Teachers' notes

Why is carbon dioxide so important? – examining the evidence

These notes accompany the PowerPoint presentation *correlation_causation.pdf*

Introduction

In working through this activity students should be able to appreciate that there is a considerable body of evidence linking global climate change (particularly temperature changes) to rising carbon dioxide levels. They should also learn that no single piece of evidence is conclusive and that carbon dioxide is not the only factor involved.

Questions for the students are included in the 'Notes' window of the PowerPoint slides.

Sequence

The **introductory page** (Slide 1) can act as the focus of a short class discussion. We see so much information on carbon dioxide as the major influence on climate change that they may never have considered the basis for the hypothesis.

Students could then work through the activity alone or in pairs, discussing the two questions for each piece of evidence and writing short notes on their answers.

The **final section** (Slides 12-13) invites them to think about different kinds of evidence. These are useful examples so that, although the answers should be fairly obvious, it is a worthwhile activity.

The **conclusion** (Slides 14-15) can again be a class discussion. Further information from climate sceptics could be introduced here to extend the activity.

Notes for slide 11

Climate models consist of equations which represent all the important processes which go on in the atmosphere and oceans and on the land. Some of these equations represent how radiation is absorbed and re-emitted by the different gases in the atmosphere.

This figure shows observations of temperatures on the different continents as well as the temperature produced by two different climate models. In one model (red) the composition of the atmosphere is changed with time according to observations of how it has actually changed. The model shows warming temperatures, in excess of what actually happened. In the second (green) model, other effects are added – how the amount of radiation emitted by the Sun changed over the period, changes in composition of the atmosphere due to volcanic eruptions (which emit a lot of dust which reflects incoming solar radiation) as well as how the quantity of other aerosols (such as sulphur from industrial processes) in the atmosphere has changed. This green model does a much better job at reproducing how the climate of the 6 continents changed over the last 100 years.

Notes for slide 14

There is a lot of uncertainty in climate models. Two models which do equally well at reproducing the climate of the 20th century may produce very different forecasts of the 21st century. The 'error bars' on the model forecast get bigger as you go further into the future. It is not possible to say exactly what will happen, but it may be possible to work out what is most likely to happen. That's what the climateprediction.net project is trying to do.

Suggested answers

A Antarctic Ice cores

1. Over these long time scales the correlation is impressive. Periods of higher temperature are always accompanied by higher carbon dioxide concentrations.

2. Correlation does not prove causation, both could be caused by a common third factor.

There are several anomalies where temperature falls despite high carbon dioxide, e.g. 120 000 BP.

The data contains many uncertainties.

Much of it is from only one source, ice cores from Lake Vostok, Antarctica.

B Last 150 years

1. Dramatic rise in carbon dioxide correlates with recent rapid rise in temperature.

2. Temperature rise only from 1920s though carbon dioxide started rising before this. This could be explained by heat capacity of oceans.

Correlation does not prove causation.

C Gases and radiation

1. This provides a mechanism to explain the causal effect suggested by the correlations.

2. There is dispute over the relative magnitude of the effect of the water vapour. Water vapour concentrations fluctuate over a wide range of values.

D. Using theory to make predictions

1. Using the assumed effect of greenhouse gases to make predictions leads to reasonably accurate predictions when tested against actual observations.

2. The predictions which also include other factors are consistently more accurate than those using greenhouse gases only.

The models include all greenhouse gases, not just carbon dioxide.

climateprediction.net