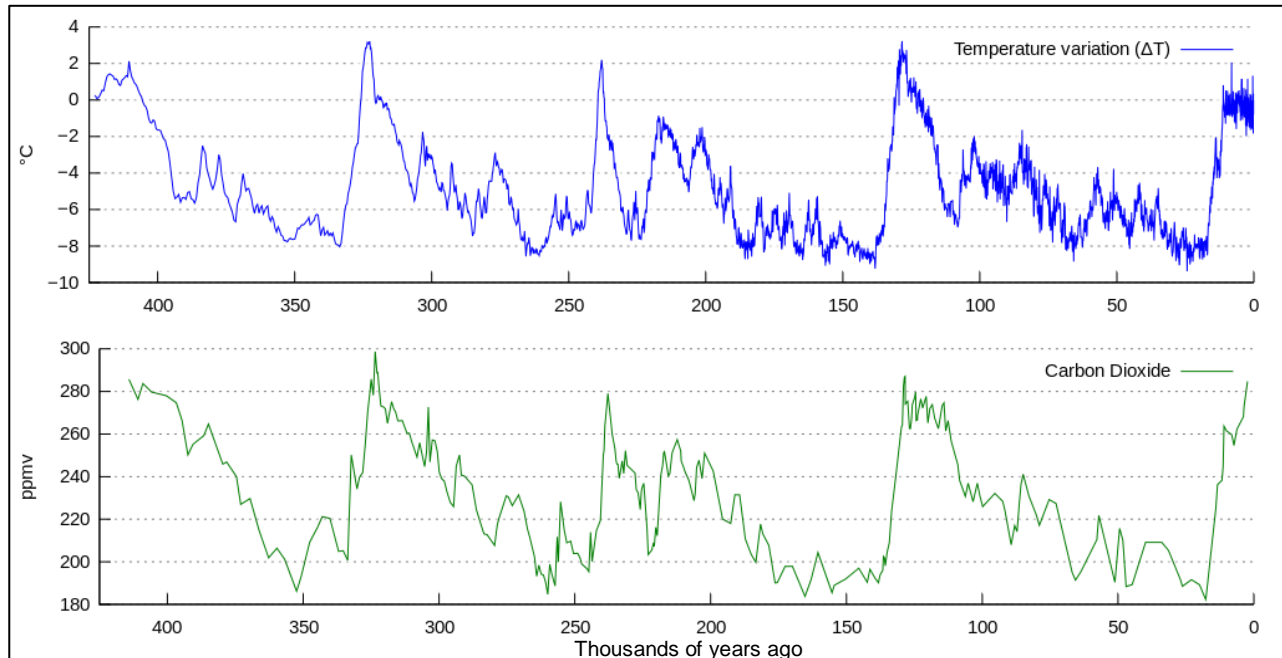


## How can the ice core evidence for climate change be explained? An educational opportunity for discussing evidence, hypotheses and possible responses

The Vostok ice core was drilled through the oldest part of the Antarctic ice sheet to gather data on the climate of the Earth thousands of years ago. The ice sheet is formed of hundreds of thousands of layers of annual snowfall, which contain information on the temperature of the Earth at the

time (through the composition of their oxygen isotopes) and the amount of carbon dioxide in the atmosphere at the time (trapped in microscopic bubbles of air).

The results are shown in the two graphs below.



From: Vostok Petit data.svg, published under the Creative Commons Attribution-Share Alike 3.0 Unported licence.

To answer the questions that follow, your pupils will need to know that there is a lot of scientific data showing that the Earth is warming today. There are also several so-called 'greenhouse gases', including water vapour, carbon dioxide and methane, which absorb heat re-radiated from the Earth's surface, and so keep the atmosphere (and the Earth underneath), warmer than they otherwise would be. They should also know that cold sea water can dissolve more carbon dioxide than warm sea water.

Ask your pupils to discuss, based on the graphs, which of the following could be possible:

1. increased carbon dioxide in the atmosphere leads to increased temperatures;
2. the amount of carbon dioxide in the atmosphere and the temperature are not related to each other;
3. increased temperatures lead to increased amounts of carbon dioxide in the atmosphere;
4. increased temperatures AND amounts of carbon dioxide are being caused by something else changing.

They might conclude that there is a relationship between carbon dioxide in the atmosphere and temperature (so statement 2 is incorrect) but that any of the other three statements could be correct.

This would lead to further discussion on:

1. If increased carbon dioxide in the atmosphere leads to increased temperatures – how can this be explained? *A. increase in the greenhouse gas, carbon dioxide, leads to increased warming.*
3. If increased temperatures lead to increased amounts of carbon dioxide in the atmosphere –
  - a. How can this be explained? *A. Warm sea water can hold less carbon dioxide than cold sea water.*
  - b. How can the increase in temperature be explained? *A. If increases in carbon dioxide are not causing the warming, then warming may be caused by increases in other greenhouse gases, e.g. water vapour or methane, or by changes in the amount of solar energy received by the Earth – Milankovitch cycles, discussed below.*
4. If changes in both are being caused by 'something else' – what might that be? *A. Some possibilities are discussed above.*

This would then lead onto more discussion of, in cases 1, 3 or 4, how humans should respond to these changes.

## The back up

**Title:** How can the ice core evidence for climate change be explained?

**Subtitle:** An educational opportunity for discussing evidence, hypotheses and possible responses

**Topic:** An opportunity to show how a complex scientific topic can be used in the classroom to show how science depends upon evidence and interpretation.

**Age range of pupils:** 14 years onwards

**Time needed to complete activity:** 15 minutes

**Pupil learning outcomes:** Pupils can:

- discuss whether 'correlation does not prove causation';
- describe similarities and differences between graphs of data;
- explain different interpretations of any similarities noted;
- explain why scientists can come to different conclusions based on the same data;
- explain why 'climate change' is a complex issue.

### Context:

Climate change is sometimes described as one of the 'wicked' problems, one that is very difficult to address because evidence is contradictory, interacting and changing, whilst the 'goalposts are moving'. Nevertheless, not only is it important to address such issues educationally, but it provides excellent opportunities for good science teaching.

This exercise addresses the issue of whether 'correlation does not prove causation' (that if two factors correlate, whether one causes the other, or *vice versa*, or whether both may be linked to a third variable and so they are not directly linked to one another).

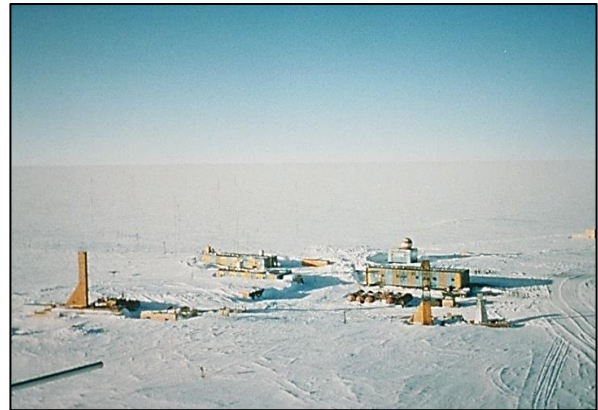
The evidence for Earth's warming today includes: regular increases in global temperatures; increased melting of ice caps, glaciers, and Arctic sea ice; migration of species towards the poles; bleaching of the Great Barrier Reef off Australia due to unusually warm seas.

The scientific principles behind greenhouse gases causing global warming are widely discussed on the internet.

The variation in the amount of solar energy received by the Earth was predicted by Milankovitch based on different properties of the Earth's rotation as it circles the Sun. There is current scientific disagreement about the importance of these effects, with some scientists interpreting the data to show the Earth should be cooling whilst others predict slight warming of the Earth (but not at the rate currently being seen).

The Vostok ice core data have been largely confirmed by ice-core drilling elsewhere.

Some scientists argue that when the variations in the Vostok core are studied in detail, the increase in carbon dioxide comes AFTER the increase in temperature.



View of the Vostok core-drilling site.

*Published by Todd Sowers, LDEO, Columbia University - in the public domain because it originally came from the U.S. National Oceanic and Atmospheric Administration.*



French, Russian and American scientists in the Vostok team photo, holding ice cores.

*From: [http://www.ncdc.noaa.gov/paleo/slides/slideset/15/15\\_305slide.html](http://www.ncdc.noaa.gov/paleo/slides/slideset/15/15_305slide.html) Todd Sowers, LDEO, Columbia University and in the public domain from the U.S. National Oceanic and Atmospheric Administration.*

Given the evidence that the Earth is warming, that this may be being caused by increased levels of greenhouse gases in the atmosphere, and that these increases are likely to be due to human activity, a sensible response would be to reduce the levels of greenhouse gases being released into the atmosphere.

### Following up the activity:

The Vostok data show that the amount of methane in the atmosphere also varies in a similar way to that of carbon dioxide. Methane is a more powerful greenhouse gas than carbon dioxide but its levels in the atmosphere are much lower and it comes out of the atmosphere at faster rates than other greenhouse gases. Pupils could discuss the possible importance of methane, given these factors.

**Underlying principles:**

- When data correlate, the cause of the correlation should be debated before linkage between the variables is assumed, and then the form of the linkage also needs careful examination.
- There is evidence from a range of sources that the Earth is in a warming phase today.
- There is ice core evidence that warming Earth temperatures correlate with increased amounts of carbon dioxide and methane in the atmosphere.
- There is disagreement amongst some scientists over whether increased temperatures are being caused by increased amounts of greenhouse gases or *vice versa* or even if a third variable might be involved.
- A sensible response to most 'global warming' scenarios would be to reduce the volumes of greenhouse gases being added to the atmosphere by human activity.

**Thinking skill development:**

This exercise involves pattern-seeking or construction, with debate around the results producing cognitive conflict and metacognition. Discussions around how the results should be interpreted and how humans should respond involve bridging to today's situation.

**Resource list:**

- copies of the two graphs for pupils to examine

**Useful links:**

- Graphs of the Vostok core data can be found by typing 'Vostok core' into a search engine like Google™.
- The British Geological Survey 'Climate through time' poster available at:  
<http://www.bgs.ac.uk/discoveringGeology/climateChange/climateThroughTime.html>

**Source:** Chris King of the Earthlearningidea Team.

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