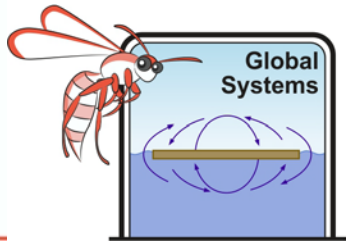


Humans and Climate – Teachers Notes

Science will accept evidence (data) that is collected in a properly conducted experiment which is observable, measurable and repeatable. This sort of data has been and is being collected for current climate change investigations.

1. **Evidence that the level of carbon dioxide level in air is increasing.**
   Many scientists around the globe have directly measured increasing levels of CO_2 in the atmosphere over both terrestrial and oceanic environments during the last 40 years or so. This data has been extrapolated back to cover the last 420,000 thousand years by adding ice core data from Antarctica. Ice traps air bubbles containing CO_2. The data supports the concept that a rapid increase of CO_2 in the atmosphere began from the start of the Industrial Revolution and has continued to increase since then.

   Does this data support the concept that a change in human behavior, the increased use of fossil fuels as humans became more industrialised, caused an increase of carbon dioxide levels in our atmosphere? Yes.

   Is this data:

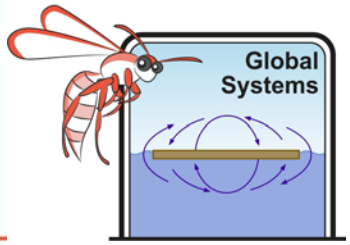
Observable	Measurable	Repeatable
X	X	X

   How can the quality of this data be improved? Test more areas, repeat measurements and improve accuracy and precision of measuring instruments.

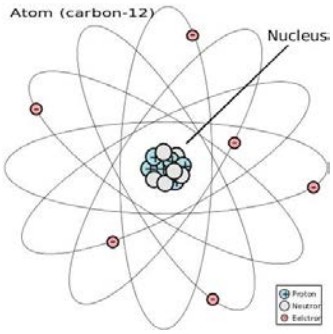
   Does this data alone ***prove*** human behaviour is responsible for climate change? No, but it supports the proposition that carbon dioxide levels in the atmosphere are increasing and have done so since the Industrial revolution.

   Is this primary evidence, secondary evidence or proxy evidence? Primary evidence as it was collected for this purpose using scientific methods.

   We also have historical records from books and stories, which indicate that our land clearing, forest burning, industrial activities and burning of fossil fuels increased rapidly since the Industrial Revolution. Is this primary evidence, secondary evidence or proxy evidence? Proxy evidence. It infers that this MAY be so but does not rely directly on observable data.



2. Evidence from isotopes of carbon indicating increased carbon dioxide levels in the atmosphere due to human activity (the burning of fossil fuels).



Carbon exists as three isotopes ^{12}C, ^{13}C and ^{14}C. Isotopes are atoms with the same number of protons and therefore the same chemical behaviour but they have different numbers of neutrons. ^{12}C is the most common carbon atom found naturally, ^{13}C is only 1% of all carbon atoms, and only one atom in one trillion is ^{14}C. Plants have a lower ^{13}C to ^{12}C ratio than the atmosphere. Fossil fuels are made from plants. And therefore burning them would cause the ^{13}C to ^{12}C ratio to drop even further. Plotting the proportions of carbon isotopes trapped in air bubbles in ice core demonstrates directly this measurable drop since 1850.
Does this data suggest that human behavior rather than outgassing from volcanic activity or any other natural process is the most likely cause of the increase in carbon dioxide levels?Yes

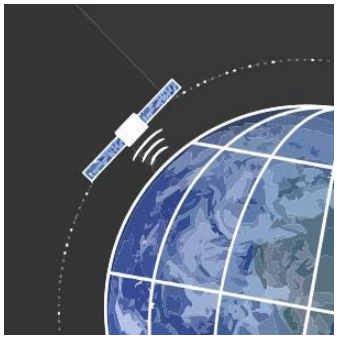
Is this data:

Observable	Measurable	Repeatable
X	X	X

Is this primary evidence, secondary evidence or proxy evidence? Primary evidence. It was collected for this purpose using scientific methods.

Does this data prove human behavior alone is responsible for climate change? No, but it supports that proposition.

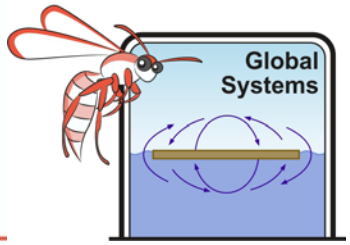
3. Evidence of increased retained atmospheric heat from space based satellites.



Most radiation from the Sun is directly reflected back into space. Since 1970, space satellites in varying orbits round the planet have measured the amount of infrared radiation being reflected back to space. Satellite data demonstrates that our planet is reflecting increasingly less infrared (heat) radiation. Our atmosphere is retaining the heat, and warming.

These observations agree with surface measurements, which also demonstrate that the atmosphere is warming. Over this period solar radiation hasn't increased, indeed measurements suggest the Sun has become a little cooler over the last 35 years. The infrared energy level increase must be due to reduced reflection and/or increased absorption within Earth's atmosphere.

Does this data suggest the increase of temperature is due to increased energy from the Sun? No.



What does this data indicate? It indicates that the mechanism for retaining the heat must lie within the atmosphere.

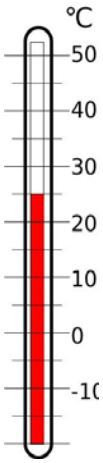
Can we use this data to say that human behavior is responsible for increased heat in the atmosphere? Not directly.

Is the data:

Observable	Measurable	Repeatable
X	X	X

Is this primary evidence, secondary evidence or proxy evidence? Primary evidence as it was collected for this purpose using correct scientific methods.

4. Evidence of rising surface temperatures

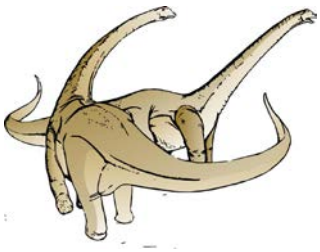


In Australia, Bureau of Meteorology records show that 15 of the last 16 years have been the hottest on record.

Can we take this alone as evidence that the planet is warming?
No, we need records from across the world to demonstrate that this is a global phenomenon. Some areas could be cooling down.

The "State of the Climate" report 2016 by CSIRO and the Bureau of Meteorology however adds more information in its global section. It notes that our planet's average CO_2 levels are steadily rising. Current levels are the highest in the last two million years. 2015 was the warmest year on record for the globe since reliable surface records began in 1880. Globally averaged ocean temperatures and heat content are increasing.

5. Geological evidence of past periods of warming coinciding with high CO_2 levels.

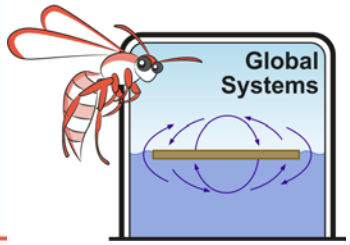


For about ten million years before the K/T (or K-Pg) Extinction event when dinosaurs died, there is geological evidence for rapid climatic warming, or desertification. Concurrent volcanic activity may have released large amounts of CO_2 into the atmosphere increasing atmospheric temperatures.

The greatest extinction event in Earth's history, known as The Great Dying was also accompanied by a long period of desertification and volcanism. 0ver 95% of living things died out, including marine life. Coral and bivalve skeletons were obviously reduced suggesting that the oceans has become acidified by increasing levels of CO_2.

Is this primary, secondary or proxy evidence of climate change? This is proxy evidence that relies on interpretation. Interpretations can vary from scientist to scientist. We need more observable, measureable and repeatable data.

Humans and Climate – Teachers Notes



Bringing the different sources of evidence together.

Can we now propose that carbon dioxide levels are increasing? Yes.

Where does this evidence come from? Measurements of increased CO_2 levels in the atmosphere directly and from ice core.

Can we now propose that burning fossil fuels releases CO_2 into the atmosphere? Yes

Where does this evidence come from? Carbon isotope ratio measurements.

Can we propose that our atmosphere is getting hotter? Yes.

Where does this evidence come from? Satellite and surface monitoring.

Can we state that the three pieces of evidence above ***proves*** that humans burning fossil fuels, clearing land and burning forests have caused global climate change? No, but we can state that all this evidence supports that concept and it can be used to help create useful models we can use to predict what might happen in the future.