (IPCC, 2007). High quality measurements of near-global sea level have been made since late 1992 by satellite altimeters. These data have shown a fairly steady increase in global mean sea level of around 3.3 ± 0.4 mm/year over the period 1993–2009 (http://www.cmar.csiro.au/sealevel/sl_hist_last_15.html). This is about 50% larger than the average value over the 20th century. Whether this represents a further increase in the rate of sea level rise is not yet certain.

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Prepared by CSIRO for the Department of Climate Change

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