

Grantham Briefing Note 1 – September 2013

The slowdown in global mean surface temperature rise

DR SIMON BUCKLE AND DR FLORA MACTAVISH

Overview

- Global mean surface temperature increased by about 0.85°C over the period 1880-2012. Each of the last three decades has been warmer than all previous decades in the instrumental record and the decade of the 2000s has been the warmest.
- Climate change is a long term trend, and a few decades worth of data are needed to separate the warming trend from natural variability.
- The recent slowdown in the observed temperature trend for 1998 - 2012 relative to 1951 - 2012 is probably attributable in roughly equal measure to cooling from internal climate variability and reduced external forcing of the climate system.
- Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. In the absence of major volcanic eruptions or long-term changes in solar energy reaching the Earth, global mean surface temperature for the period 2016 - 2035 is likely to be in the range of 0.3°C to 0.7°C higher than for 1986 -2005.
- Global mean surface temperatures are projected to continue to rise further over the 21st Century. With very strong mitigation action, global mean surface temperature by the end of the century, relative to the average over 1850 – 1900, is unlikely to exceed 2°C. However, if current emission trends continue, an increase of more than 4°C is as likely as not.

Why is the slowdown in global surface temperature rise important?

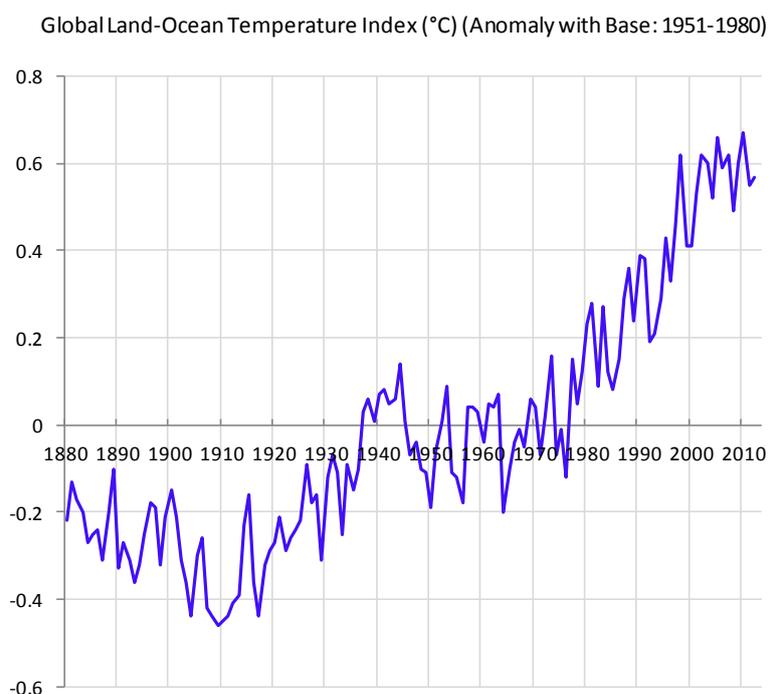
In response to the rise of carbon dioxide and other greenhouse gases in the atmosphere, climate model projections for this century and beyond show continuing increases in global mean surface temperature, although there are significant regional differences in the degree of warming.

Yet global annual mean surface air temperatures have not increased as rapidly over the past 15 years as over the previous 30 years. This so-called hiatus has led to suggestions that global warming has stopped, or that air temperature is not as sensitive to atmospheric CO₂ concentrations as previously thought. Understanding why this slowdown is happening is both an important scientific challenge and highly relevant to policy decisions on how to respond to climate change.

The observed temperature record over the 20th Century (see Figure 1) shows periods of slower and faster warming in response to a number of factors, most notably natural variability in the climate system on both short and long timescales, the changes in atmospheric composition due to large-scale human emissions of greenhouse gases and aerosols from burning fossil fuels and land-use change, volcanic activity and small changes in the level of solar activity.

The period 1997-98 coincided with an exceptionally strong warming of the eastern equatorial Pacific Ocean (a very strong El Niño event). This released significant heat into the atmosphere which amplified the global mean surface temperature anomaly by an estimated 0.2°C or more, with a lag of around six months. This one event has a major effect on estimates of short-term temperature trends that include data for 1998, increasing estimates for the trend up to 1998 and reducing trend estimates for the subsequent period. The overall effect of the El Niño/Southern Oscillation (ENSO) phenomenon on surface temperatures during this subsequent period has been one of cooling.

Figure 1: Global mean land-ocean temperature index, 1880 to present, relative to the base period 1951-1980 (Source: NASA GISS)



The emissions scenarios used by the IPCC Fifth Assessment Report (AR5)

AR5 uses four Representative Concentration Pathway (RCP) scenarios with widely differing emissions pathways, reflecting differing levels of ambition in tackling climate change. The lowest, RCP2.6 is a very strong mitigation scenario, with CO₂ levels peaking by 2050 at ~443ppmv. RCP4.5 has a continuing rise in CO₂ concentrations to the end of the century, when they reach ~538ppmv. In RCP6.0, CO₂ concentrations rise more rapidly, reaching ~670ppmv by 2100. RCP8.5 continues current rapidly increasing CO₂ emission trends with CO₂ concentration reaching 936ppmv by 2100.

What does AR5 say about the slowdown?

AR5 reports that:

- Global mean surface temperature has increased by about 0.85°C (with a 90% confidence range of [0.65-1.06]¹) over the period 1880-2012.
- It is extremely likely that “human influence has been the dominant cause” of the observed increase in global mean surface temperatures from 1951-2010.
- Each of the last three decades has been warmer than all previous decades in the instrumental record. The decade of the 2000s has been the warmest in the instrumental record.
- Despite this robust multi-decadal warming, there is substantial inter-annual to decadal variability. Trends based on short records are very sensitive to the beginning and end dates and do not in general reflect long term climate trends. For example, including the effect of the very warm initial year, the rate of warming over 1998 to 2012 is 0.05°C [-0.05 to +0.15] per decade, while that over the longer period of 1951-2012 is 0.12°C [0.08 to 0.14] per decade.
- The recent observed slowdown in the temperature trend for 1998-2012 relative to 1951-2012 is probably attributable in roughly equal measure to a surface cooling contribution from ocean-atmosphere internal variability and a reduced trend in the external forcing of the climate system. The lower external forcing during the later period is due to a downward phase of the solar cycle and a series of small volcanic eruptions.
- AR5 expresses medium confidence that the difference between observed and model trends of global mean surface temperature during 1998-2012 is to a substantial degree caused by internal decadal variability, with possible contributions from inadequate model representation of radiative forcing and, in some of the AR5 models, an overestimate of the climate response to increasing greenhouse gases.
- The long-term climate simulations show a trend in global mean surface temperature over 1951-2012 that agrees with the observed trend, with very high confidence.

What does AR5 say about projections for near-term changes in temperature?

Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. In the absence of major volcanic eruptions (which would cause significant temporary cooling) or long-term changes in solar irradiance, AR5 says that in the near-term, it is likely that the global mean surface temperature for the period 2016-2035 will be in the range of 0.3°C to 0.7°C higher than for 1986-2005.

For the next few decades, internal variability will continue to be a major influence on climate, particularly in the near-term and at the regional scale. By the middle of this century, projected changes will be substantially affected by the choice of emissions scenario.

¹ The range in square brackets is the 90% uncertainty interval. This is expected to have a 90% likelihood of covering the value being estimated. There is an estimated 5% likelihood that the value could be above the range given and 5% likelihood that the value could be below that range. A best estimate of the value is given where available. Uncertainty intervals are not necessarily symmetric about the corresponding best estimate.

What does AR5 say about projections for long-term changes in temperature?

Global mean surface temperatures are projected to rise further over the 21st Century under all the RCP scenarios, with scenario dependence as shown in Table 2 below. To obtain the total change relative to 1850-1900, 0.61°C should be added to the change relative to 1986-2005².

Table 2: Projected long-term changes in global mean surface temperature for 2081-2100.

Scenario	Change relative to 1986-2005		Change relative to average for 1850 - 1900
	Mean	Likely range (5-95% of model ranges)	
RCP2.6	1.0	0.3 - 1.7°C	Unlikely to exceed 2.0°C
RCP4.5	1.8	1.1 - 2.6°C	Likely to exceed 1.5°C
RCP6.0	2.2	1.4 – 3.1°C	Likely to exceed 2.0°C
RCP8.5	3.7	2.6 – 4.8°C	As likely as not to exceed 4°C

It is virtually certain that in most places there will be more hot and fewer cold extremes over most land areas on daily and seasonal timescales as global mean temperatures increase. It is very likely that heat waves will occur with a higher frequency and duration. Occasional cold winter extremes will continue to occur.

References

Intergovernmental Panel on Climate Change, Summary for Policy Makers (2013)

NASA GISS Surface Temperature Analysis (http://data.giss.nasa.gov/gistemp/graphs_v3/). Data downloaded on 9 September 2013.

Neelin, J. David, Climate Change and Climate Modelling, Cambridge University Press (2011)

Trenberth, K. E., J. M. Caron, D. P. Stepaniak, and S. Worley, Evolution of El Niño–Southern Oscillation and global atmospheric surface temperatures, J. Geophys. Res., 107(D8), doi:10.1029/2000JD000298, 2002.

² An earlier version of this note said “It should be noted that for changes from the preindustrial value, about 0.9°C should be added to the change relative to 1986-2005.” For clarity, the change relative to 1850-1900 is now given, rather than the change relative to preindustrial; the new figure is from the IPCC report.