Restless climate: Lessons using data skills

Royal Geographical Society with IBG
Advancing geography and geographical learning

Lesson 1: Global warming pause: a myth or reality?

Lesson objectives

- To use global mean temperature data compiled by the UK Met Office and NASA to investigate patterns of warming and cooling since 1850
- To use the same temperature data to test the claim that global warming has paused since the powerful El Niño event in 1998

Setting the scene

According to provisional figures released by the UK Met Office[1], 2016 was the warmest year since records began in 1850. The global mean temperature was 0.77°C above the average for 1961-1990, narrowly beating the previous warmest year 2015. In fact, 9 out of the 10 warmest years on record have all occurred in the 21st century. The missing top 10 year occurred in 1998 which, just like 2015/16, had a particularly strong El Niño event in the Pacific Ocean. Despite this remarkable run of warm years, some opponents to action on climate change claim that global warming has actually paused since 1998. Others challenge the reliability of the temperature statistics based on known shortcomings of the data – measurement, sampling and coverage uncertainties.

Within this context we should also recognise that climate is a 30 year average of recorded weather conditions. The UK's Meteorological Office maintains long-term averages of the UK's climate – as do other national weather agencies – based on standard 30 year periods, following World Meteorological Organisation recommendations.

This might appear to be a rather fruitless argument. However, the global mean temperature record has huge ramifications for international efforts to curb human-induced climate change. Those in favour of reducing greenhouse gas emissions – such as carbon dioxide and methane – point to rising temperatures as evidence of dangerous change in the climate system. They fear that major impacts such as deadly heatwaves, irreversible melt of the Greenland Ice sheet and sea level rise could be triggered if global warming passes the 2°C mark. Using 1850-1900 as the baseline, there has already been 1.1°C of warming and, at the Paris climate negotiations in 2015, governments agreed to aim for a limit of 1.5°C of warming.

Those opposed to curbing emissions are concerned about the cost of decarbonising economies. They use the same global mean temperature data to show that fears about global warming are unwarranted. Some also argue that models of the climate system do not simulate the observed warming very well and are, therefore, an unreliable tool for predicting future changes. This lesson will take you to the heart of the data used by both camps.

[1] http://www.metoffice.gov.uk/news/releases/2017/2016-record-breaking-year-for-global-temperature

The data
Global mean temperature statistics are published every year by three international agencies: the UK Met Office; the National Aeronautics and Space Administration (NASA); and the National Oceanic and Atmospheric Administration (NOAA). The records are based on surface temperature measurements collected by weather stations, ships, buoys and Antarctic research stations. These various sources of information are blended using statistical methods that account for changing and uneven patterns of sampling over time and space. For instance, there were relatively few weather stations in the 1850s compared with now, and there are still large gaps in data for Polar Regions, parts of Africa, Asia and South America. High altitude arctic environments are under-represented too, yet are experiencing some of the most rapid rates of warming. Temperature instruments and methods of measurement (on land and at sea) have changed over time. Some records must also be corrected for artificial warming caused by urban development since the Industrial Revolution.

This lesson uses publicly available global temperature data compiled by:

(a) NASA Goddard Institute for Space Studies (GISTEMP):https://data.giss.nasa.gov/gistemp/
(b) The Climatic Research Unit and Met Office Hadley Centre (HadCRUT4): http://www.metoffice.gov.uk/hadobs/hadcrut4/

Tasks

1. **How have temperatures on Earth changed since 1850?**
   Look at the GISTEMP (Figure 1) and HadCRUT4 (Figure 2) data then describe the most striking patterns of global temperature change over space and time.

   Figure 1. GISTEMP temperature anomalies in 2016 compared with the 1961-1990 mean

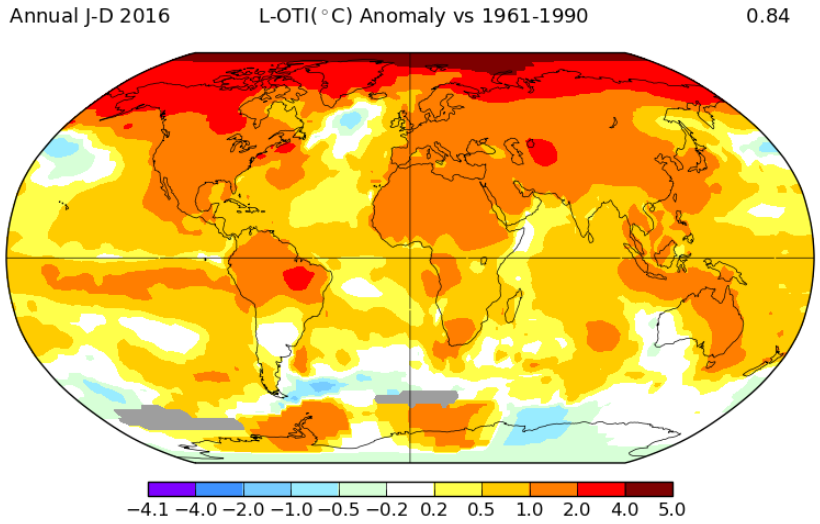
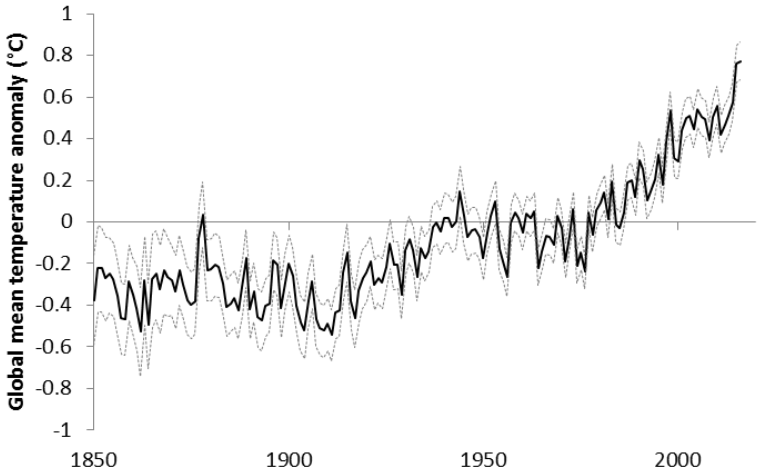


Figure 2. HadCRUT4 annual global mean temperature anomalies since 1850



2. **What are the causes of the uneven patterns of warming in space and time?**
Break your answer down into those factors that tend to cause regional warming and those that contribute to cooling. Explain particularly what is happening in the Arctic, in the area south of Greenland and also note/describe the effect of El Niño in the Pacific Ocean.

Tip: Refer to the following online video (duration 5:10) for a summary of the main factors affecting Earth temperatures – both their measurement and behaviour:
https://www.futurelearn.com/courses/data-tells-a-story/1/steps/106873

3. **How have global mean temperatures changed since 1998?**
Download the Microsoft Excel file 'L1_Data_HadCRUT4.xlsx', the accompanying 'Datasheet 1'. [Note that these data were used to plot Figure 2]. HadCRUT4 data for the period 1998 onwards are shown in Table 1.

Table 1. Best estimates of the global mean annual temperature anomaly since 1998. Data source: HadCRUT4

Year	Annual temperature anomaly (°C)
1998	0.536
1999	0.306
2000	0.293
2001	0.439
2002	0.497
2003	0.508
2004	0.448
2005	0.544
2006	0.505
2007	0.492
2008	0.394
2009	0.506
2010	0.556
2011	0.421
2012	0.469
2013	0.512
2014	0.575
2015	0.760
2016	0.773

Use the data in Table 1 to hand-draw a scatterplot of global mean temperature (dependent variable) against year (independent variable).

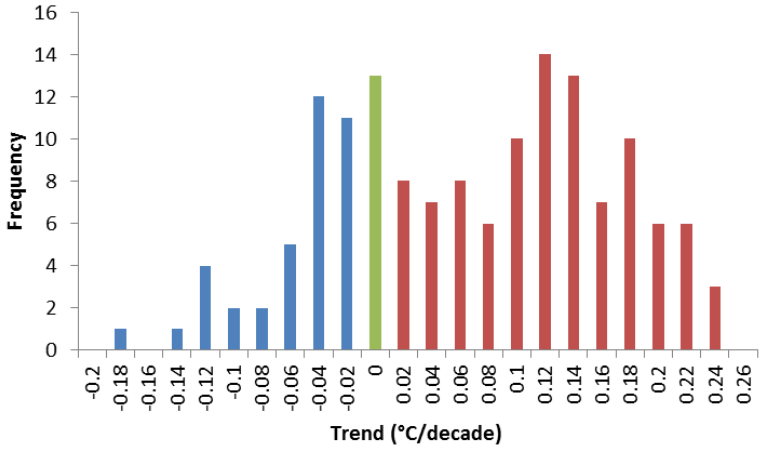
Add the best fit line and estimate the gradient to TWO DECIMAL PLACES. The gradient is the average rate of change of global mean temperature during the period of record selected. In this case it is positive – indicating a warming trend in units of degrees Celsius *per year*.

Take it further: Look at the distribution of points. What are the most important data outliers and how might these have affected the trend? What would happen to the trend if these outliers are ignored when drawing the best fit line?

4. **How unusual was the temperature trend between 1998 and 2016?**
Figure 3 shows a histogram of global mean temperature *trends* for all 19-year blocks of data since 1850. Blue bars represent the blocks of time during which global mean temperature cooled; green when there was no change; and red when the planet warmed.

Convert your trend estimate from Task 3 (degrees Celsius *per year*) into degrees Celsius *per decade* (by multiplying by 10). Compare your trend estimate with the distribution of values shown in Figure 3. How unusual was the trend during the period 1998-2016 compared with all other 19-year blocks of data? How often has global warming stood still (i.e. had zero trend with time)?

Figure 3. Global mean temperature trends for all 19-year blocks of data since 1850



Take it further: Use the LINEST function in Excel to derive for yourself all of the 19-year trends shown in Figure 3. Select column 2 for “known_y’s” and column 1 for “known_x’s”. Ignore the other two options (“const” and “stats”). What are the 19-year periods with the most rapid (a) cooling or (b) warming trends? These periods are shown by the bars at the opposite end of the histogram in Figure 3.

Plenary
Return to the main lesson question: on the balance of evidence examined, have global mean temperatures really paused in recent years?

Ask the group to invent a newspaper or blog headline announcing the 2016 global mean temperature anomaly with an accompanying paragraph of narrative. One half of the group should frame their individual headlines and articles from the perspective of a climate scientist; the other half should adopt the position of a climate sceptic.

Discuss how these contrasting messages might be received by political leaders and the wider public.

Further reading
For a primer on the methods of global mean temperature measurement and 'pause' debate see: Wilby, R.L. 2017. What is the global mean temperature and how has it changed? In: *Climate change in practice: Topics for discussion with group exercises*. Cambridge University Press, Cambridge.