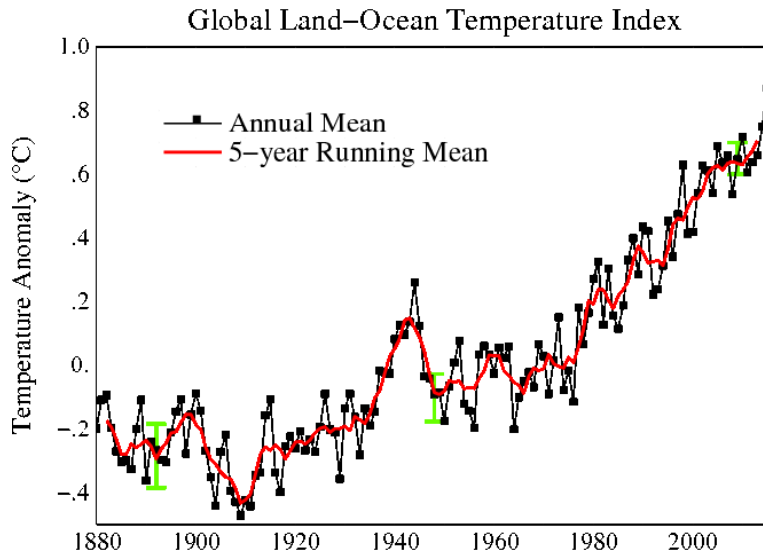


# The Competing Hypotheses

## Hypothesis 1 - Solar radiation is the cause of recent global warming:

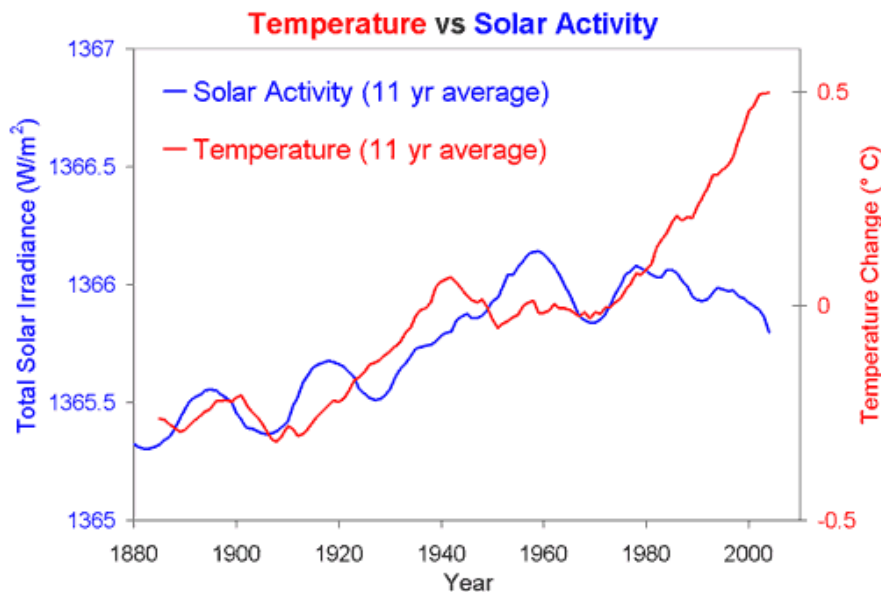
H1-Figure 1 - NASA data depicting the trend in recent global atmospheric temperature



[http://data.giss.nasa.gov/gistemp/graphs\\_v3/fig.A2.gif](http://data.giss.nasa.gov/gistemp/graphs_v3/fig.A2.gif)

H1-Figure 2 - Trend in temperature and solar irradiance over the same period.

**Solar Radiation Intensity** is a measure of the amount of energy in the radiation that comes in from the sun. This figure presents this amount of energy (Solar Activity; blue) and the atmospheric temperature over the same time period.

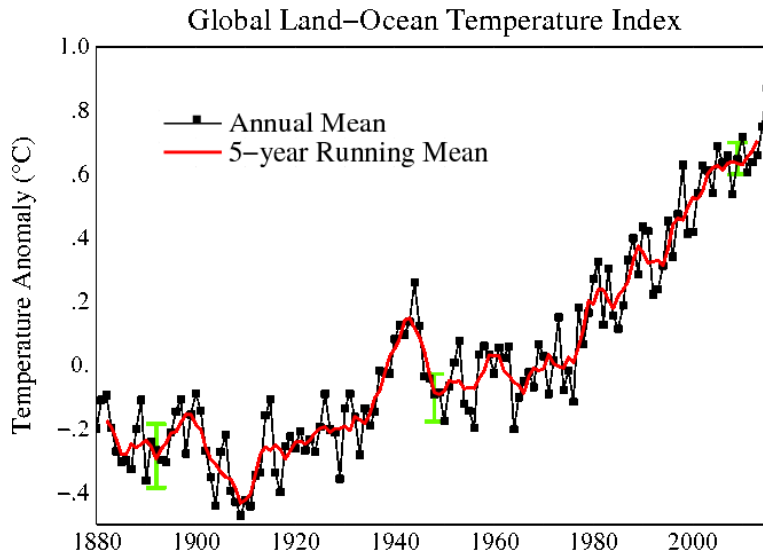


<http://www.skepticalscience.com/solar-activity-sunspots-global-warming.htm>

**Question:** Is the hypothesis that Solar Radiation is the cause of recent global warming supported? Explain.

## Hypothesis 2 - The Milankovitch Cycle (wobble of the Earth) is the cause of recent global warming:

H2-Figure 1 - NASA data depicting the trend in recent global atmospheric temperature



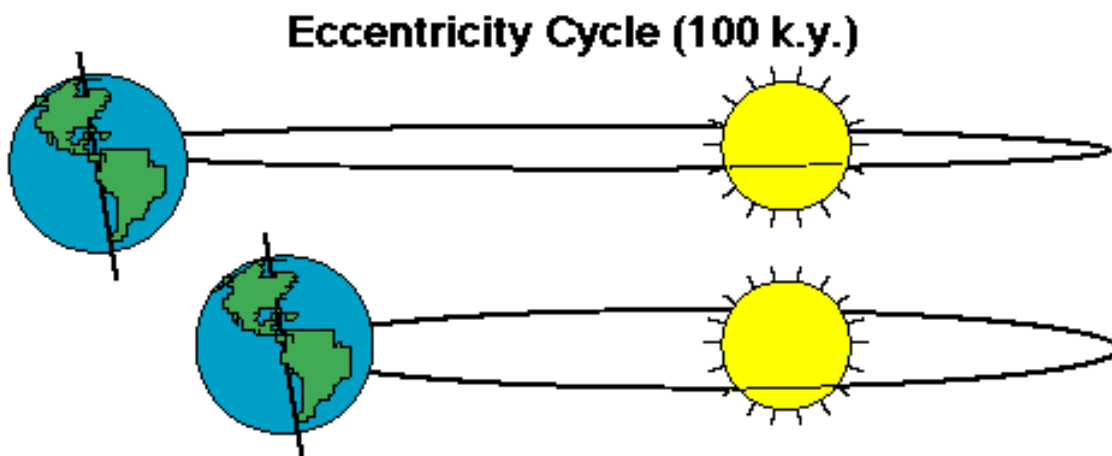
[http://data.giss.nasa.gov/gistemp/graphs\\_v3/fig.A2.gif](http://data.giss.nasa.gov/gistemp/graphs_v3/fig.A2.gif)

### Milankovitch is three sub-cycles

H 2-Figure 2 –Sub-cycle 1: The shape (Eccentricity) of the Earth’s Orbit around the sun varies due to the impact of neighboring planets.

The path of the orbit varies between slighter longer and thinner and slightly fatter due to the gravitational pull of neighboring planets as they approach earth. This influences the annual cycle of intensity of incoming solar radiation.

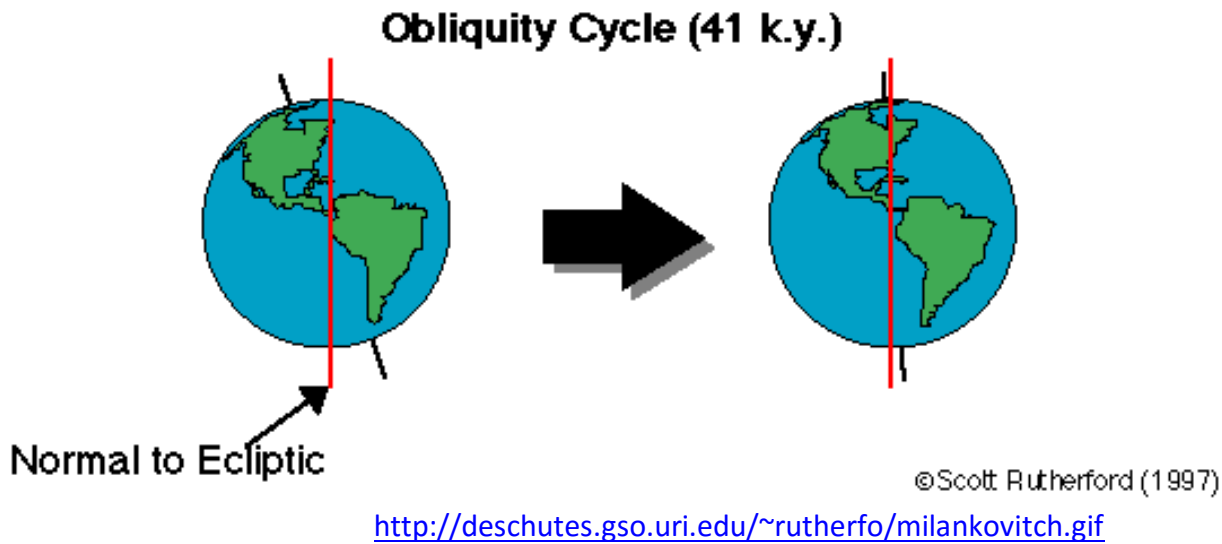
Note: 100 k.y. means 100 thousand years



<http://deschutes.gso.uri.edu/~rutherfo/milankovitch.gif>

H 2-Figure 3 – Sub-cycle 2: The tilt of the Earth (Obliquity of the Ecliptic).

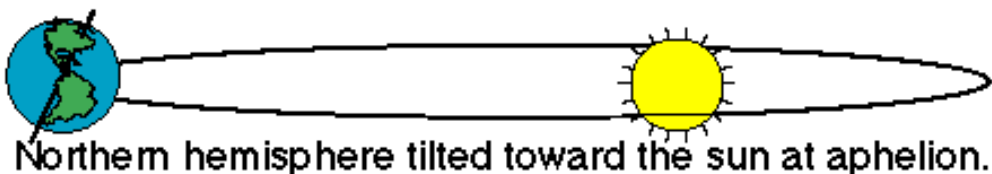
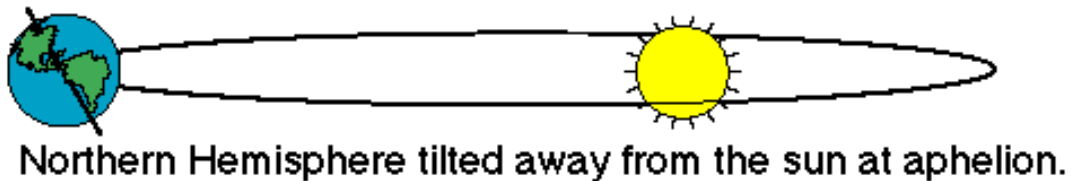
The tilt of the earth away from the vertical axis (red line) causes our seasons. This tilt is not constant. It varies from 22.1 to 24.5-degrees (exaggerated in the image) over a 41,000 year cycle. Currently the tilt is 23.44-degrees. This change in tilt influences the relative difference between summer and winter temperatures.



H 2-Figure 4 – Sub-cycle 3: The rotation of the tilt (Precession of the equinoxes) vary.

The direction of the tilt depicted in sub-cycle 2 is not constant. It also rotates as illustrated in the 2 drawings below. The consequence of this is that the time of the arrival (and departure) of the seasons moves forward on the calendar. For example, winter solstice (now December 21) will move over a 19,000 to 23,000 year cycle through December 20, December 19, and so on.

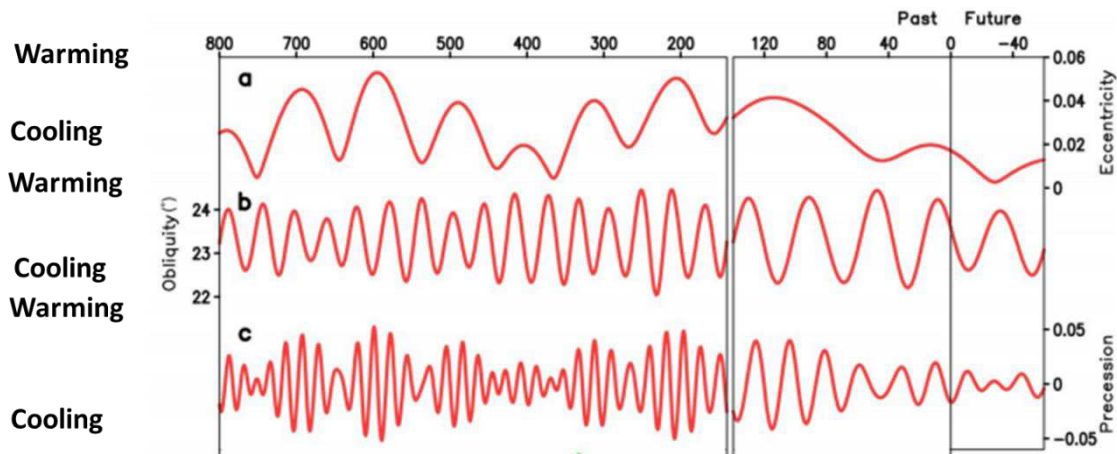
### Precession of the Equinoxes (19 and 23 k.y.)



<http://deschutes.gso.uri.edu/~rutherfo/milankovitch.gif>

H 2-Figure 5 - The current influence of the three Milankovitch sub-cycles on global temperature.

During the course of the overall cycles, the temperature of the earth fluctuates slightly. The impact of these sub-cycles is illustrated in this figure. When the red line is up, the influence is warming, when down, the influence is cooling. Follow these lines from left to right and identify what should be happening to the global temperature (0 is now). The combined impact of the Milankovitch cycles was the driving force behind the ice ages of the last 2 million years.



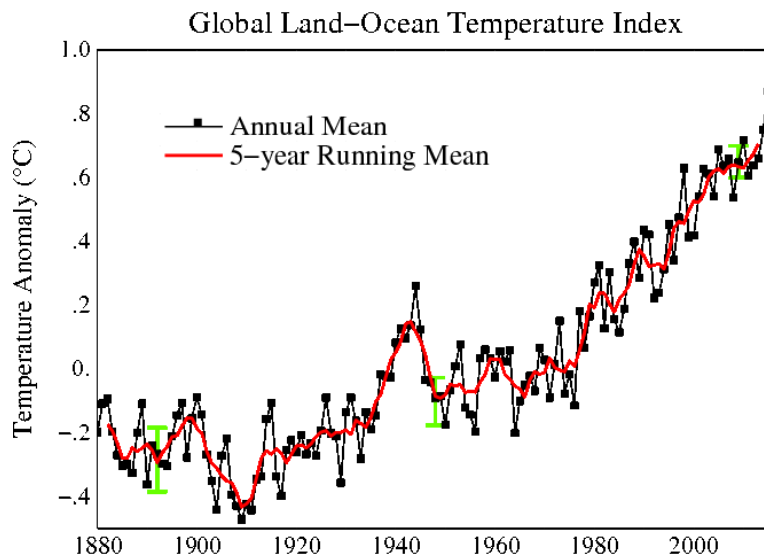
[http://www.stopgreensuicide.com/Ch5\\_Paleo\\_WG1AR5\\_SOD\\_Ch05\\_All\\_Final.pdf](http://www.stopgreensuicide.com/Ch5_Paleo_WG1AR5_SOD_Ch05_All_Final.pdf)

**Question:** Is the hypothesis that the Milankovitch cycle is the cause of recent global warming supported? Explain.

### Hypothesis 3 Volcanic activity is the cause of recent global warming:

What is the correlation between volcanic activity and the El Niño Southern Oscillation (ENSO) and global temperature?

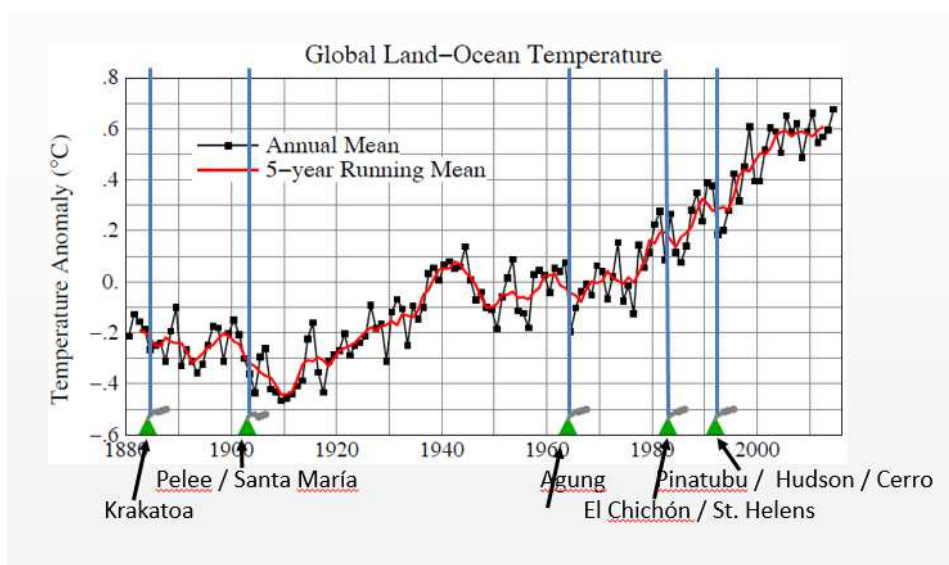
H3-Figure 1 - NASA data depicting the trend in recent global atmospheric temperature



[http://data.giss.nasa.gov/gistemp/graphs\\_v3/fig.A2.gif](http://data.giss.nasa.gov/gistemp/graphs_v3/fig.A2.gif)

H 3-Figure 2 - Global temperature trends with major volcanic eruptions indicated.

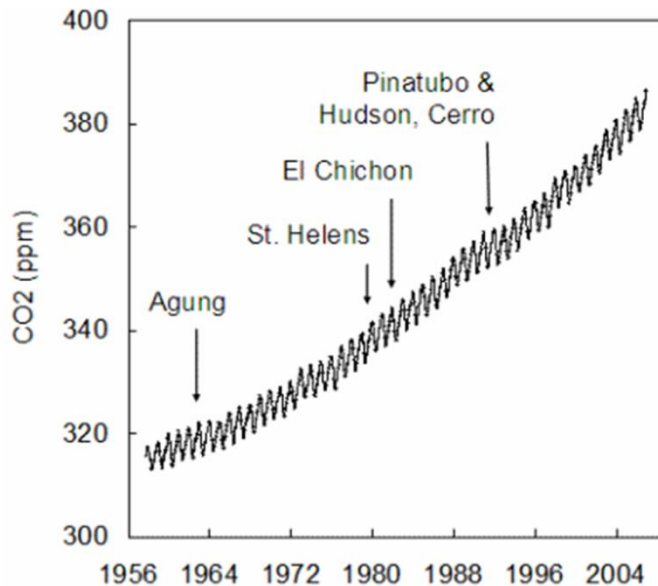
This figure depicts global temperature over the last 130+ years and several major volcanic episodes depicted by the green triangles at the bottom of the figure. Identify what happens to temperature following the volcanic episodes.



<http://csas.ei.columbia.edu/2015/01/16/global-temperature-in-2014-and-2015/>

H 3–Figure 3 - Global atmospheric carbon dioxide concentration indicating volcanic impact.

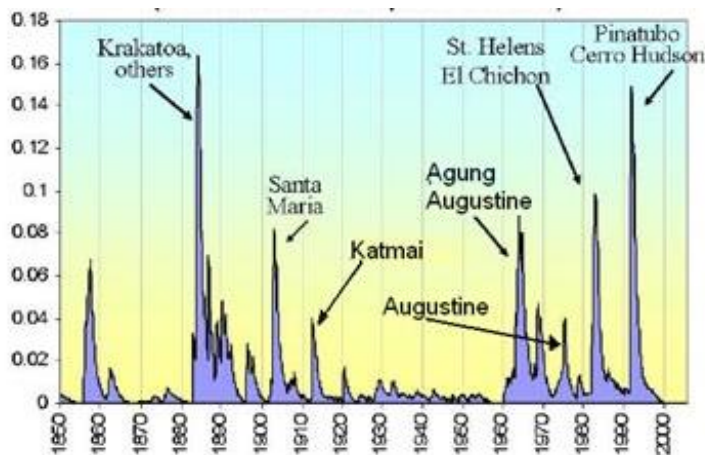
The main gas argued to be responsible for global warming is carbon dioxide. Proponents of this hypothesis claim that, since volcanoes emit carbon dioxide, they are responsible for recent warming. While it is true that volcanoes emit carbon dioxide, compared to human activity, the amount is very small. Identify what the impact of volcanic eruption is on the carbon dioxide trend in the atmosphere.



<http://blogs.edf.org/climate411/2007/05/21/volcanoes/>

H 3–Figure 4 - Stratospheric volcanic aerosol concentration in relation to eruptions

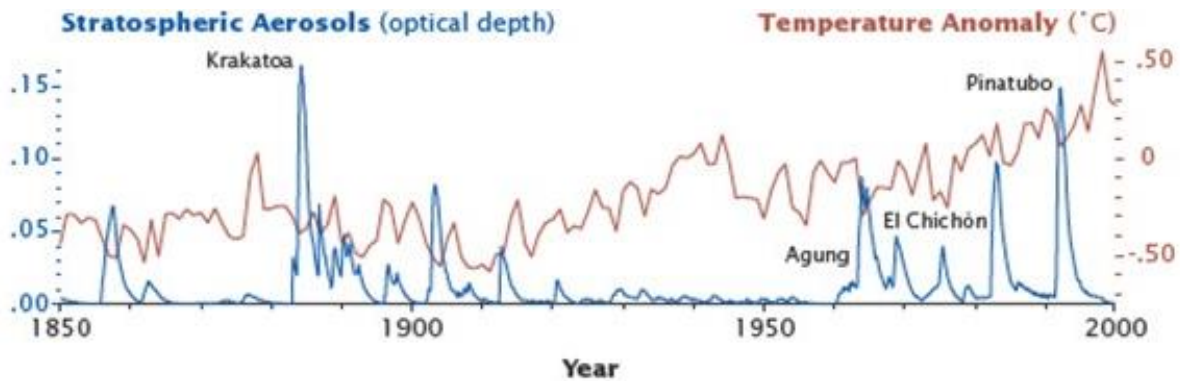
In addition to emitting carbon dioxide, volcanoes emit small particles of ash and droplets of condensing gases. These are collectively known as aerosols. (These are not quite the same as what we commonly call aerosols in aerosol sprays.) Identify what happens to the atmospheric aerosol concentration following volcanic eruptions.



[http://images.intellicast.com/App Images/Article/175\\_16.jpg](http://images.intellicast.com/App Images/Article/175_16.jpg)

H 3–Figure 5 - Stratospheric volcanic aerosol concentration, temperature, and volcanic episodes.

Aerosols in the upper atmosphere reflect incoming radiation back out into space, thus preventing its reaching the earth's surface. This has a slightly cooling effect on the global temperature. In this figure, aerosol concentration (blue) is illustrated in relation to temperature (red). Identify what happens to atmospheric temperature following the volcanic eruptions (named in black).

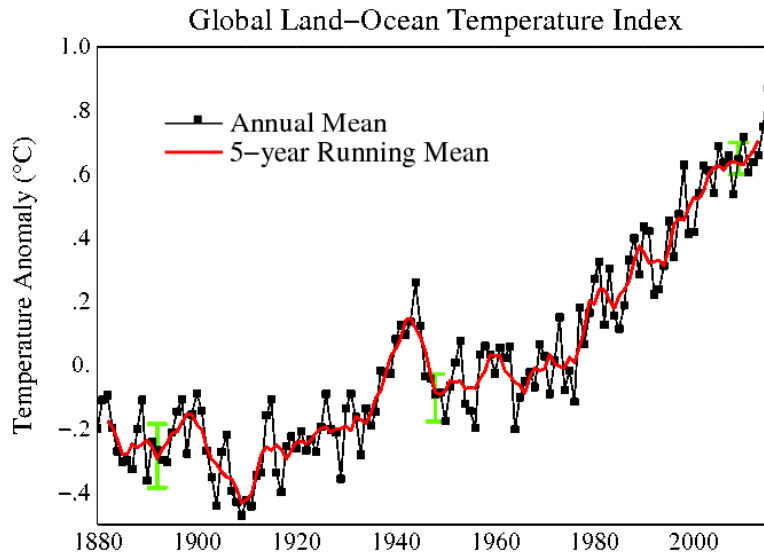


<http://earthobservatory.nasa.gov/Features/Aerosols/page3.php>

**Question:** Is the hypothesis that Volcanic activity is the cause of recent global warming supported? Explain.

## Hypothesis 4 - The El Niño Southern Oscillation is the cause of recent global warming:

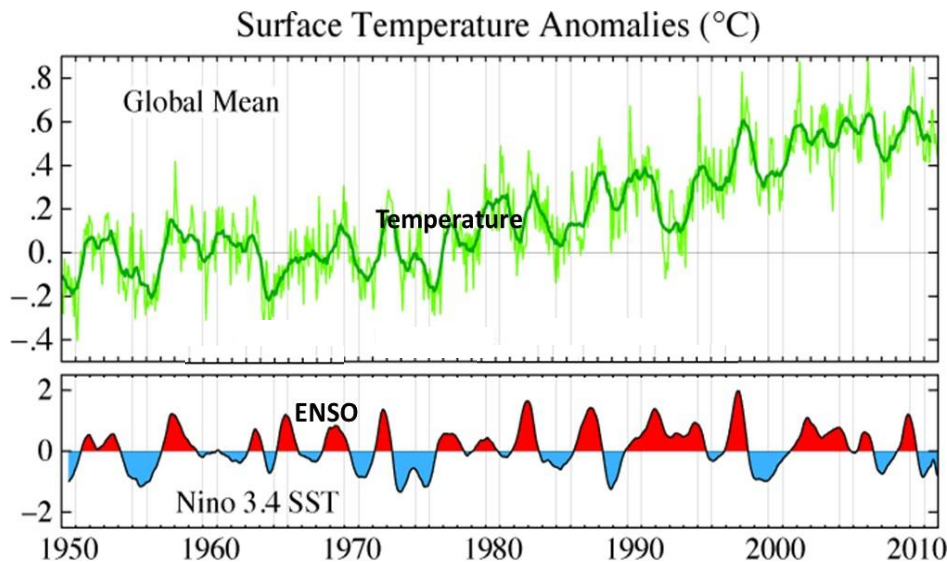
H4-Figure 1 - NASA data depicting the trend in recent global atmospheric temperature



[http://data.giss.nasa.gov/gistemp/graphs\\_v3/Fig.A2.gif](http://data.giss.nasa.gov/gistemp/graphs_v3/Fig.A2.gif)

H 4–Figure 2 - Sea surface temperature in the Pacific compared to El Niño warming (red) and La Niña cooling (blue).

The El Niño Southern Oscillation (ENSO) is a cycle involving ocean currents and wind directions in the tropical Pacific Ocean. The net effect of this cycle is a slight warming during El Niño (red) and a slight cooling during La Niña (blue). These phases alternate on a somewhat irregular basis. This figure depicts the Sea Surface Temperature (SST; green) at a location designated as Nino 3.4 in the Pacific Ocean. Identify the relationship between El Niño patterns and surface temperature (green).



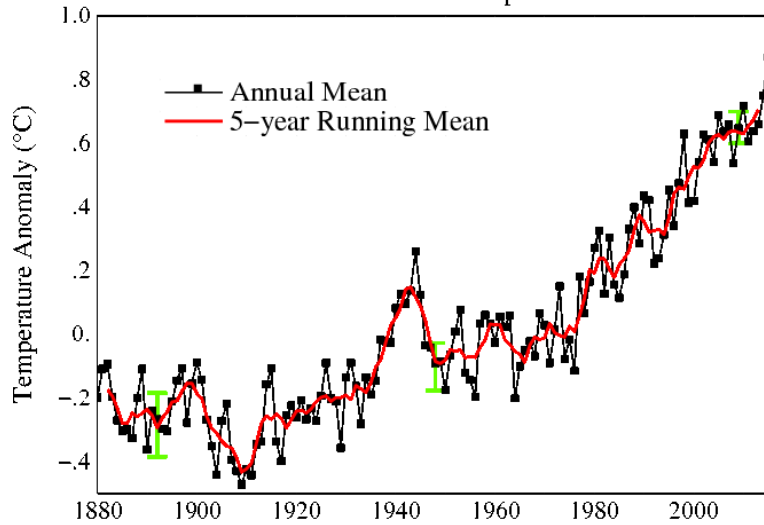
<http://data.giss.nasa.gov/gistemp/2011/>

**Question:** Is the hypothesis that The El Niño Southern Oscillation is the cause of recent global warming supported? Explain.



## Hypothesis 5 - Greenhouse Gas Emissions are the cause of recent global warming:

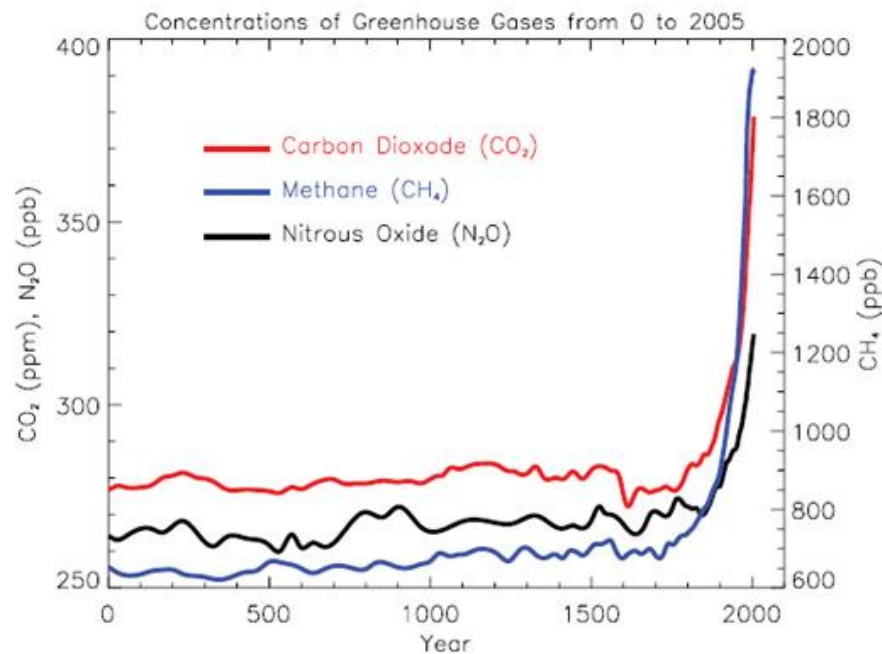
H5-Figure 1 - NASA data depicting the trend in recent global atmospheric temperature  
Global Land–Ocean Temperature Index



[http://data.giss.nasa.gov/gistemp/graphs\\_v3/Fig.A2.gif](http://data.giss.nasa.gov/gistemp/graphs_v3/Fig.A2.gif)

H5-Figure 2 – Atmospheric concentration of the dominant greenhouse gases (Carbon Dioxide, Methane, Nitrous Oxide) over the last 2,000 years.

Identify the trends in concentrations of the greenhouse gases: Carbon Dioxide (ppm), Methane (ppb), and Nitrous Oxide (ppb) over the last 2,000 years.



<http://www.global-greenhouse-warming.com/greenhouse-gas.html>

**Question:** Is the hypothesis that greenhouse gases are the cause of recent global warming supported? Explain.