Global Warming

Answers

1. Looking at the trends

(a) Why is there an annual fluctuation due to growing plants?
CO_2 is taken up in photosynthesis and given out in respiration. During a growing season plants will be photosynthesising at a much higher rate, so uptake of CO_2 reflects this.

(b) Which process is affecting the fluctuation? Mainly photosynthesis.

(c) What is the trend over the years from 1959? Increase in CO_2

(d) Why is it useful to have both the monthly averages and the annual averages plotted?
The monthly average is of interest because it shows the fluctuations due to the growing season. It could be that a change in length of the growing season indicates climate change.
The annual average smoothes the data so that the overall trend is clear i.e. that CO_2 concentration is increasing from year to year.

(e) What is the approx. increase in CO_2 between 1930-40, 1960-70, 1980-90?
8-10ppm, 10-12ppm, 15-18ppm

(f) What is happening to the rate of increase?
It is increasing.

(g) How may deforestation bring about local climate change?
The transpiration is reduced resulting in less precipitation and less evaporative cooling.

(h) Does deforestation always increase CO_2 emissions?
When a forest is cut and burned CO_2 is immediately released into the atmosphere as the carbon compounds stored in the wood is converted to CO_2. This would not be the case if the wood was not burned. If the wood was left to rot the same process would occur, but much more slowly, through decomposition. Replacing the forest with a productive crop could result in *increased* rate of uptake of CO_2, but the soil is rarely fertile enough for this, and the carbon stores in the wood still account for huge emissions.

(i) Why is it that an area in the tropics may become much less 'productive' after deforestation, even if a crop is planted or grassland replaces the forest?
The nutrients are stored in the 'standing crop' in a forest, i.e. the trees. When these are removed, the nutrients are removed, leaving an infertile soil. If the trees are burned on site, the ash contains nutrients, but in a form that is easily leached out of the soil by heavy rainfall. Absence of tree cover and tree roots will increase the effect of leaching.

References

Textbook
Chapter 12 page 156

Specification
10.4 Fuels and the global environment

(j) How will this affect CO_2 emissions in an area?

CO_2 emission occurs when wood is burned. As mature forests in dynamic equilibrium take up CO_2 at a similar rate to its emission, it is not correct to state that emissions will increase if forest is removed, apart from the large emission due to release of the stored carbon during burning.

(k) Is there any evidence from this data that CO_2 causes global warming?

If two variables appear to be correlated, this does not mean that one is caused by another. Correlation between variables is useful evidence along with other evidence, e.g the link between increase in CO_2 and temperature is supported by data showing that CO_2 acts as a greenhouse gas.

2. Examining the data

(a) Why is it appropriate to show e.g. a value for monthly average temperature over several years rather than continuous plots of temperature?

The important variable being examined here is the changes in temperature over the years. An average value removes the regular fluctuations due to time of day, weather conditions etc., allowing a clearer comparison to be made between the years.

(b) Summarise why anomalies are useful rather than absolute values.

Anomalies are the departure from average of a particular value. They are used to describe climatic variability over large areas, especially where there may be large differences between the recording stations, e.g. in valley and up a mountain the absolute temperature will be very different. If both sets are compared with the normal average temperature for that site for the time of year, this anomaly figure from both sites can be combined to give an average over a wide geographic area.

(c) The raw data on climate change can rarely be used without adjustment. Why may adjustments need to be made?

New instruments and observing procedures - changes may affect readings; station moves to different location; station closures may affect the average of a larger area; urbanisation, defoliation, or foliation of the local area surrounding a station will affect the climate, but these changes must be separated from the overall trend due to global factors; data processing techniques may affect the final figures.

(d) Now work out which gas in 1994 had the most effect on global warming. You need to use the ppbv of the gas, and the GWP for that gas to calculate the effect.

GAS		**Global warming effect**
CO_2	358,000 x 1 =	358,000
Methane :	1,721x 21 =	36,141
Nitrous Oxide :	311 x 310 =	96,410
CFC-12 :	0.503 x 6,650 =	3,344.95
HCFC-22 :	0.105 x 1,350 =	141.75
Perfluoromethane :	0.070 x 6,500 =	455
Sulphur hexa-fluoride :	0.032 x 23,900 =	764.8

(e) Why do you think there may be some differences?

The perception of which gases are contributing most to global warming will reflect the publicity and reading that you have been exposed to. It could be that publicity is aimed at the anthropomorphic activities which can realistically be reduced by individuals, e.g. using your car less. There may be less highlighting of the use of fertilisers for the general public in this context.

It is important to understand which of these gases have increased significantly over the years due to human activity, as a large effect on global warming does not necessarily indicate that humans are responsible.

(f) Using the information in the report, and the data in the table of greenhouse gases used above, and your calculations, how would you legislate internationally for the reduction of greenhouse gases? List the questions you would need to ask, and the information you would need to know in addition to the relevant facts you already know.

Some important points here include :

From the table of data, it is necessary to look at whether the gases have actually increased by a significant % over the period, whether there are anthropomorphic reasons for this increase, and whether there is a realistic mechanism for reducing them.

There may be benefits e.g. of using fertilisers, that need to be weighed against benefits of reducing their use to reduce global warming.

The legislation needs to take into account the fact that developed countries may need to be subsidised to introduce 'cleaner' technologies.

(g) Suggest why it not possible to give an exact value of GWP?

It could be that GWP values are calculated in a laboratory situation with pure gases which does not directly translate to gases in an atmospheric mixture of gases. Other gases and particles present and other factors such as radiation present from other sources may affect GWP.

3. Making predictions about the future

(a) Summarise the assumptions that have to be made in order to model predictions in this way.

Assumptions need to be made about future legislation affecting emissions, introduction of cleaner technologies, population growth, rate of deforestation etc.

(b) What are the problems with coming to conclusions about the effect of human activities on global warming?

The above assumptions produce a widely varying set of models predicting the future, and much of the data collected is open to interpretation form both sides of the argument. It is difficult to give proof of cause and effect in such a complex system, with so many factors affecting the outcome.

GLOBAL WARMING

An activity in the following four stages:
(1) Looking at the trends The fluctuations and trends are related to cause and effect.
(2) Examining the data The problems with collecting data of this nature and presenting it in a meaningful way are examined. Why average values and anomalies are used, and why the raw values need to be adjusted.
(3) Making predictions about the future Global warming is a complex issue and modelling for the future involves making assumptions.
(4) The overall picture A time line is produced as a group activity to summarise the information discovered about this topic.

1. Looking at the trends

One cause of global warming is the presence of greenhouse gases such as CO_2 in the atmosphere. Examine the graph of CO_2 measurements taken in Mauna Loa: http://www.climateark.org/vital/06.htm

(a) Why is there an annual fluctuation due to growing plants?
(b) Which process is affecting the fluctuation?
(c) What is the trend over the years from 1959?
(d) Why is it useful to have both the monthly averages and the annual averages plotted?

Go to the graph of global atmospheric CO_2 concentrations
http://www.climateark.org/vital/07.htm
(e) What is the approx. increase in CO_2 between 1930-40, 1960-70, 1980-90?
(f) What is happening to the rate of increase?

http://earthobservatory.nasa.gov/Library/Deforestation/deforestation_3.html
(g) How may deforestation bring about local climate change?
(h) Does deforestation always increase CO_2 emissions?

What about if mature forest is replaced by a rapidly growing agricultural crop? In a mature forest there may be a 'dynamic equilibrium' where CO_2 taken up in photosynthesis is equal to CO_2 produced in respiration. Most agricultural crops have a high rate of production where photosynthesis exceeds respiration.

(i) Why is it that an area in the tropics may become much less 'productive' after deforestation, even if a crop is planted or grassland replaces the forest?

See http://earthobservatory.nasa.gov/Library/Deforestation/deforestation_4.html
(j) How will deforestation affect CO_2 emissions in an area?

Examine the temperature and CO_2
for the past 10000 years:
http://www.climateark.org/vital/02.htm
(k) Is there any evidence from this data that CO_2 causes global warming?

2. Examining the data

Most of the data on climate change shows *average values* and *anomalies* rather than every actual reading.
(a) Why is it appropriate to show e.g. a value for monthly average temperature over several years rather than continuous plots of temperature?

http://lwf.ncdc.noaa.gov/oa/climate/globtemp.html
Read this explanation of why anomalies are used rather than absolute temperatures for an area.

(**b) Summarise why anomalies are useful rather than absolute values.**

http://www.ncdc.noaa.gov/ol/climate/climateresearch.html#ABOUT
Read the section on 'How Climate Data is Used'
(c) The raw data on climate change can rarely be used without adjustment. Why may adjustments need to be made?

http://www.climateark.org/vital/intro.htm
Look at the data showing the main greenhouse gases.
(d) Looking only at the left hand list of gases, quickly put these gases into an order, with the gas you consider has the greatest effect on global warming at the top.
Now work out which gas in 1994 had the most effect on global warming. You need to use the ppbv of the gas, and the GWP for that gas to calculate the relative effect.

Do your calculations give the same order as you had in your list?

(e) Why do you think there may be some differences?

The download 'The Scientific basis : summary for policy makers' from the IPCC working group: http://www.grida.no/climate/ipcc_tar/vol4/english/pdf/wg1spm.pdf gives a good summary of data collected and effects on climate etc. (This is a download about half way down the page.)
(f) Using the information in the report, and the data in the table of greenhouse gases used above, and your calculations, how would you legislate internationally for the reduction of greenhouse gases?
List the questions you would need to ask, and the information you would need to know in addition to the relevant facts you already know.
You could compare your legislation with the actual legislation researched in activity 4.

Notice from the text below the data table that there is an 'uncertainty value' on GWP of +/- 35%.
(g) Suggest why it not possible to give an exact value of GWP?

3. Making predictions about the future

http://yosemite.epa.gov/OAR/globalwarming.nsf/content/Impacts.html
Browse through the data showing potential impacts of climate change.
(a) Summarise the problems and the assumptions that have to be made in order to model predictions in this way.

http://www.ucsusa.org/global_environment/global_warming/index.cfm and select Fact vs Fiction.
This site answers some of the arguments disputing global warming predictions.
(b) What are the problems with coming to conclusions about the effect of human activities on global warming?

4. The overall picture

(group activity)

Use the web sites from this activity and from the SPU web site to create a summary time line on global warming running from e.g. 1800 to 2100. Members of the group can be given one area to research.

http://www.newscientist.com/global/globaltimeline.jsp you may need to select timeline
http://www.greenpeace.org/~climate/climatecountdown/

Include very brief notes on:
- the developments and discoveries which informed thinking on global warming
- international conferences and legislation relating to global warming
- data to summarise any changes e.g. CO_2 levels, temperature, sea levels and wider effects of these changes e.g. desertification, species migration/extinction, flooding etc.

Present the timeline in a suitable format to all the class.