CLIMATE COMMISSION

Climate Commission Summary Statement: The Earth continues to warm.

Key points:

(1) The Earth continues to warm strongly. Scientists assess this based on long term observations of the heat content of the ocean, the air temperature (an indicator of the heat content of the atmosphere), and the amount of heat absorbed by the land, glaciers, ice sheets and sea ice.
(2) Understanding changes in climate requires data over long time periods, at least 30 years and preferably much longer.
(3) The best measure of global warming is ocean heat content as it absorbs nearly 90% of additional heat trapped by greenhouse gases. Global ocean heat content has increased substantially over the last 40 years, and the strongly upward trend has continued through the most recent decade up to the present.
(4) Singling out short term trends in air temperature to imply that global warming is not occurring is incorrect and misleading.

There has been significant confusion in the press in recent months about whether the Earth is continuing to warm. In late 2012 the UK Met Office, which is similar to the Australian Bureau of Meteorology, released updated data regarding the short-term forecast of global air temperature.

It found that:

> "Global average temperature is expected to remain between 0.28 °C and 0.59 °C (90% confidence range) above the long-term (1971-2000) average during the period 2013-2017, with values most likely to be about 0.43 °C higher than average."

This prompted some commentators to report that global warming had stopped. This seriously misrepresents both what the Met Office found and what is actually happening.

This briefing corrects the confusion and confirms that the Earth is continuing to warm at an alarming rate.

How do we know the Earth is warming?

Global average air temperature near the surface is only one of many indicators that climate scientists use to determine the state of the Earth's climate system. A good analogy is your family doctor, who uses a wide range of measurements – not just your temperature – to determine the state of your health.

While surface air temperature is the indicator that we experience in our day to day lives, climate scientists use a wide range of other indicators that also show the state of the climate system. These include:

Ocean heat content (see Figure 2 below)
Sea surface temperature
Sea-level rise
Sea ice cover
Global snow cover
Mass of land-based glaciers
Mass of polar ice sheets
Species migrations
Tree-line changes

All of these factors must be considered over a long time frame, usually over 30 years (and preferably much longer), to accurately assess the long-term change in climate, as distinct from natural variability. While all of these indicators show their own modes of variability and regional variations, taken together at the global scale, they paint a clear picture of a strongly warming Earth, with a trend that continues to the present.

2. What is the most important indicator that the Earth is warming?

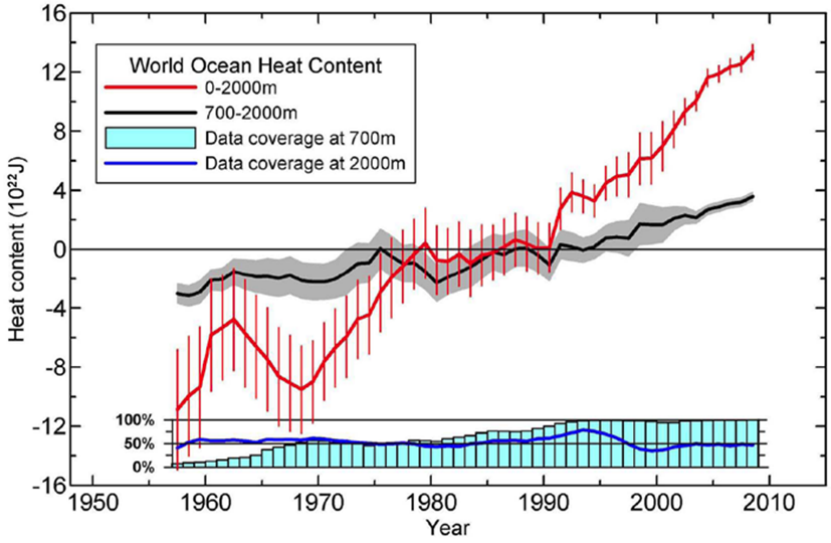
Greenhouse gases act as a blanket trapping additional heat energy at the Earth's surface and in the lower atmosphere. This is a natural phenomenon, and the physics are very well understood. As human activities add more greenhouse gases to the atmosphere, more heat is being trapped at the Earth's surface. The first step in understanding climate change is to understand where this additional heat goes. The vast majority of the extra heat does not go into the atmosphere and thus raise the air temperature but rather into the ocean. Here is the budget for where the extra heat goes (Table 1):

Table 1: Where the extra heat goes. (Source: IPCC 2007)

Compartment of the Earth's surface	Percentage
Oceans	89.3
Atmosphere	3.1
Land	4.8
Glaciers/ice caps (continental)	1.4
Greenland ice sheet	0.1
Antarctic ice sheets	0.4
Arctic sea ice	0.9
Total	100.0

As shown in Table 1, the single best measure of whether the Earth is warming is the change in heat content of the ocean. This is shown in Figure 1, which is the latest available analysis taking the long-term trend up to 2009. Note that over the last 40 years the heat content of the ocean has increased substantially, and the strongly upward trend has continued through to the most recently available data.

Figure 1: The increase in total ocean heat content from the surface to 2000 m, based on running five-year analyses, from 1957 to 2009. Reference period is 1955–2006. Vertical bars represent +/–2 standard deviations about the five-year estimate. Caption refers to red line only.



Source: Levitus, S., Yarosh, E. S., Zweng, M. M., Antonov, J. I., Boyer, T. P., Baranova, O. K., Garcia, H. E., et al. (2012). World ocean heat content and thermosteric sea level change (0–2000), 1955–2010. Geophysical Research Letters, m. doi:10.1029/2012GL051106

3. What does the air temperature record actually show?

The air absorbs approximately 3% of the additional heat trapped by greenhouse gases.

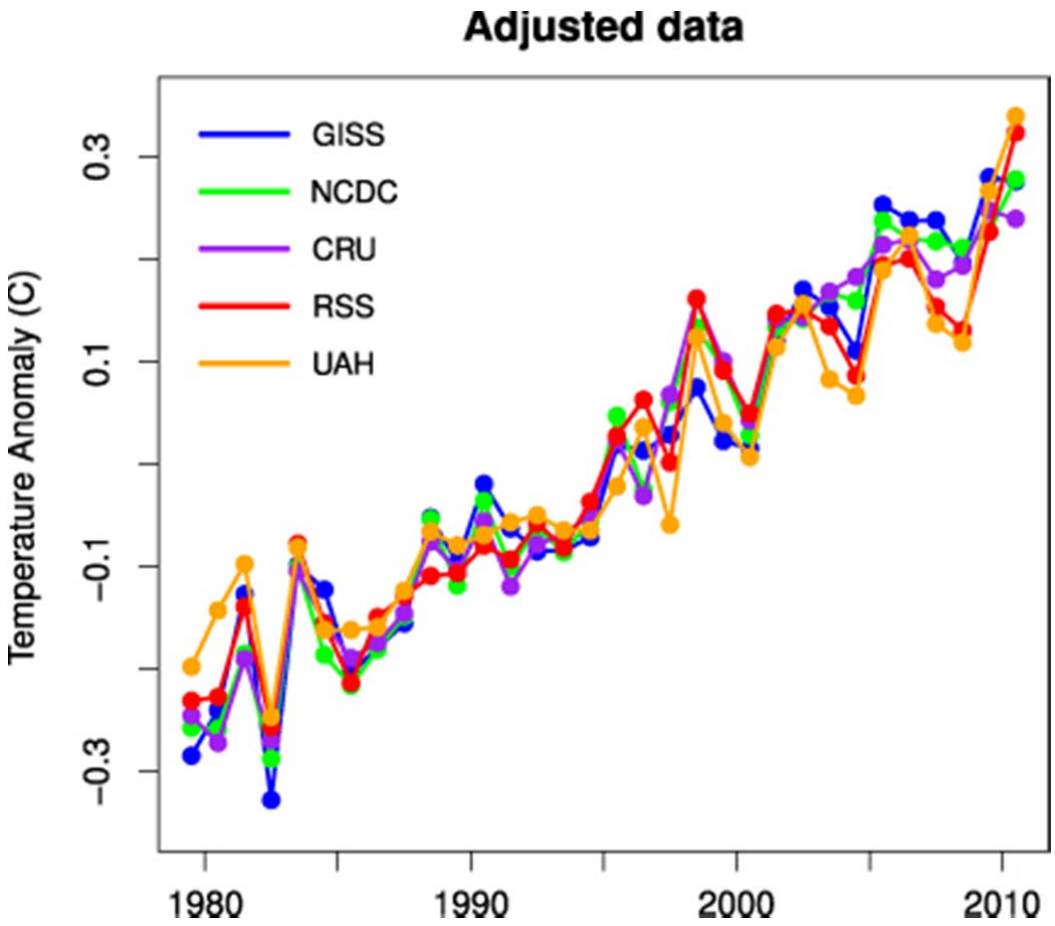
Over the last 50 years global air temperature has been increasing. Some years are cooler and some years are hotter than others, however, the long term trend is up. Over the last 50 years every decade has been warmer than the one before it, including the 2000-2009 decade. In fact, 2000-2009 was the hottest decade since records began and stands out on the temperature record.

Air temperature is influenced by climate change, as well as by natural factors such as changes in incoming solar radiation, volcanoes and patterns of variability such as the El Niño Southern Oscillation (ENSO). On shorter time frames – annually, a few years, or up to a decade or two, these natural factors are important influences on the global average temperature and can mask the underlying, long-term trend due to the increasing greenhouse gas concentrations. ENSO is one of the most important of these. El Niño years are warmer than average while La Niña years are cooler. This is why climate scientists take a long "time series" – spanning many decades – to examine the underlying trend in temperature and separate out the variability "noise" from the longer term trend (the "signal").The Met Office temperature prediction for 2013-2017 is essentially a prediction of the short-term effects of natural factors and has little to do with the longer-term temperature trend.

Scientists look to see whether the underlying warming trend re-appears when the masking effects of natural factors are accounted for. The adjusted temperature record is shown in Figure 2.

The answer is obvious. When the masking effects of natural factors are removed, the underlying trend of rising air temperature comes through loud and clear right up to the present.

Figure 2: Global average temperature record adjusted for changes in incoming solar radiation, aerosols from large volcanoes, and the warming/cooling from ENSO events.



Source: Foster, G., & Rahmstorf, S. (2011). Global temperature evolution 1979– 2010. Environmental Research Letters, 6(4), 044022. Retrieved from http://stacks.iop.org/1748–9326/6/i=4/a=044022

4. What is the long term future trend in global air temperature?

There may be periods of years up to a decade or two where the long-term trend is masked by natural factors, but the long term trend will continue to be rising air temperature, along with rising ocean heat content, and further loss of snow and ice. The extent of this warming of the planet will depend, for a large part, on the further amount of greenhouse gases that are emitted into the atmosphere from human activities.

References:

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