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## Data on global warming

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Climate change encompasses many things, but almost all of them are tied (in the current times) to global warming. Global warming is causing climate patterns to change, and so it is really the main process affecting the earth's climate today.

Carbon dioxide (CO<sub>2</sub>) and other gases (but mainly CO<sub>2</sub>) have risen and are thought to be the main driver of the current global warming. As of 2015, carbon dioxide makes up only about 0.04 percent of the earth's atmosphere, which is just 4 parts per 10,000 (or 400 parts per million - its standard unit of measurement). Can such a small quantity influence global temperatures? What do measurements of CO<sub>2</sub> and temperatures actually show?

Before looking at temperatures in recent times, let's look at temperatures in the past. For the last million years or so, the dominant climate mode on earth (about 90 percent of the time) has been one of ice sheets and cold temperatures. The brief periods of warmth between the ice ages (called interglacials) have occurred about every 90,000 to 100,000 years, and they last an average of 10,000 to 15,000 years. The current interglacial started about 11,000 years ago when the last ice age ended.

In Figure 1, temperatures of the last 11,000 years are shown, with the latest time on the far right (the data ends around 1850). This data is only for one site (an ice core from Greenland) and may not be representative of a global average. Also, since no thermometers were in use back then, the temperatures are a best-guess estimate. Still, numerous cold and warm periods show up in the past, with some of the warm periods actually warmer than today's temperatures. The current warm period (approximated by the dashed red line at the far right) has readings approaching the Medieval Warm Period (about a 1,000 years ago).

Figure 1 (lower portion) also shows a graph of estimated CO<sub>2</sub> from another ice core, this one from Antarctica. Note how the temperatures rise and fall with little correlation to the CO<sub>2</sub> value, although the range of values is small, only about 260 to 280 parts per million (ppm).

Now let's look at temperatures of the past 150 years. Most observations of temperature weren't regularly recorded until the latter half of the 1800s, with locations on land widely scattered, and even fewer readings of sea surface temperatures. More locations were added in the 1900s, along with a better quality of observations. It has really only been since the end of World War II that there has been a decent worldwide coverage of land stations. Sea surface readings though have really only reached a reasonable level of coverage and accuracy since about 1980.

There are five main datasets of global average temperature, three of them surface based (land and sea surface temperatures) and starting in the latter half of the 1800s. These surface datasets all pretty much use the same information, but differ in how each one handles data-sparse areas. They also differ in the base period they use to determine differences (anomalies) from the average temperature (one set uses a base period of 1951-1980, while another uses 1981-2010).

The other two datasets are satellite based and start around 1980 when some scientists wanted a better way to measure the earth's temperatures. These datasets portray the temperature of an atmospheric layer from the surface to about 10,000 feet over almost the entire globe. Hence, the areal coverage of the measurements is much better, especially over the oceans. The satellite datasets show less warming than the surface-based ones, and aren't widely known by most people.

In Figure 2, global monthly average temperature anomalies since 1860 for one of the surface datasets is shown, with the current time on the far right. Also shown (green line) is the CO2 data, with values estimated around 280 to 310 ppm through about 1958 or so (dashed line). After that, CO2 has been accurately measured and it has risen to the current value of 400 ppm.

Temperatures have overall been gradually warming since the end of the Little Ice Age in the 1850s and 1860s. There was some slight cooling from about 1880 to 1910, followed by warming from 1910 to about 1945. Temperatures were then slightly cooler from 1945 to about 1977 (with widespread concern in the 1960s and '70s about returning to a little ice age).

Warming then occurred from 1977 to around 2002. Note that the warming from 1910 to 1945 was very similar to this most recent warm period, even though CO2 values were much lower. Since about 2002, temperatures have remained relatively about the same.

Figure 3 shows the average global monthly temperature from one of the surface datasets since 1958, and the amount of CO2 (it varies seasonally). Note that temperatures were decreasing during the 1960s until about 1977, even though CO2 was still rising. Also note that with CO2 continuing to rise into the 2000s, temperatures since about 2002 have not risen at all, except for some warming showing up very recently.

This warming since 2014 however can be attributed to the current El Ni-o. A majority of the temperature peaks in Figure 3 can be attributed to El Ni-o episodes where abnormally warm water rises to the surface in the equatorial Pacific Ocean. This current El Ni-o started in the late summer and autumn of 2014 with rising global temperatures, and will linger into 2016. It is nearly as strong as the 1997-98 Super El Ni-o that was the warmest one since records began in 1950.

So, is carbon dioxide the control knob of global temperatures? Check out the data yourself. Go to [woodfortrees.org](http://woodfortrees.org) to read about the datasets and make your own temperature plots. Or take a look at [climate4you.com](http://climate4you.com) and learn about the many aspects of the current and past climate.

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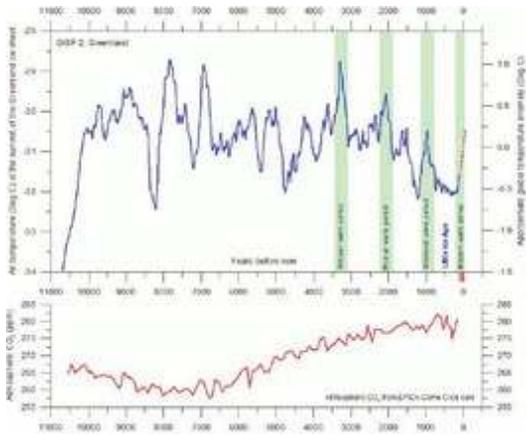


Figure 1

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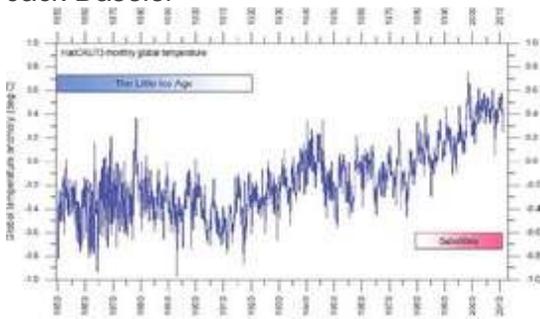


Figure 2

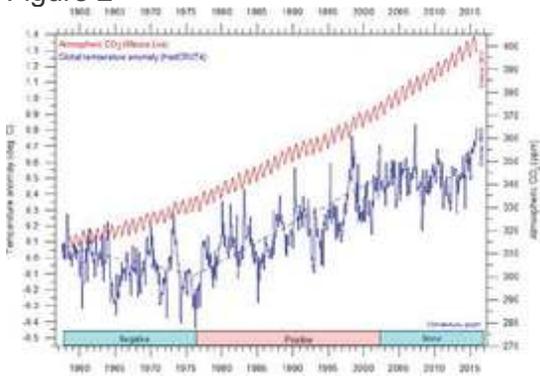


Figure 3