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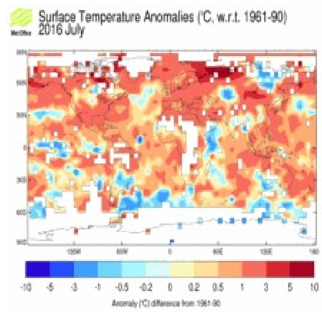
Global surface temperature

Temperature measurements made over land and in water across the globe are used to tell us how temperature has changed over time and how temperatures vary from region to region.

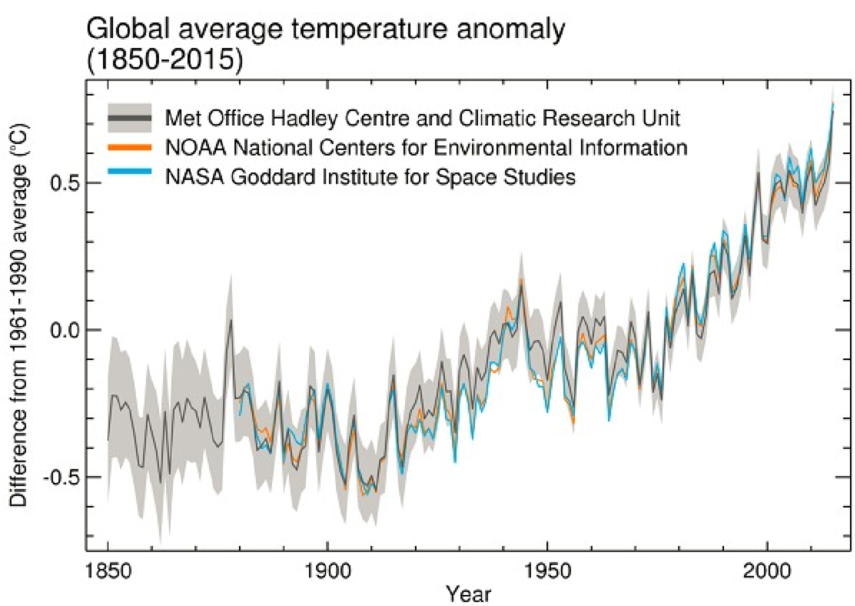


Current temperature

Shown on the right is a map of the temperature anomalies in the most recent month of HadCRUT4 - a global surface temperature dataset produced by the Met Office Hadley Centre in collaboration with the University of East Anglia Climatic Research Unit (CRU) . The anomalies are the difference between the current temperature and the average for this month in data recorded from 1961 to 1990, so the map is showing whether each part of the globe is currently warmer or cooler than this reference period. Gaps in the map occur where there were no observations.

What can be seen in the map?

In most months coherent areas of above and below average temperature can be seen, often extending for thousands of kilometres. See our Climate bulletins for descriptions of the main features of the surface temperatures in this month.



Global average temperature time series

The data shown in the map can be used to calculate the global average temperature anomaly. The same can be done with the data from the other months of the dataset to give a time series that shows how global average temperature has changed over time.

The plot on the right shows annual global average temperature anomalies from HadCRUT4 (black line). These represent our best estimates of global surface temperature. However, because there are difficulties in the calculation, the true value of global surface temperature might differ from these best estimates. We put a lot of effort into understanding how much these could affect the numbers and the result is the gray shading in the plot. We expect that the true value of the global temperature will fall within that shaded area in 19 out of 20 cases.

Other groups also produce surface temperature datasets, for example the National Aeronautics and Space Administration Goddard Institute for Space Studies (NASA GISS) and the National Oceanic and Atmospheric Administration National Climatic Data Center (NOAA NCDC) . These are produced separately to HadCRUT4 and use different methodologies (see How is HadCRUT4 produced? for more details). Global average temperature anomalies from these datasets are also shown in the plot (orange and blue lines respectively). Although many of the features of the time series are very similar, the global average temperature calculated from each are not exactly the same owing to the differences in the methodologies used.

What can we see in the time series?

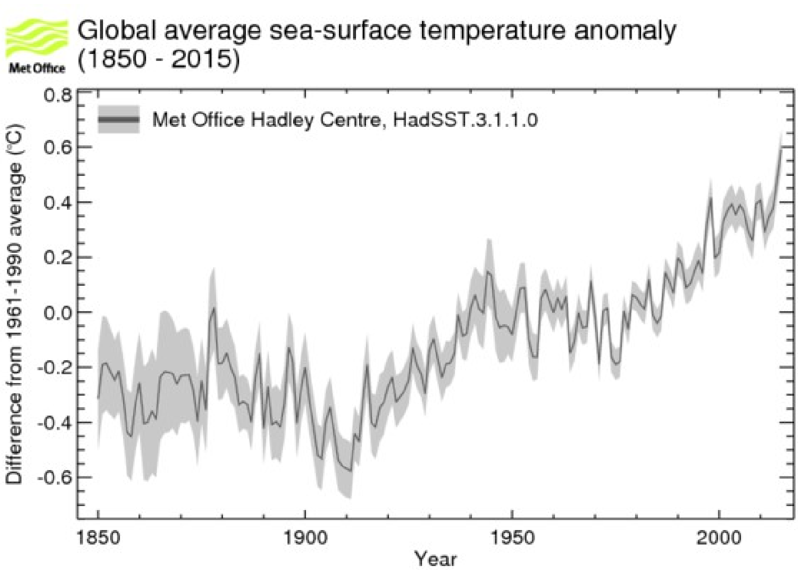
Global average land and sea surface temperatures have increased since 1850, thought to be caused by:

- The Intergovernmental Panel on Climate Change (IPCC) concluded that "most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."
- There is more uncertainty about the causes of the changes observed in the early part of the 20th-century. Possible influences include solar, volcanic and greenhouse gas factors, and natural variability that is internal to the climate system.

Overlaid on the longer term changes in global temperature are faster fluctuations. Examples of these are:

- Conspicuous warm spikes in the temperature series, such as those in late 1870s and in 1998 show the effect on global temperatures of El Niño events, which recur every three to eight years. See also the Explanation of some of the terms used in the bulletins.
- Brief dips in global temperature are often associated with La Niña, such as those in 1999-2000 and 2008 .
- Volcanic eruptions also lead to temporary cooling of the earth's surface. Large tropical eruptions, like Mount Agung in 1963 and Mount Pinatubo in 1991 have the largest effects on global temperatures because from the tropics the volcanic material can spread into both hemispheres.

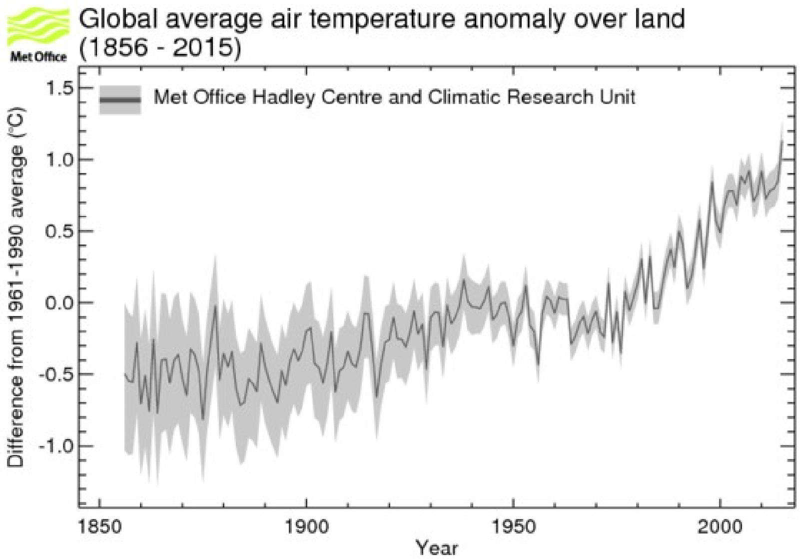
The land and ocean



components of global temperature

It is possible to calculate global averages of temperatures over land, over the ocean or using all the data.

- **Ocean and sea temperatures:** the component of the HadCRUT4 dataset that contains the ocean and sea surface temperature data - normally abbreviated to sea surface temperature (SST) - is called HadSST3 . The time series formed from only these data tell us how the temperature at the surface of the oceans has changed over time.
- **Land temperatures:** the land part of the HadCRUT4 dataset is called CRUTEM4 . This is a collaboration between the Met Office and the CRU . A time series formed from these data shows us how the temperature near the surface of the land has altered over the past 160 years.



- **Combined ocean, sea and land temperatures:** the sea and land components are brought together in HadCRUT4 . A time series calculated from these combined data tells us how the global (land and sea) average temperature has changed over time.

More information about how we calculate these time series is on our pages about the Near-surface temperature over land and Surface temperature of the oceans and seas.

The plots on the right show sea, land and combined annual average temperature anomaly times series (black lines) and the 95% confidence ranges in the values (gray areas; as with the previous time series we expect the true value to fall within this range in 19 out of 20 cases).

How is HadCRUT4 produced?

HadCRUT4 is made up of observations recorded over more than 160 years and is extended up to the present each month with the new data that have been recorded.

Where do the data come from?

Tens of thousands of temperature observations are taken across the globe each day, both on land and at sea.

- **Sea** surface temperature observations come from buoys deployed across the world's oceans and ships in the Voluntary Observing Ship Programme . Together they take around 1.5 million observations each month. These are checked by computer and any obviously inaccurate readings are excluded. More information is available at our page about the Surface temperature of the oceans and seas.
- The temperature over **land** comes from about 1,300 observing stations each month. Stations take daily readings and use them to create a monthly average, which is then sent off for use by climate researchers. The figures from each are checked both by computer and manually to find and remove any problems. More information is available at our page about Near-surface temperature over land.

These observations are combined with archives of historical observations that have been gathered over the past 160 years. The historical data are adjusted to minimise the effects of changes in the way measurements were made.

How is the global average temperature calculated?

The data are first converted into 'anomalies'. Anomalies are the difference in temperature from the 'normal' level. For HadCRUT4 the 'normal' level is the long term average for each area over 1961 to 1990.

Anomalies are used because:

- They are relatively constant over large areas, even if the actual temperature at different locations is quite different. In other words, the anomalies can tell us something about the temperature over a much larger area than the temperature that is actually measured.
- They help to avoid biases by making the data record less sensitive to missing data.

For example, imagine a situation where observations from an observing station in the Arctic were missing in one month. If actual temperatures were being averaged together, the global average temperature would seem warmer in that month because temperatures in a cold region of the globe were missing. This does not occur when averaging anomalies, although the lack of knowledge of the temperature anomaly in that region would still reduce the accuracy of the global average.

The anomalies are aggregated onto a regular grid that divides the earth's surface into 'squares' that are equally spaced in latitude and longitude. Global average temperature is calculated from these grid squares. The squares do not all have the same area, but this is taken into account in the calculation.

There are often large areas from which we receive few, or no, observations. If no observations were made in a grid square in a month then that grid square is not included in the average. The gaps where there are no observations are largest at high latitudes. We calculate an uncertainty estimate which indicates how far from the 'true' global average our estimate is likely to be.

What do other groups do differently?

The graphic showing global average temperature anomalies from the HadCRUT4 , NASA GISS and NOAA NCDC datasets reveals that there are some differences between them. One of the main reasons for this is in how each group treats the gaps in the data.

- For HadCRUT4 only grid squares where observations were made in a month are used to calculate global average temperature.
- NASA GISS assumes that temperature anomalies remain coherent out to distances of 1200km from a station. In this way they can estimate temperatures through much of the Arctic and Antarctic using only a small number of well separated stations. Because the Arctic has warmed faster than the rest of the planet, the NASA GISS analysis runs a little warmer than HadCRUT4 in recent years.
- The analysis produced by the NOAA NCDC makes a more conservative assumption and fills fewer of the gaps.

Table of global temperatures

The table shows global average temperature anomalies for the past 26 years from the three major global temperature datasets. Anomalies have been calculated relative to the average for the period 1961-1990. Original data sources can be found at these locations: HadCRUT4 , NASA GISS and NOAA NCDC . More information about the HadCRUT3 data can be found on the HadCRUT4 page .

Global average temperature anomalies

Year	HadCRUT4 in°C (95% confidence range)	HadCRUT3 in °C (95% confidence range)	NCDC in °C	GISS in °C
2015	0.75 (0.66 to 0.84)		0.78	0.76
2014	0.57 (0.48 to 0.66)		0.62	0.64
2013	0.50 (0.41 to 0.59)	0.46 (0.36 to 0.55)	0.54	0.55
2012	0.47 (0.38 to 0.56)	0.40 (0.30 to 0.49)	0.50	0.53
2011	0.42 (0.33 to 0.51)	0.35 (0.25 to 0.44)	0.45	0.50
2010	0.56 (0.47 to 0.65)	0.50 (0.40 to 0.59)	0.58	0.62
2009	0.51 (0.42 to 0.60)	0.44 (0.34 to 0.54)	0.51	0.54
2008	0.40 (0.31 to 0.48)	0.31 (0.21 to 0.41)	0.42	0.44
2007	0.49 (0.41 to 0.58)	0.40 (0.30 to 0.50)	0.49	0.56
2006	0.51 (0.42 to 0.60)	0.43 (0.33 to 0.53)	0.49	0.53

2005	0.54 (0.45 to 0.64)	0.47 (0.37 to 0.58)	0.54	0.59
2004	0.45 (0.36 to 0.54)	0.43 (0.33 to 0.53)	0.45	0.44
2003	0.51 (0.42 to 0.60)	0.46 (0.36 to 0.56)	0.49	0.51
2002	0.50 (0.41 to 0.59)	0.46 (0.36 to 0.55)	0.48	0.53
2001	0.44 (0.35 to 0.53)	0.40 (0.30 to 0.50)	0.42	0.44
2000	0.30 (0.21 to 0.39)	0.24 (0.14 to 0.33)	0.30	0.32
1999	0.31 (0.22 to 0.40)	0.26 (0.17 to 0.36)	0.32	0.32
1998	0.54 (0.45 to 0.62)	0.52 (0.42 to 0.61)	0.51	0.53
1997	0.39 (0.30 to 0.48)	0.36 (0.26 to 0.45)	0.39	0.38
1996	0.18 (0.09 to 0.27)	0.12 (0.03 to 0.22)	0.20	0.24
1995	0.32 (0.23 to 0.41)	0.28 (0.18 to 0.37)	0.33	0.36
1994	0.21 (0.12 to 0.30)	0.17 (0.07 to 0.26)	0.22	0.22
1993	0.15 (0.06 to 0.23)	0.10 (0.01 to 0.19)	0.16	0.14
1992	0.11 (0.02 to 0.19)	0.06 (-0.03 to 0.15)	0.13	0.13
1991	0.25 (0.17 to 0.34)	0.20 (0.11 to 0.29)	0.28	0.32

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