How has temperature changed in the last 140 years?

Active Listening Questions:
- What evidence of global warming does Dr. Cox provide?

**WHAT:** In this clip from the 2006 public lecture "Will the Living Climate Save Us From Climate Change?" Peter Cox explains how basic measurements of the Earth's average climate show a warming trend over the last 140 years. Dr. Cox points out the cooling during the 1940's through the 1960's and a resumption of warming from the mid 1970's until the present. He attributes the cooling period to the effect of aerosols, such as sulfate aerosols, temporarily countering the warming effect of carbon dioxide. The overall trend, however, reveals a warming of the global average atmosphere, warming that is occurring at an unprecedented rate.

**HOW:** As evidence that the Earth is warming, Dr. Cox shows the global temperature record from thermometers at weather stations and ships from all over the world dating back into the mid-19th century. The red bars are individual years. The black lines that look a bit like whiskers in each bar represent the uncertainty in the measurements each year. The heavy blue line is a running average that shows the general trend. The change in temperature is about 0.7 deg C and is shown as a departure, or anomaly, from the 1961-1990 average. See the image under “Clip Activity” for a more recent version of the graph from the Met Office Hadley Centre shown by Dr. Cox.

**WHY:** The graph displayed by Dr. Cox is iconic and has been supported since its creation by additional data and research. It represents temperature records gathered from teams of scientists in different countries, pooling together data to create a world-view of changing temperature, and it provides an example of climate change detection. Its upward trend depicts recent warming of the past several decades that do not follow the natural variability in the Earth's temperature, either in magnitude of the change in temperature or the rate at which it is occurring.

**SO WHAT:** The research of Dr. Cox and his colleagues offers a clear, evidenced-based representation of how the planet is changing. An increase in the average global temperature could lead to drastic changes in local climates, shifts in weather patterns, or even changes in biodiversity. Research on how temperatures have changed over the last few centuries help scientists to infer potential human impacts and project how global temperatures might shift in the future, allowing for an opportunity to plan and prepare for potential changes.

**BIO:** Peter M. Cox is an expert in climate change modeling from London in the U.K. His educational background is in Physics and Theoretical Physics, but he spent his years at the Hadley Centre thinking about interactions between ecosystems, atmospheric composition, and the physical climate system.
TAKING THE REINS

Discussion Questions:
Discuss with a friend or record your thoughts in a journal.

• In the graph shown by Dr. Cox, why doesn’t the trend line show a smooth, steady increase?
• Why are smooth lines uncommon when graphing natural phenomena?

Quiz Questions:

Quiz 1. Which of the following can be inferred from the graph Dr. Cox shows during this clip?
   a) The temperature has been increasingly warmer than average every year since 1880.
   b) The temperature has shown an overall general trend of increase since 1880.
   c) The temperature has primarily been cooler than average since 1880 with a few years being much higher than average.
   d) The temperature has been split about evenly between being higher than or lower than average since 1880.

Evidence of Global Climate Warming

- 2005 and 1997 the two warmest years on record
- 9 of the 10 warmest years on record in the last decade

Surface Temperature Increase of about 0.7°C since 1900
Taking the Reins: Further Activities

Clip Activity: Understanding the Chart:
Take a look at the updated version of the graph displayed by Dr. Cox (on the previous page), and record work in your science journal or discuss the graph with a friend.

- Explain in your own words what this graph depicts.
- What were some of the coldest years on record?
- What were some of the warmest years on record?

How has the temperature changed in the last 140 years?

Read it like a scientist!

- This graph represents departures from global average surface temperature over the last ~140 years.

- The x-axis represents time by year.

- The y-axis represents how a departure from the average temperature of 1961-1990.

- The red bars represent the average temperature, and the gray bars show the uncertainty in the measurements.

- The thick blue line shows a running average.

Glossary Term: Feedback

How a system responds when something within that system is changed, causing a looped response. Positive feedback means that an event will augment the response of the system, while negative feedback will diminish the response.
Go Beyond: Exploring Graphs

Using a spreadsheet such as Excel (or on graph paper, by hand), make your own temperature graph with NASA data: http://data.giss.nasa.gov/gistemp/graphs/Fig.A2.txt.

• Option 1: See if your graph looks similar to the ones from the NASA website.

• Option 2: Look at the Met Office graph used by Dr. Cox on page 2. Select a different set of years to use for your average zero-line. Redraw the graph.
  - Does it look the same as or different from the graph whose average was taken from 1961-1990?

Further Reading:

To watch the complete public lecture by Peter Cox, visit agci.org and click on “public lectures.” This lecture is called “Will the Living Climate Save Us from Climate Change?” and is from 2006.

For more information on creating temperature graphs, visit NASA’s webpage: http://data.nasa.gov/gistemp/graphs/