Introduction and Purpose of Guide

The global warming issue needs balance. This guide provides science that is not part of the general debate. Some would argue that it is biased. This is partly true, but necessary because there is a need to balance what is generally known with what is not generally known. There is also a need to indicate how information is misrepresented or distorted. The Guide does not comment on the motive behind what has happened or why.

Temperature trends are a function of the period chosen. The world warmed since the 1680s and reached a peak in the 1940s, but has slightly cooled since then, as satellite data shows. So what is the discussion concerning global warming all about? Answer, the scientifically unsupportable claim that the warming is due to increases in atmospheric carbon dioxide from human sources. The warming since 1680 correlates with changes in the sun, not carbon dioxide. Suggesting that CO2 is a pollutant confuses the issue, but also distracts from dealing with real pollution issues.

Of course we should also work to reduce consumption of fossil fuels! There are some very good reasons; it's a finite resource, it can produce poor air quality in concentrated urban areas, it will save money in the long term. Climate change is simply the wrong and worst reason for urging the reduction. Many countries are beginning to realize this and there is a significant shift to nuclear energy as a 'cleaner' source of almost unlimited energy. There are other alternative energies such as hydrogen, solar, wind and tidal, but most of these are not viable or available in the quantities we require. Many only appear to be good alternatives because government subsidies distort the realities.

The suggestion is that the teacher should not make any judgments about climate change or alternative energies, but challenge the students to argue against the prevailing wisdom. It is a rigorous and self-educating technique so effective in debates.

The teacher can have the student research alternative energies with the same scientific rigour that is suggested in this unit on climate change. Pose the question asked by Aaron Wildavsky of his students that became the title of his book, *Yes, But is it True?"* The main reason students should learn this approach is because it is how science must work. You don't seek to prove something true to try to show it is not true. Karl Popper said it best, "Our belief in any particular natural law cannot have a safer basis than our unsuccessful critical attempts to refute it."

Curriculum Fit

The information provided is for presentation of material for Grades X, XI and XII. The material ranges from purely academic and scientific to general commentary to reports in everyday media.

Teachers often face the problem of dealing with complex subjects for which they have no formal training – this is especially true in social studies. The environment and climate are issues that have a scientific base but have implications because of their impact on the human condition and the human impact on the environment and climate. Ideally teachers and students will have the scientific education to then discuss the implications of these issues for society in general. It is one of the reasons why in some jurisdictions they are the Social Sciences and in others Social Studies.

The material presented here is primarily designed to assist the Social Studies/Sciences teacher or even the Civics teacher. However, it is of value for Science teachers who know that while science is ideally amoral and apolitical it is never so.

It is also important to recognize that history contains valuable sources of scientific information. For example, in climate change a large area of research exists in what are called phenologic studies.

Phenology is defined as: the study of cyclic and seasonal natural phenomena, especially in relation to climate and plant and animal life. Historical records of planting harvesting or many other sources provide valuable climate information.

The Philosophical Background

Loss of credibility of science is serious at any time, but especially now when a major shift in philosophy is happening - what academics call a paradigm shift. We are moving from the end of the Scientific and Technological Revolution to a new order, or view of people and the planet.

The Scientific Revolution began in 1543 with a reluctant revolutionary Nicolas Copernicus, presenting a theory about the solar system. He replaced the earth (geocentric) at the center with the sun (heliocentric). This began a long process of undermining the Catholic belief in the structure of the solar system outlined 2000 years earlier by Aristotle.

Copernicus triggered renewed research in astronomy and mathematics that is still going on today with the work of Stephen Hawking. The two men are linked through the centuries by famous men of science including, Johannes Kepler, Galileo Galilei, Isaac Newton, and Albert Einstein. Their ideas profoundly changed the scientific view of the universe and our solar system, but for most people they were of little consequence. A late 1990s survey in Europe found 17% of the population still believes the sun orbits the earth, not as Copernicus had it. As long as the sun rises and sets everyday it doesn't matter what science believes. The same is true of Newton's findings about gravity. As long as a person doesn't fly off into space, it's of little daily or even yearly consequence, but it is of consequence in a longer and larger context.

Charles Darwin was also a reluctant revolutionary, but he found like Copernicus that once the cork was out of the bottle it couldn't be replaced. The church was upset in both cases, realizing like all dominant authorities how ideas were the ultimate danger. But Darwin's ideas had much wider and more profound consequences because they spoke directly to all people. Copernican ideas were too vast for medieval and most modern minds to grasp and therefore were less threatened. The church tried to bring their concerns to earth by arguing that his statement about an infinite universe left no space for heaven. It's difficult for us to grasp how important this was for medieval people. The threat of excommunication, denial of all church rites including access to heaven, makes little sense otherwise. But very few people knew about Copernicus or the church's concerns.

Effective, but a rarely used argument these days is *reductio ad absurdum*, or reducing to the absurd. The church said Darwin's view proposed humans were descended from apes - virtually, your grandparents were gorillas. Unlike all previous scientific theories, they realized Darwin's theory spoke directly and personally to everyone. Previously, science was remote from most people's lives, mysterious, obscure, of little consequence, now it was in every home, every church, and every school. The scientific debate shifted away from, amoral, rational, logical to became variously religious, moral, philosophical or some combination, but always emotional.

Darwin's theory spawned a whole new school of study generally called the social sciences. Many believe this is at best a contradictory term, at worst an oxymoron. The central theme of all the academic areas of sociology, political science, economics, psychology, anthropology, and human geography is the human animal. A specific segment included Social Darwinism, in which his scientific ideas of evolution, nature, and animals were applied to humans and human behaviour. In many ways these disciplines are contradictions because they try to show how humans are no different than the other animals, yet very different. The scientific view effectively rejected God as the reason for human existence on earth. Now, like all other animals, we were at the mercy of nature. We were no longer here for God's purpose so we didn't have His protection, we have to deal with nature and its threats on our own. Prior to formal religions, people's belief systems are collectively called animism and revere natural objects such as the sun, moon, animals or birds. A deep-seated fear of nature and her ability to take lives underlies our concerns about environmental issues, especially global warming.

We emerged from the Cold War and the threat of nuclear annihilation with relief, although some believe the threat is still present. Many argue humans’ need an overwhelming presence of doom. If nature doesn't provide one, we create real or imaginary threats. Or is it as Raymond Aron said, "In search of hope in an age of despair, the philosopher settles for an optimism based on catastrophe."

Threats of global warming or depletion of the ozone layer are more disturbing, because of their scale. There was always hope sense would intervene to avert a nuclear annihilation. Exploitation, of these fears is compounded when governments say we can stop global warming, or repair the hole in the ozone. All we have to do is change our behaviour and all will be well. This assumes we have accurate information about the problem, understand the mechanisms of the earth's systems, know the causes of the change and are capable of taking the correct remedial action without creating worse problems. With global warming, ozone depletion, and many other environmental issues, none of these conditions exist.

Science, with our compliance, has replaced God leaving society to make the decisions and take actions to resolve problems. But even this is not the real issue. Religion is about morality, a code of living, which in most cases makes the individual or group accountable for their actions. Science is amoral, and essentially not accountable for its findings or actions. Society is left to deal with the moral and other questions that arise. Some scientists are aware of this dilemma and a few have warned society, usually without success. For example, Einstein wrote to the President of the United States warning of the potential dangers of nuclear power and urging politicians to show leadership in controlling the threat.

At the end of the 20th century people enjoyed the advances of science and technology, but negative side effects were becoming apparent in some instances. In most cases there were no scientific or technological solutions, the 'technological fix' was not an option. Now the issues required a moral answer, but these were thrust on a society morally confused. Well, not everyone! Those with very fundamental religious views had no problem, often aggravating the issue by taking a 'holier than thou' position. Most realized they needed a moral position, but didn't want the one offered by the fundamental groups.

Some turned away from one organized religion to another - the green movement. Here was a nice, simple, morally superior, non-religious, solution. Stop your immoral behaviour and all will be well. Return to the respectful ways of 'primitive' peoples from today and yesterday. The errors in this position require a book or two. The dilemmas and moral conflicts created for the green religion when 'primitive' people want the benefits of science and technology or resurrect traditional ways, such as whale hunting, are increasing every year. One daring challenge is found in Shepard Krech III's book "The Ecological Indian."

So we have reached a midpoint in the transition from one paradigm to another. The religion of science replaced formal religion, but in doing so became more dogmatic than the religion it replaced. This is happening because there is a moral vacuum during the shift, a situation that in political circumstances allow demagogues to advance their simplistic, undemocratic ideas that usually cause untold damage before sanity prevails.

Global warming is perhaps the extreme example of a victim of the current moral and intellectual vacuum. Most people incorrectly believe it is a change in climate due to human interference and confuse it with the Greenhouse Effect. They also believe both are new phenomena that are the result of impacts of the industrial world.

The Y2K fiasco was a fitting end to the 20th century. Predictions of doom and gloom following computer failure and subsequent technological collapse all proved to be totally incorrect. Despite vigilant search by media around the world no problems were found; the transition from one century to the next went without incident. Some governments claimed it was because of their vigilance, but this was simply an idle attempt to justify unwarranted expenditures. The same governments warned that the greatest problems would occur in less developed nations such as Russia, China, and India because of antiquated computers. These countries spent virtually no money and had no problems, which proves the predictions were wrong and expenditures unnecessary.

This story is symptomatic of the 20th century that has been called the Age of Information, but is more properly called the Age of Misinformation, although the Age of Speculation is as good. During the 1990's someone speculated that most computers, especially those running large public systems such as utilities, transport, and banking would not recognize the change from 1999 to 2000. This would cause them to shut down creating social, economic, and political chaos across the world. Books on the subject quickly appeared and media that thrive on threats of impending doom raised concern amongst the public to almost hysterical levels. The exploiters who skilfully played on people’s natural fears of impending disaster quickly silenced anyone raising a voice of reason. Concerns reached a level where politicians were forced to react. The squeaky wheel got the grease as usual, but only if it was environmentally friendly. They directed government departments to establish policies of re-mediation for the public and private sectors. In most cases, this involved the establishment of separate units to proof the system against any potential problem. This had three major effects:

- Nobody within government was determining if the problem was real;
- It gave the theory credibility because special interest groups argued that the government would not have established the units and provided funding if there wasn't a real problem;
- These units had a personal interest in perpetuating their jobs rather than saying there was no problem. Remember it was a child who pointed out that the emperor had no clothes; the adults protected the self-interest of survival.

In this way a speculative theory developed into a prediction while avoiding rigorous intellectual and practical challenges. The truth came at 2359 hours on December 31, 1999 when all computer clocks around the world changed to the new millennium with no problems. The adage "time will tell " was appropriate, specific, and finite - the doomsayers were completely wrong.

The Y2K problem has already slipped into oblivion, a fate that will befall most other 'predictions' of doom in the age of speculation. I can hear the doomsayers shouting, "What if you're wrong?" What they're really saying is "Shouldn't we act anyway? The answer is not necessarily, but extremists use the blunt weapon of fear to cancel the use of calm, objective, reasonable options. The idea of acting 'just in case' is known as the Precautionary Principle and has merit in some instances, however it assumes there is some clear relatively uncontested evidence.

We cannot and should not act on every possible threat because it's not possible and it's not a 'no risk' world. We must work to reduce risk, but this requires placing risks in order, and that requires some clear relatively uncontested evidence. The fact is science can speculate on a long list of potential doom, but all that does it challenge society to decide which issues need attention. Using fear and creating hysteria makes it very difficult to make calm rational decisions about which issues need attention.

I used the following example to illustrate this point to the Parliamentary Standing Committee on the Environment regarding ozone. It was very clear the politicians did not understand that science works by presenting a hypothesis, which is then tested by other scientists.

My presentation began by listing some scientific facts.

- The earth was slowing in its speed of rotation.
- The magnetic field has weakened gradually and consistently over the last several decades: if this trend continues the magnetic field will reach zero in approximately 120 years.
- When the earth's magnetic field disappeared as it has done many times mass extinction of species occurred.

I wanted to know what action my government planned for this impending disaster? Immediately one member expressed outrage at my presentation pointing out the issue was ozone. He completely missed my point and compounded his error by protesting how Galileo would be ashamed of me.

As a scientist, I was pursuing the deductive scientific method identified by Thomas Kuhn. This means taking a collection of facts and attempting to develop a hypothesis linking and explaining them. I could have developed such hypotheses all day about a series of impending disasters, but this does not make them real or true.

In the other scientific method a theory is developed and then tested in the laboratory all with facts gathered in the field. Kuhn called this the inductive method. It's rare for either method to exist in a pure form, but in both cases they are challenged and rigorously tested. The theory is proved, proved with modifications, or rejected. If proved, at some point it will become a law of science, but this can take a long time. It requires that predictions made by the theory prove correct – the ability to predict is good definition of science.

Sir Isaac Newton included in his *Principia Mathematica* the theory of gravity, yet today we talk about the law of gravity. There was no conference at which scientists gathered to say it had been a theory long enough, the transition occurred when the theory made accurate predictions: and there is the key, because a very simple definition of science is the ability to predict. This raises interesting questions about weather forecasts, but more of that later.

Albert Einstein's theory of relativity was published in 1904 but remains a theory 100 years later. Some predictions have proved correct yet science continues to have reservations and withholds the designation of law. Hesitancy speaks to another important part of the scientific method. Every hypothesis, whether inductive or deductive, is based upon a set of assumptions. They are both the strength and weakness and become a point of attack in most cases. The other goal is to gather facts that either support or destroy the hypothesis; or as T.H Huxley said, "The great tragedy of science - the slaying of a beautiful hypothesis by an ugly fact. "

The most famous of formula in science e = mc2 is logically derived from Einstein's assumptions. The letters "c" represents the speed of light and Einstein assumed nothing in the universe could travel faster. In the year 2000, a scientific paper was published reporting the discovery of something traveling faster than the speed of light. If correct, the theory collapses and the formula will become a footnote in scientific history.

Charles Darwin published his theory on the evolution of species in 1859. It remains a theory today for several reasons, but most importantly because it has never been seriously challenged by science. Darwin was by default chosen as the scientist whose work would finally overcome the power of religion. Science began the conflict with the revolutionary ideas of Copernicus and the struggle continued into the 20th century. Today we have the religion of science that has become more dogmatic than their religion it replaced. Any scientist who challenged Darwin would provide ammunition for the enemy. Creationists would leap on the opportunity to denounce evolutionary theory and replace it with creationism.

Scientists continue to create hypotheses using both methods, but now there is a disturbing development effectively preventing science being science. The normal sequence of theory followed by challenge and testing is short-circuited.

Two scientific journals receive the most attention from journalists seeking sensational stories. Very few journalists have any scientific training, but that wouldn't matter since they are seeking stories that fit the prevailing environmental hysteria of the day. Articles that seem to reinforce the global warming hypothesis usually receive attention while those contradicting or raising serious questions are avoided. The media piece usually receives a high profile and is reinforced by information of little relevance except to skilfully influence the public. For example, a story on the change in frequency of hurricanes will begin with reference to global warming when that subject isn't mentioned in the original article.

Over the years I was always amazed by what stuck in the mind of the public about an issue. They invariably believed something was proven fact or that a prediction was made. Most of the time there were no facts only estimates and no predictions only theories. What happens to cause the transition?

A vigilant but unscientific monitoring of media stories on environmental issues seems to provide the answer. Most journalists include the conditional words and phrases necessary in the original scientific work. Word such as, could, and phrases like it appears that, usually appear in the story. The problem is they are taken in but not recorded by the public. What they remember is the headline in newspaper or single statement at the beginning of the newscast. Invariably, these are simple positive unconditional statements often changing the story from estimates to fact, and theory to prediction. If the story appears on television and in the newspaper the repetition reinforces the accuracy and credibility of the story.

Special-interest groups take the information, usually without reference to the original article, and include it in their campaign sometimes making it the sole focus of their propaganda. Skilful manipulation exaggerates the potential threat, ignores the scientific limitations and exploits people's fears so an objective search for the truth are no longer possible. Frequently the level of concern leads to public demand for action and politicians are left with little choice.

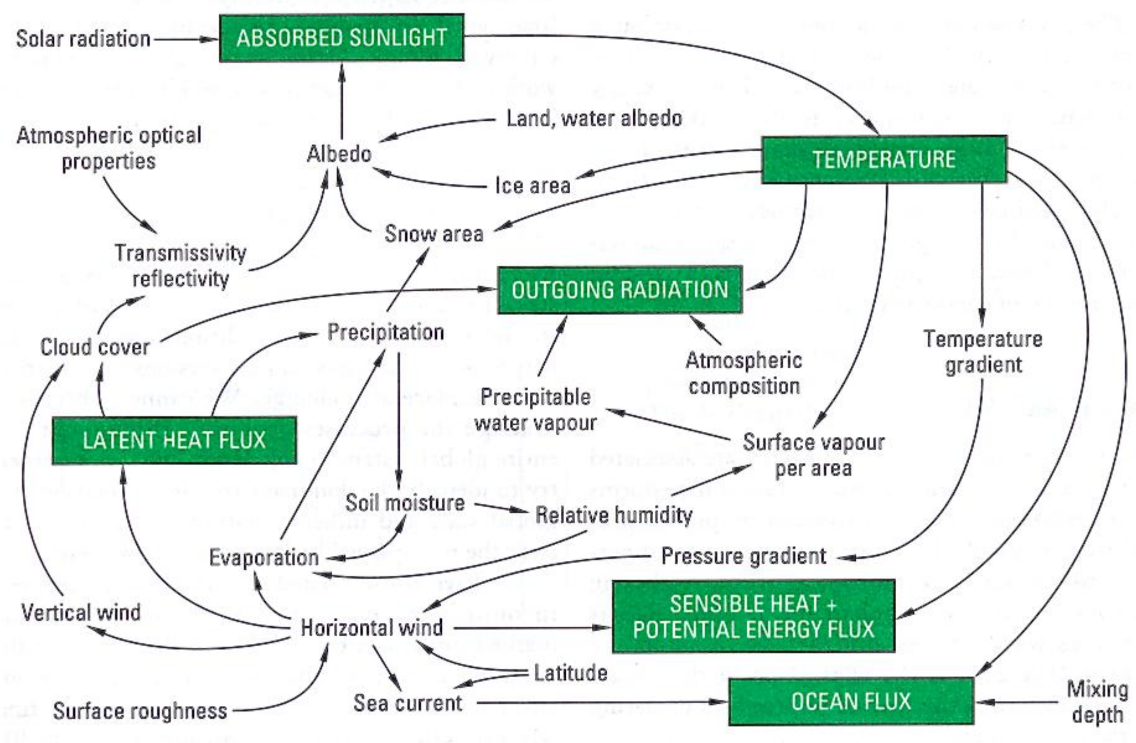
A steady campaign of propaganda, public meetings and rallies, perpetuate and expand the fears. The issue is so widely discussed that most people are not willing to even entertain the idea that it is not true. Those who seized the moral high ground silence opponents. Government involvement that should serve to put the issue in perspective usually fuels the hysteria. National and international conferences occur with the democratic but illogical cast of characters ranging from the well informed to the poorly informed to the deliberately misinformed. Hysteria, emotionalism, and much hand wringing occurs, but too often the wrong decisions are taken.

Annotated Definitions

Climate is the sum of all weather events over of time or in a region.
NOTE: All images in this section are available on the disc as PowerPoint slides.

Weather:

When you stand outside you experience weather. It is what scientists call white noise because it is the total of individual red noises. It is the total of and the interaction between everything from cosmic radiation from deep space to volcanic heat on the bottom of the oceans and everything in between. A simple diagram of the complexity just within the atmosphere/ocean portion illustrates the problem.



Source: Fundamentals of Physical Geography, Briggs, Smithson, Ball et al..

Imagine standing outside a stadium with 120,000 fans. What you hear is the white noise of their combined individual red noise inputs. First you have to isolate each individual noise then determine which are more important than others then determine how they interact with each other.

Global Warming:

A simple definition of global warming is a rise in the temperature of the earth, but for most people including too many scientists, the answer doesn't end there. The phrase has become a generic term for harmful changes in the atmosphere brought about by human actions, specifically the addition of carbon dioxide. This concept is now so entrenched that to use it in proper context almost guarantees misunderstanding. Most people incorrectly think global warming and Greenhouse

Effect (GE) are the same thing, but the latter can cause global cooling as well. Many believe GE is a new phenomenon caused by humans. It has existed for billions of years.

Global warming is now a political phrase used to invoke fear. In fact a warmer Earth brings many benefits, but those rarely receive attention. Students need to learn that people worry about change, but when it happens as it always has, some will gain and some will lose. In fact, a colder earth is more problematic for plants, animals and therefore humans. All this makes it necessary to understand the science, both good and bad.

A slightly more complex and accurate answer to the question "What is global warming?" recognizes how global temperatures rise when more energy is entering the atmospheric system than is leaving. It also acknowledges there are innumerable causes of change. And that is the problem! Global temperature varies a great deal without human input. We only have a rough idea how much, and far less understanding of the mechanisms.

Global cooling did not engender the same reaction in the 1970's. Besides, there was no clear culprit, no apparent human action that could be a narrow focus for science, governments, or special interest groups. An increase in atmospheric dust was a possible culprit, because of its ability to reduce sunlight, however, science was just starting to examine the role of volcanic dust in climate change. Even today understanding of the amount of dust, (technically aerosols) and its role in the atmosphere is extremely limited. But that's not the only limitation to our knowledge about climate change.

I don't intend to predict what will happen with climate, although the past provides some valuable clues virtually unknown to most people. Unfortunately lack of knowledge or understanding forces people, especially politicians, to react to threats of impending global disaster.

How this came about requires a larger context and that in itself is rare these days. Few people understand that our view of the world is only the current view, it was not yesterdays view and it won't be tomorrow's view. Each view is the official view planted in people's minds by the total of their upbringing – parents, schools, politics, religion all combine to form an individual's view. One measure of the effectiveness of this experience is the current conflict between the western essentially Judeo-Christian view and that of the Islamic world. An individual in either group has difficulty understanding how a person in the other group can't see 'the 'truth'.

Science currently considers the earth an unchanging or constant system. Energy from the sun, gases in the atmosphere, the amount of land, the volume of the oceans, and the total amount of water are all considered constant. There are movements from one to the other, for example, freshwater evaporates from the ocean is transported to the land, falls to the ground and eventually returns to the ocean. Unfortunately, the assumption of constancy has little validity in reality and creates considerable difficulty for advancing science.

Each year a certain amount of energy is received from the sun; that is from outside the earth's system. It's not constant, but we will accept that scientific assumption for now. If the same amount of energy leaves the earth's system and escapes to space, then there is balance. Theoretically, and if all else stays equal, the global temperature should remain the same as the previous year. When more energy enters the system than escapes global temperature will rise. Similarly, if more escapes than enters, the temperature decreases.

We calculate the global annual temperature by taking all daily temperature averages (the difference between the high and low for the 24 hours) for a year and dividing by 365 to obtain an average. Currently it is approximately 15°C (59°F). This is only done for the period when we have thermometer measured temperatures for the world, a period of about 130 years. Few discuss the total range of annual temperatures in the earth's history. Most attention is given to temperature variations during the last phase of the Pleistocene Ice Age, from 22,000 years ago to the present. Estimates place the range of temperature variation at 10°C in the last 10,000 years, although it is probably greater, and certainly wider in the earth's 5 billion years of history.

There are many reasons why we don't know about past temperatures. It's important to list a few so you understand the skepticism about current 'wisdom' on global warming. The time scales of these events are vast, but they are processes always in progress. Every single year they have some effect on the climate.

- Solar physics reports the sun emitted much less energy in the first part of its lifecycle; this is known as the ‘faint sun' phase.
- As the sun orbits the Milky Way galaxy and the galaxy rotates the solar luminosity (energy emitted) fluctuates.
- Changes in the sun appear cyclical and include fluctuations in solar output evidenced by sunspots and flares. The sun also increases and decreases in size causing changes in energy emitted.
- Changes in the orbit, tilt and relationship of the earth to the sun over tens of thousands of years – the Milankovitch Effect.
- The earth's atmosphere has changed in composition over time and therefore its ability to allow sunlight to enter and heat to escape. It has also changed for different periods of time and with varying intensities.
- The amount of landmass and distribution of continents has changed significantly through time. Each configuration creates different ocean circulation and climate patterns.
- There are great changes in the amount of heat stored in the oceans. Heat energy can circulate for 10,000 years before resurfacing.
- Polar ice caps vary considerably in extent seasonally and over time. There are Ice Ages approximately every 150 million years and dramatic fluctuations within each Ice Age.
- Transparency, the ability of the atmosphere to admit and absorb, energy from the sun and the surface of the earth varies when short-term events such as volcanic eruptions, large dust storms or forest fires occur.
- The Earth's magnetic field that intercepts particles of matter called the solar wind, varies through time, and frequently disappears altogether as polarity reverses. This changes the pressure on the atmosphere and electrical conditions in the upper atmosphere, and the climate.

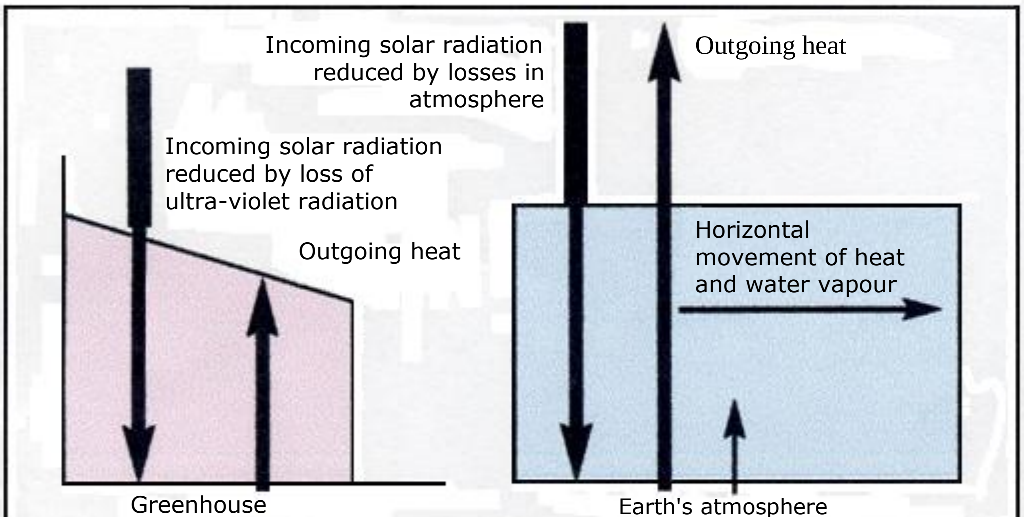
Time scales vary from annual to millions of years and while one is creating warming another is causing cooling. We don't know all the causes, and we certainly don't know how they interact. There are people studying each of the areas listed, but they're never strung together as in nature. Most studies fall into one of four categories:

- Extraterrestrial changes in the galaxy, especially sun/earth relationships (astronomy)
- Changes in the sun (solar physics)
- Changes in the atmosphere (meteorology)
- Changes in the oceans and ocean/atmosphere interactions (oceanography)

Any element can have a short-term influence, but the sun is the overall key. Add the lack of data and understanding of mechanisms and you begin to understand why considering human produced carbon dioxide, as the sole cause for change makes no scientific sense.

Greenhouse Effect

The so-called 'greenhouse effect' is **not** the major factor controlling our planet's climate. It is not even a good analogy of how the earth's atmosphere is heated. Many people refer to 'climate change' and the 'greenhouse effect' as if they were synonymous. They are not because changes in the so-called greenhouse gases (GHG) can cause cooling as well as warming, just as a reduction in the amount of energy coming from the sun causes cooling.



Heat energy is trapped in the greenhouse at left, while it gradually escapes to space in the earth system

Incoming solar radiation (often abbreviated to insolation) already reduced by ultraviolet radiation absorbed in creating ozone passes is further reduced because it cannot pass through the glass of the greenhouse. The remainder passes through the glass and hits inside surfaces. This sets the molecules of that surface in motion – something called Brownian Movement. It is incorrect when people say they 'feel' the sun. What they feel is the increased motion of the skin's molecules. This is why it is called sensible heat. You can achieve the same feeling and effect by simply rubbing the skin.

The major difference and critical to understanding why the atmosphere doesn't act like a greenhouse is that all the sensible heat in a greenhouse is transferred by conduction. That is, the molecules of air touching the warm surfaces increase in Brownian Movement by collision with the molecules in that surface. They then collide with other molecules until slowly the entire air temperature in the greenhouse is raised.

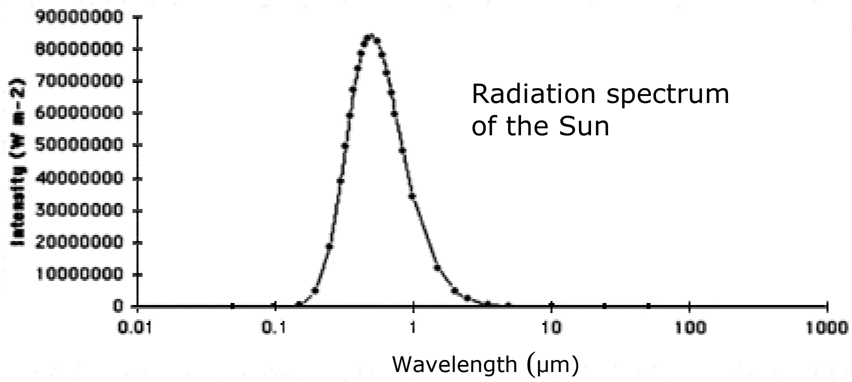
The atmosphere is heated partially by this conduction but more by convection, evaporation and advection. When the air molecules are warmed they become lighter than the surrounding air and thus rise to warm the upper atmosphere in the process of convection.

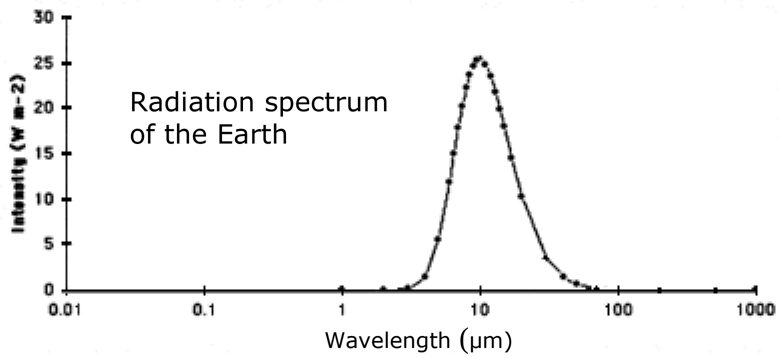
While sunlight increases the molecules of the land and they move more rapidly they cannot 'escape.' However, molecules of water are more mobile and less tightly tied together and can escape in the process of evaporation. The energy used to create this escape is stored in the water molecule (water vapour) and thus carried away from the surface. The energy they store is called latent heat and is released to the atmosphere when the water vapour condenses to from water droplets. This is why temperatures rise when precipitation occurs.

Temperature differences between regions create pressure differences shown on the weather map as High and Low pressure regions. Nature does not like inequality and will move air from the High region to the Low. Technically this is called advection, but more commonly known as wind and it is a major movement of heat energy.

The combination of conduction, convection, evaporation and advection all work to distribute sensible heat throughout the atmosphere.

All surfaces emanate energy depending on their temperature. The temperature of the object determines the wavelength of the energy emitted. Wavelength is the distance from one peak of a wave to the peak of the next and in the diagram is measured in microns (μm). The sun emits mostly shortwave energy (less than 7 μm) while the Earth emits mostly long wave energy (more than 7μm). Here is a diagram comparing the differences.



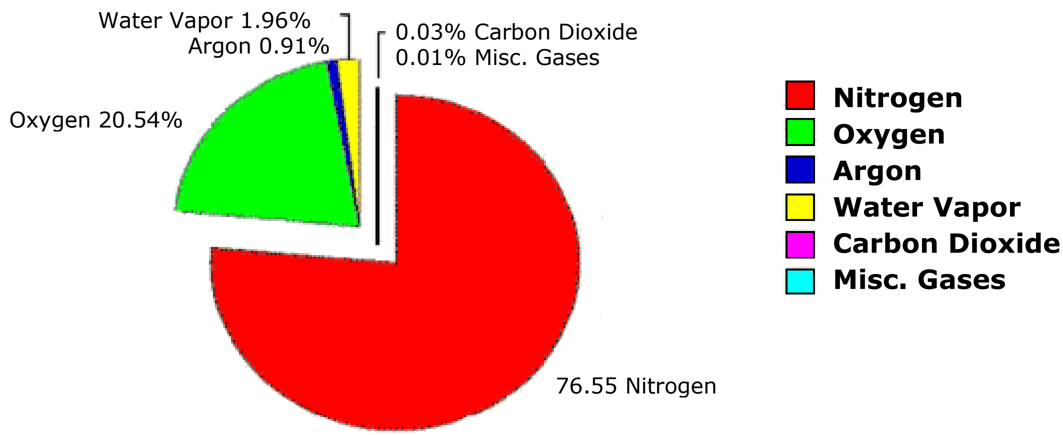


The glass in the greenhouse allows the solar short wave energy through but blocks the long wave Earth energy. The glass acts like a one-way valve. Because the long wave energy or sensible heat can't escape the greenhouse temperature increases. The only way it is stopped is by allowing the heat out through or blocking the sunlight.

The claim is that certain gases in the atmosphere act in a similar way to the glass, thus the greenhouse effect analogy. They allow sunlight in, but prevent heat from the Earth's surface from escaping.

Before we look at the individual greenhouse gases it is important to put them in the context of the entire atmosphere. For example, carbon dioxide that gets all the attention is a very small component of Earth's total atmosphere On this pie chart it is shown at twice its actual thickness so it is visible.

The Gases That Comprise Earth's Atmosphere



Gas Percentage (Volume)

Nitrogen	78.08
Oxygen	20.95
Argon	0.93
Water Vapor	0 to 4
Carbon Dioxide	0.0385
Neon	0.0018
Methane	0.00017
Helium	0.0005
Hydrogen	0.000055
Nitrous Oxide	0.000031
Nitrogen Oxides	0.0000251
Carbon Monoxide	0.00002
Ozone	0.000004
Sulfur Dioxide	0.00000002

Notice that Water Vapor is unique because it is the only one that varies from close to 0% at the Poles to 4% in equatorial regions.

Now take the greenhouse gases as 100% and the break down is shown in the table below. Water vapour is 95% of greenhouse gases by volume, and, while somewhat less than 95% by impact, is still by far the most significant greenhouse gas. The remaining 5% of greenhouse gases include methane (CH4), carbon dioxide (CO2), the vast majority of which comes from nature.

Anthropogenic (man-made) Contribution to the "Greenhouse Effect," expressed as % of Total (water vapor INCLUDED)			
Based on concentrations (ppb) adjusted for heat retention characteristics	% of All Greenhouse Gases	% Natural	% Man-Made
Water vapor	95.000%	94.999%	0.001%
Carbon Dioxide (CO2)	3.618%	3.502%	0.117%
Methane (CH4)	0.360%	0.294%	0.066%
Nitrous Oxide (N20)	0.950%	0.903%	0.047%
Misc. Gases (CFC's, etc.)	0.072%	0.025%	0.047%
Total	**100.00%**	**99.72%**	**0.28%**

Source: Professor Fred Singer

We should really rename the planet Water instead of Earth. Besides its importance to the existence of life as we define it, it has properties not found such a combination in most other elements on the planet. It can exist in three phases as a solid (ice), liquid (water) and gas (water vapour) at the same temperature. It has very high heat capacity so it is a superb cooling or heating agent. It has high surface tension and fluidity so it is an excellent transporting agent among other capacities. It is not compressible so it can its force can turn turbines and produce energy. Its ability to support life is one reason why almost all efforts to find life on other planets involve a search for water.

One phase is as water droplets, which though microscopic individually, exist in such volumes that they are visible as clouds. Clouds act to both cool and warm the planet as they both reflect incoming sunlight from space and absorb infrared energy (heat) coming from the ground, reradiating it in all directions, including back to the ground. Whether a cloud has a net cooling or warming effect depends on the type and height of the cloud but, in general, clouds have an overall cooling impact on the Earth - this effect is not handled adequately in today’s computerized climate models. Unfortunately, there are many other factors not handled properly or well in the computer models.

There is no evidence that human additions to atmospheric CO2 (primarily through the burning of fossil fuels, land use change, and plant decay) are causing the Earth to warm. CO2 levels and temperatures varied widely, rising and falling, long time before human civilization. The problem is they don’t show what the theory of global warming or climate change due to human activity assumes.

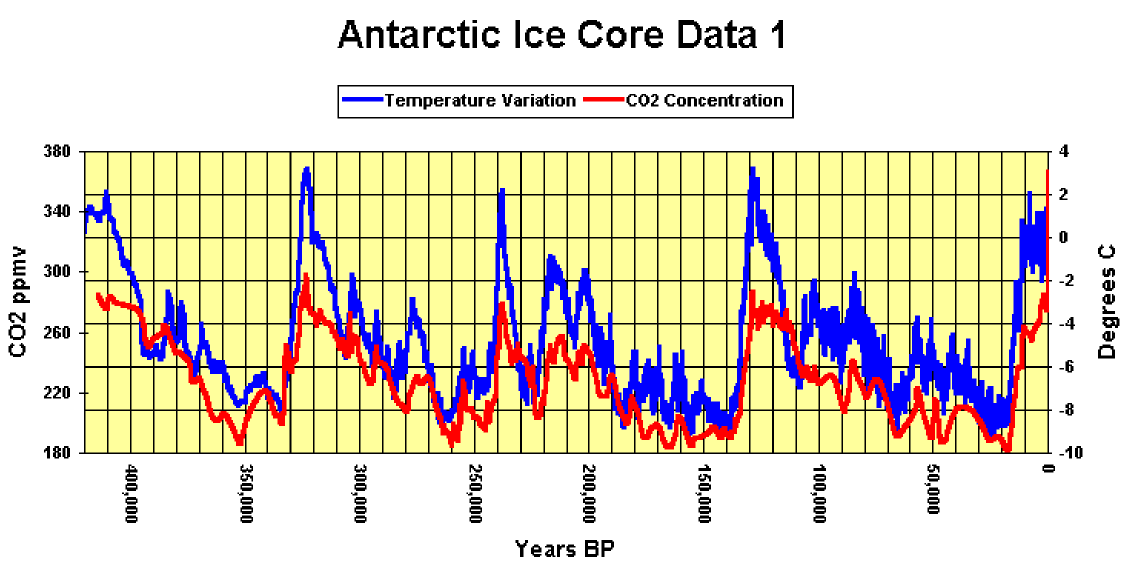
The scientific method was discussed in general terms in the section titled "The Philosophical Background." Here we need to apply it to what is generally referred to as the Anthropogenic Global Warming (AGW) theory. Assumptions made to underpin the theory are:

1. Carbon dioxide (CO2) is a greenhouse gas that delays sensible heat escaping directly to space.
2. If atmospheric CO2 increases the global temperature will increase.
3. Human production of CO2 is increasing because of industrial activity and especially the burning of fossil fuels.

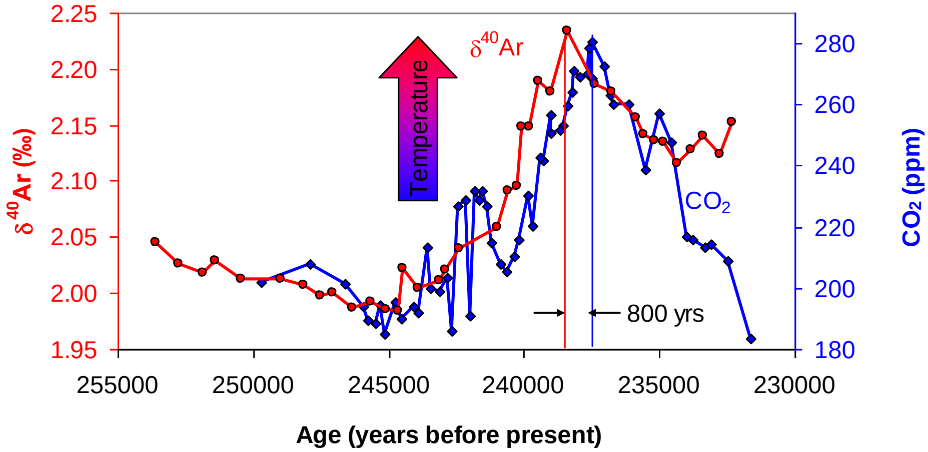
Normally, other scientists would challenge the assumptions trying to disprove the theory. This has happened but not with the vigour normally applied. The theory and assumptions were accepted as fact almost immediately. As Professor Richard Lindzen, Sloan Professor of Meteorology at the Massachusetts Institute of Technology said many years ago, the consensus was reached before the research had even begun.

Despite difficulties a few scientists continued to challenge the assumptions and carry out experiments. Starting in the late 1990s problems with the theory started to emerge, particularly with the idea that an increase in CO2 would result in temperature increase. A major piece of evidence used to support the claim that CO2 increases caused temperature increases were the ice cores and particularly the ones form Antarctica.

Here is the plot that was presented as evidence. Scientists who produced this graph warned about rushing to judgment. This is a very good lesson for students. Because two events appear correlated you cannot assume a cause and effect relationship without a clear mechanism. (see exercises for students)



The graph shows CO2 levels (red line) rising and falling apparently in unison with the temperature (blue line). It was presumed that CO2 was causing the temperature to rise. This was the assumption and conclusion presented to the public. Further research revealed that temperature was changing before CO2 in complete contradiction to the fundamental assumption (2 above) of the AGW theory. Here is a diagram that illustrates one example of the different relationship.

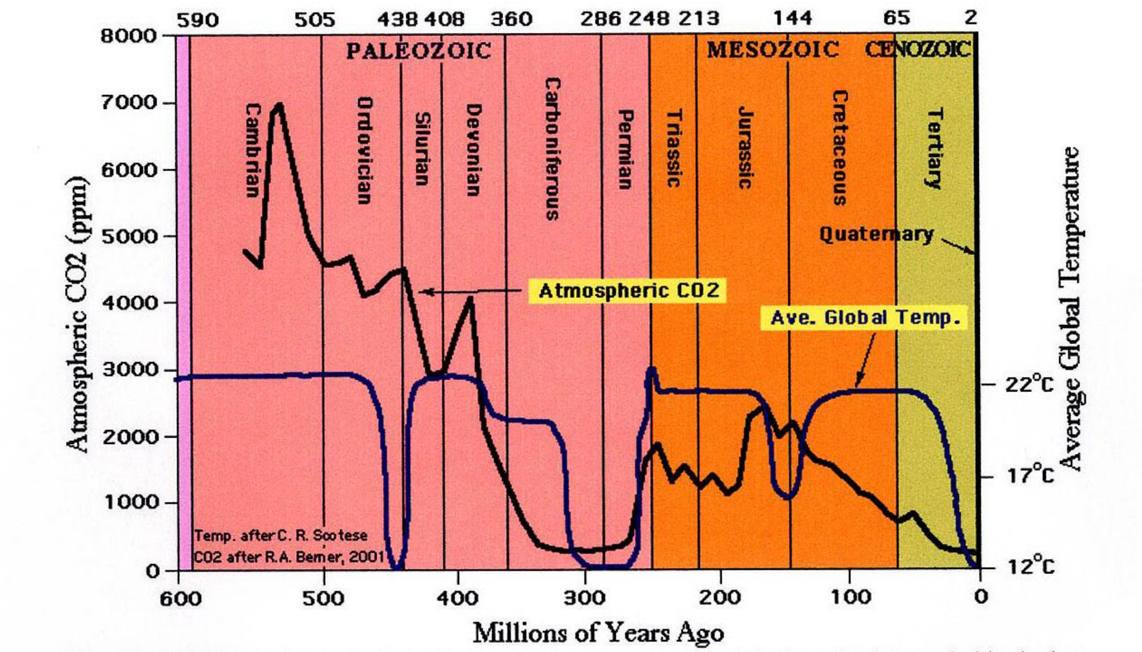


Here the colors are reversed. Red is temperature and blue Is CO2

Caillon et al. (2003, Science, 299, 1728) make the point, "This confirms that CO2 is not the forcing that initially drives the climatic system during a deglaciation [warming out of ice ages]. Rather, deglaciation is probably initiated by some insolation [solar] forcing."

(Another diagram showing a similar separation is provided in the Powerpoint slides.)

This discovery triggered further research of the relationship between CO2 and temperature in the historic record. Most notable was the following graph of the relationship between CO2 and temperature over the 600 million year geologic record.



Late Carboniferous to **Early Permian** time (315 mya -- 270 mya) is the only time period in the last 600 million years when **both** atmospheric **CO2** and **temperatures** were as low as they are today **(Quaternary Period).**

Temperature after C.R. Scotese
CO2 after R.A. Berner, 2001 (GEOCARB III)

Important points to note about this graph:

There is no correlation between CO2 and temperature at any time in 600 million years.

Current level of CO2 is 385 parts per million (ppm). This is as low as at any time in the record as the caption notes.

CO2 levels have been as high as 7000 ppm, but average approximately 1000 - 1200 ppm for the last 360 million years.

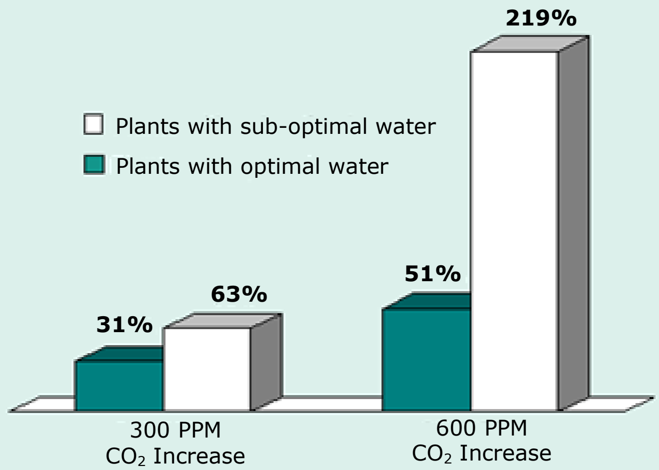
Plants and CO2:

Extensive research shows that an increase in CO2 would result in significant increase in plant growth. This is logical because plants in a process called photosynthesis use sunlight to synthesize food from CO2 and water to produce growth. The by-product of this process is oxygen, which is essential all other forms of life on earth.

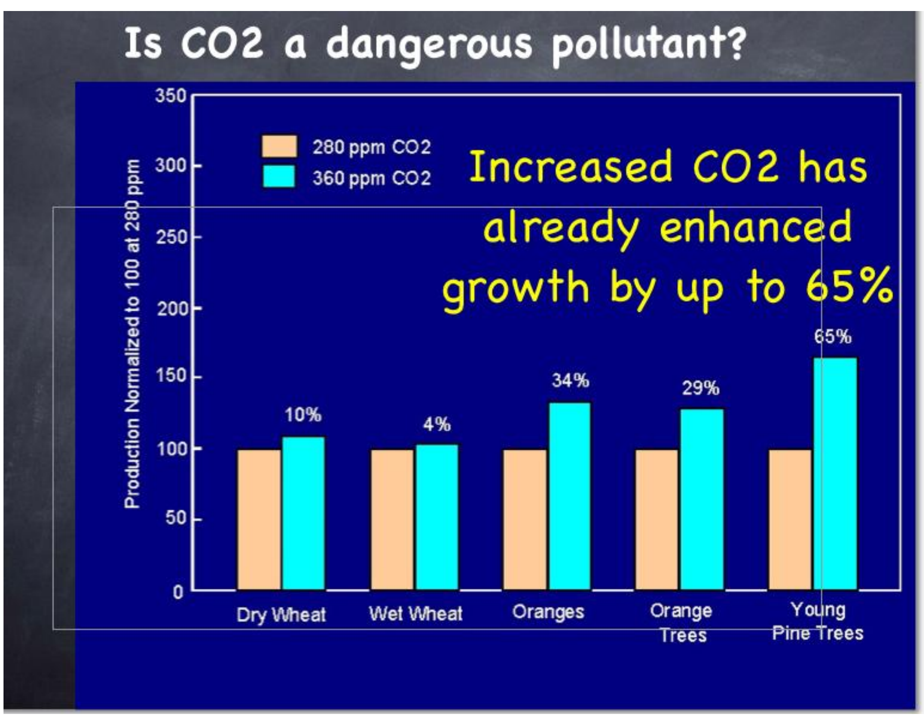
The geologic graph shows an average levels of about 1000 to 1200 ppm for the last 300 million years. Plants function best when CO2 levels are in the same range, which seems to suggest they have evolved to that level. this is further confirmed by the practice of pumping similar elevated levels into commercial greenhouses to achieve four times the yield. At current levels of 385 ppm the plants appear malnourished so further reduction have serious implications for plants and oxygen production and life on earth.

FIGURE II

Relative Plant Growth Under Increased CO_2 Conditions



Source: Sherwood Idso, *CO2 and the Biosphere: The Incredible Legacy of the Industrial Revolution* (St. Paul: University of Minnesota Department of Soil, Safety and Climate, 1995).

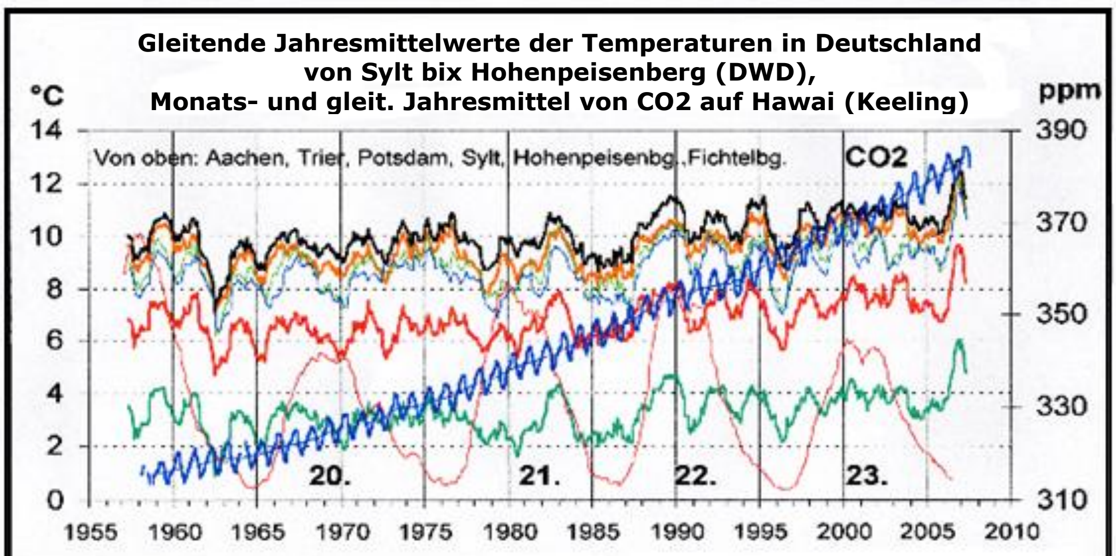


This information shows how the concept that CO2 is a pollutant is false. CO2 is not causing global warming or climate change so to maintain focus and support claims for necessary reductions it had to be cast as a pollutant.

Notice how levels have been much higher in the geologic record and remember at some level CO2 becomes toxic to some things. Of course, this is true of all things. As the 16th century alchemist Paracelsus said, the toxicity is in the dosage. Mining regulations set upper limits at around 4500 ppm for humans. Even in the classroom or crowded confined areas CO2 levels can rise above 1000 ppm and higher with no consequence.

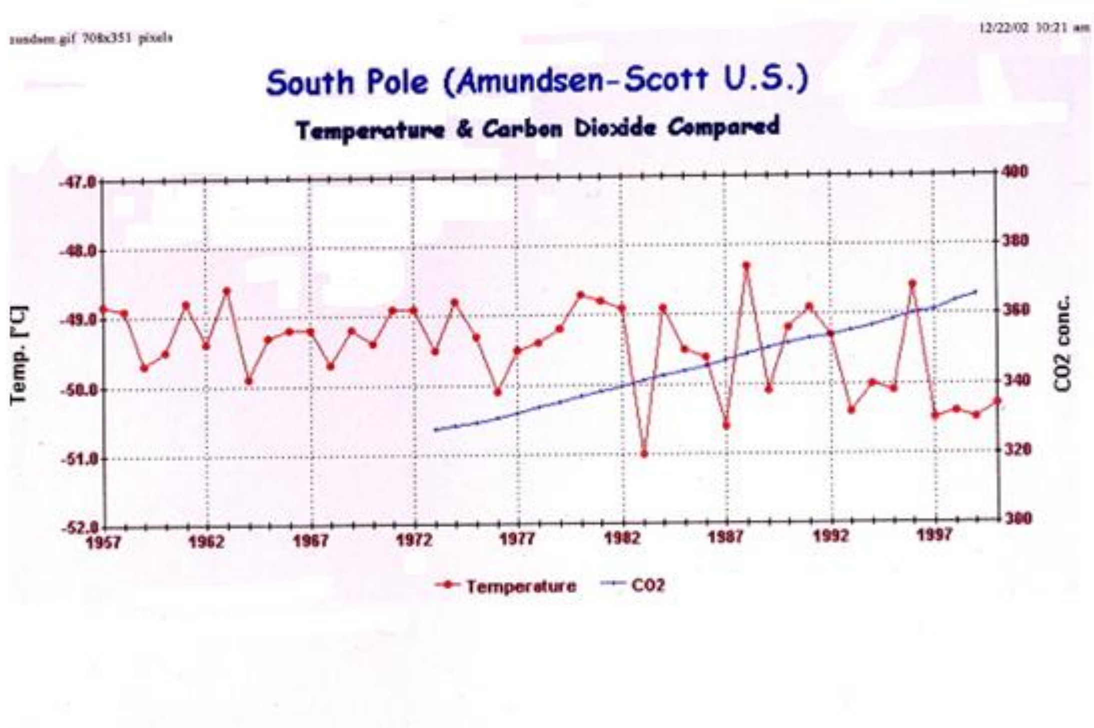
Current temperature graphs show no correlation between CO2 increase and temperature. Here is a plot of temperatures for central Europe with global CO2 increase superimposed.

Von ~ 1945 bis 1986 erfolgte eine Kaltzeit in Mitteleuropa. ab 1989 ein Temperatursprung um 0,9°C +- 0,2°C, seid dem kein wesentlicher Anstieg. Es gibt **keine kausale** Korrelation zwischen Anstieg des CO2 un bodennaher Temperatur

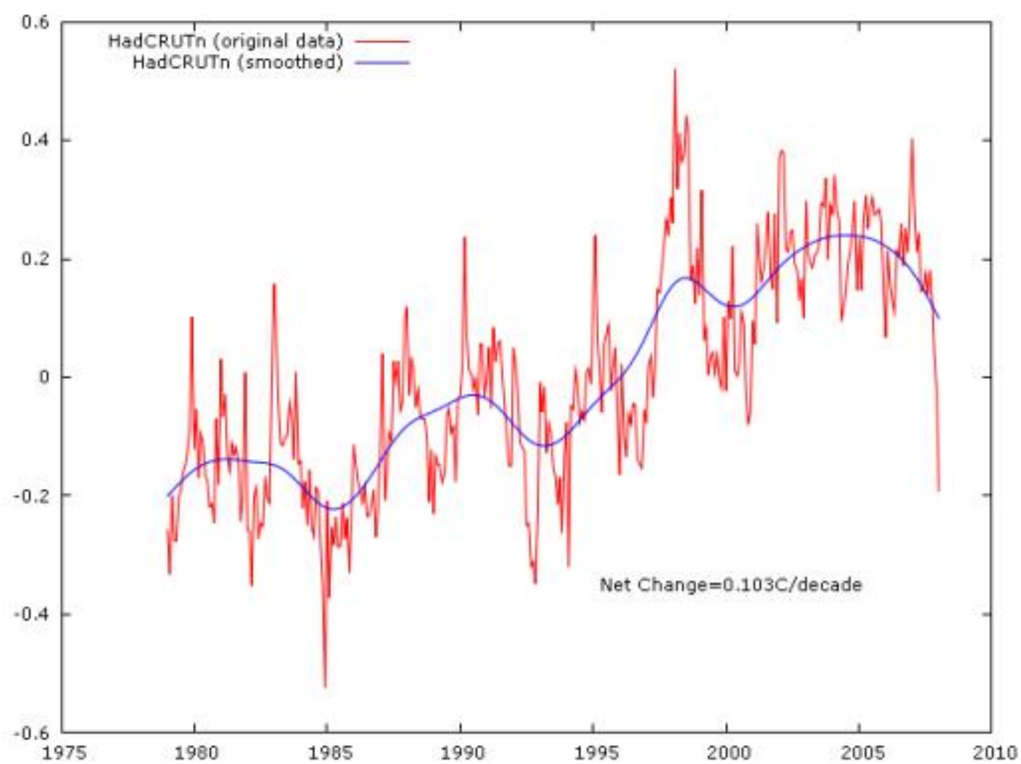


Borchert07 Abb.1 Daten: www.DWD.de, Uni Kalif.

The lack of relationship is quite obvious as it is in this earlier graph for the South Pole. Records there began in 1957 with the International Geophysical Year. It shows the lack of relationship between CO2 and temperature, but also that the South Pole has cooled over the entire period of record.



The pattern of declining global temperatures is shown here.



The drop of 0.7°C in the first three months of 2008 is equal to the claimed warming of the last 130 years. This cooling occurred while CO2 levels continue to rise.

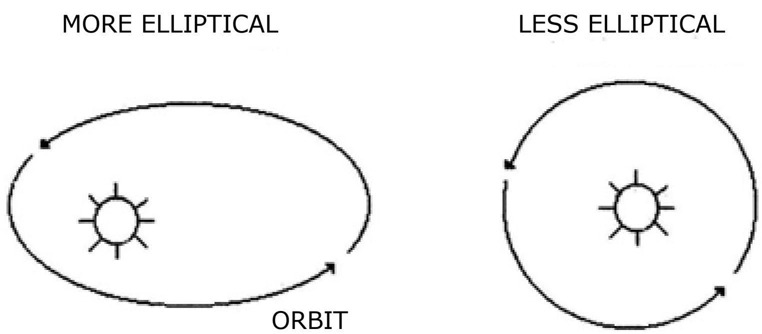
So if CO2 is not driving climate what is? The primary answer is the sun.

Solar mechanisms: The sun affects global climate in three ways.

Changes in the Sun/Earth relationships collectively known as the Milankovitch Effect.

Orbital eccentricity: Most textbooks record the orbit of the Earth round the Sun as a fixed unchanging elliptical orbit, with the Earth currently being closer to the sun on January 4th, known as perihelion (Greek - peri means near, helios means sun) and furthest away on July 4th known as aphelion. (Ap is Greek for away). At present the Earth receives approximately 3.5% more energy (above average) at perihelion and 3.5% less at aphelion.

ECCENTRICITY



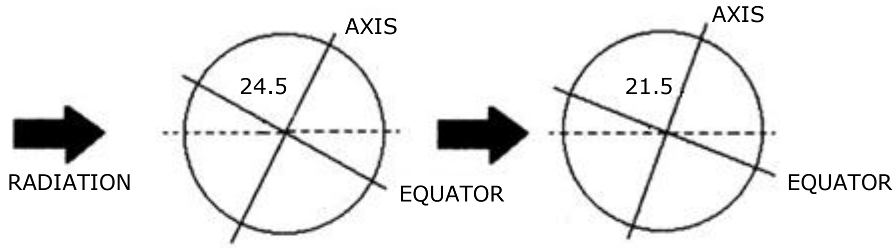
PERIODICITY:

100,000 YEARS

The orbit changes primarily because of the gravitational pull of the planet Jupiter and goes from maximum ellipse to minimum (where we are now) and back to maximum on a longer approximately 400,000 year cycle and a shorter approximately 100,000 year cycle. This means the orbit is different every single year. We have known this information for some 150 years. A Scottish researcher James Croll was calculating the impact of this change on climate as early as the 1860s. He was corresponding with geologist Sir Charles Lyell whose influence on Darwin was profound.

Axial Tilt (technically known as the Obliquity of the Ecliptic)**:** Textbooks and the public use the figure 23.5° (23° 30”) to describe the tilt of the Earth’s axis to the plane of the ecliptic. This is the imaginary plane formed by the orbit of the Earth in its annual passage around the Sun. The actual angle is approximately 23.44° (23° 26”). What most don’t know is that the angle is constantly changing from a minimum of 21.5 to 24.5°

AXIAL TILT



PERIODICITY:

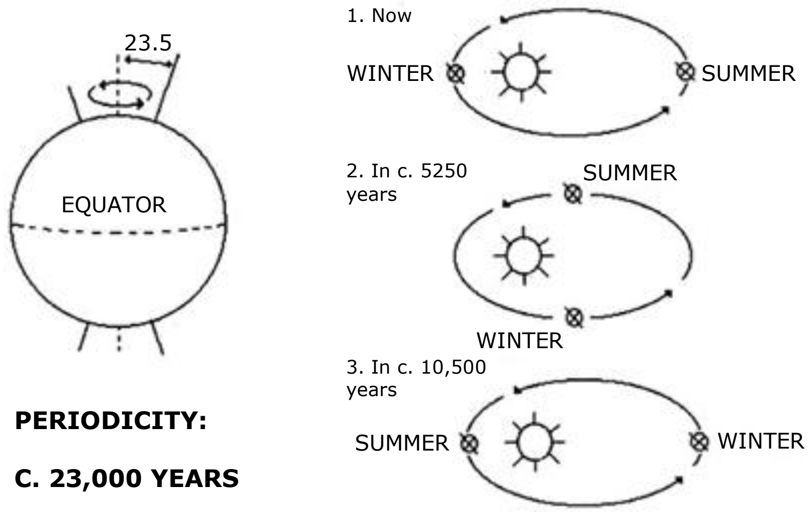
41,000 YEARS

The top diagram (source: Wikipedia) shows the tilt at the Pole while the bottom diagram shows the change reflected at the Equator. It is not known what causes these changes in tilt, although the earth spins very slowly for its mass. The important thing is that these changes mean the critical and unchanging lines humans have drawn as a function of tilt, such as the Arctic and Antarctic Circles and the Tropic of Cancer and Capricorn are actually changing all the time. This speaks to the infusion of Uniformitarianism into our view of the world.

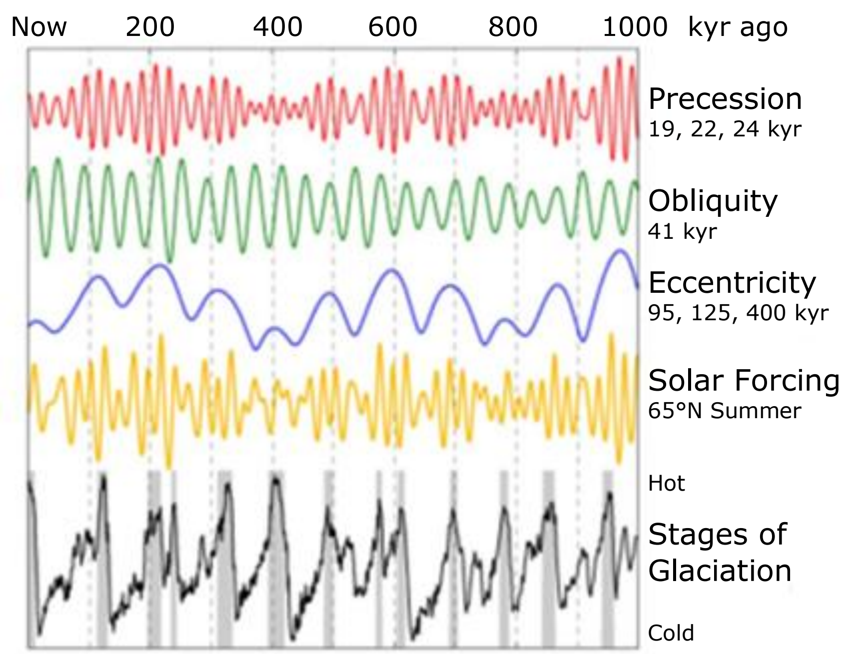
The tilt shifts from minimum (21.5°) to maximum (24.5°) and back to minimum approximately every 41,000 years. Right now the tilt angle is decreasing. You will note that different sources give different values for the amount of tilt. (see students exercises).

Precession of the Equinox: This is the most difficult change to understand and is related to the wobble of the Earth's axis. There is a gradual shift over a period of 23,000 years of the orbital relationship between the Earth and the Sun. This is best illustrated by looking at four important dates in the orbit and the dates when the Earth is closest (perihelion)and furthest away (aphelion) from the Sun. These are the Summer and Winter Solstice and the Vernal (spring) and Autumnal (Fall) equinox they all shift relative the fixed calendar humans use to mark the passage of time. One interesting aspect of this is the Pole or North Star changes through time. (see students exercise.)

PRECESSION



Each of these physical changes in the Sun/Earth relationship causes a change in the amount of energy received at the Earth. These are shown individually here (source Wikipedia):



The diagram shows the variation of solar radiation received at the earth caused by each effect. However, each is operating at the same time so it is necessary to combine them as Milankovitch did.

The Milankovitch Effect is not included in the IPCC models because they consider it a long term effect. The difficulty is their predictions are for the next 50 to 100 years so it does become a factor especially since the human impact is so miniscule.

Changes in the Electromagnetic Spectrum

The second way the sun affects climate is through variation in the electromagnetic spectrum (heat and light). This also called changes in brightness. Changes in brightness are technically known as variation in the electromagnetic spectrum, which are changes in the heat and light the earth receives. One study claimed the sun is not the cause of global warming or climate change because the variation was too small over the 11 year cycle. It is a classic example of exploitation of public lack of knowledge. It is also an example of focusing on one part of a very complex climate system as the Intergovernmental Panel on Climate Change (IPCC) has done with CO2. Claims were made that solar brightness only varied by 0.07 percent in the 11 year cycle. This sounds like a miniscule amount, but like so much these days it needs context. It is a small amount of 100 percent, but notice it does acknowledge that even this small amount can cause temperature change. Calculations show a change of 6 percent in brightness can explain all the temperature change in the Earth's history. So a 0.07 percent change is significant as part of 6%.

Changes in Corpuscular Radiation

The third form of radiation from the sun is in the form of ionized particles called the Solar Wind. We have known for a long time there is a high correlation between sunspot numbers and the strength of the Wind. We also know that the Wind causes the Aurora Borealis (Northern) and Australis (Southern)when the particles come in contact with the upper layers of the Earth's atmosphere. So we also have a correlation between sunspots and aurora, a relationship the aboriginal people of northern Canada used to make surprisingly accurate weather forecasts. (see article titled "Northern lights high, wind is nigh.") The difficulty is there was no mechanism to explain the relationship. Now there is a theory that appears to work.

You can read about the development of the theory in the book "The Chilling Stars" by Henrik Svensmark and Nigel Calder. Cosmic radiation reaches the earth from outer space, but in doing so it passes the Sun. It turns out the amount of radiation is determined by the strength of the Sun's magnetic field. Sunspots are visible evidence of changes in the magnetic field. When the cosmic radiation reaches the Earth it passes through to the lower atmosphere and the ions act as condensation nuclei.

As air rises it cools and at a temperature known as the dewpoint temperature condensation will begin. However it only occurs if there are nuclei, that is small particles, most commonly believed to be salt and clay around which the water droplet can form. Water droplets though microscopic become visible in massive numbers as clouds. It turns out that the ions of cosmic radiation also act as nuclei. As cosmic radiation increases more low clouds are formed thus blocking solar energy reaching the surface and cooling the Earth. When radiation decreases there are fewer low clouds more sunlight and a warmer earth. This explains how when sunspot numbers are high the earth is warmer and when low the earth is cooler.

The Intergovernmental Panel on Climate Change (IPCC) computer models that are the "official" record used by most governments only consider electromagnetic radiation. This explains why they claim the sun is not the cause of climate change. The Milankovitch Effect is left out because they say it is too long term to be significant. This argument ignores the fact that all three portions of tilt, precession and orbit variation change every single year and likely cause changes at least equal to human effects. Second they are making predictions for 50 and 100 years and the effects are significant over those time periods. They exclude the cosmic radiation theory because they claimed it was not available within the deadline of material to be considered. The difficulty with this argument is the theory has been in the literature since 1991.

Extended Comments on the Images in the Presentation

Note: Articles relating to some of these slides are attached. One of the best web sites for links to climate skeptics and other valuable sites is: www.john-daly.com/

Slide 1

Many records of cooling have occurred worldwide but receive little attention.

The general pattern of global temperature is related to solar activity manifest by sunspots and reflected on earth by the occurrence of aurora, both northern (aurora borealis) and southern (aurora australis). Basically when the sun is active with high sunspot numbers the earth is warm and when the sun is quiet with few sunspots the earth is cold. The number of sunspots was very low during a period called the Maunder Minimum, which coincided with the Little Ice Age a very cold period from about 1450 to 1850.

References:

An excellent book on the history of sunspot science is Soon and Yaskell's *The Maunder Minimum and the Variable Sun-Earth Connection.*

An excellent early book relating the solar connections is Herman and Goldberg's book *Sun and Climate* published by NASA.

Web sites:

www.science.msfc.nasa.gov/ssl/pad/solar/sunspots.htm.

www.exploratorium.edu/sunspots/

Slide 2

People are literally earthbound, physically and mentally. Our view of earth is distorted by our position. For example, we think the mountains are high and the oceans deep. Actually, the earth is a very smooth sphere with the difference between the top of Mount Everest is 8850m above sea level and the Marianas Trench at 10924 m is just 19774 m or approximately 20 km. Place that distance on the horizontal and it is not far. Another analogy is if you shrink the earth to the size of a snooker ball it would be smoother than the ball or conversely expand a snooker ball to the size of the earth and it would have greater distance between the high and low spots.

This photograph took us outside of our flat earth medieval view, but also made us aware of the size of our planet.

Unfortunately, it also triggered silly reactions typified by The Club of Rome predictions of Limits to Growth.

A good exercise for the students is to look at the predictions made by this group and what actually occurred.

Slide 3

The national hurricane centre provides a good resource for further studies on the frequency of these storms. There are several good studies showing no increase in severe weather events. Two Canadian scientists who have published on this issue are Madhav Kandekar and Tad Murty.

A major part of the threat of global warming is that severe weather events such as hurricanes, tornadoes and cyclones will increase. In fact, this is completely wrong. Severe weather occurs when cold air meets warm air. If the arctic warms as they predict then the temperature contrast between warm and cold will reduce and thus less potential energy for severe weather.

Students should also investigate the role of the insurance industry in this push of more severe weather. Visit the web page of Swiss Re to read about how industry can take advantage of scientific issues when they become political. www.swissre.com/

Slide 4

Nothing illustrates the fact that climate changes dramatically and rapidly in space and time than the events of the most recent Ice Age, the Pleistocene. The best book on the evolution of scientific understanding of these events is *Ice Ages: Solving the Mystery* by Imbrie and Imbrie. Just 20,000 years ago there were several major ice sheets including the one covering over half of North America. In total the ice sheets covered about 28.5 million square kilometres. These sheets began melting about 14,000 years ago and melted in approximately 5000 years. At the same time sea level rose by about 150 m. The difference between this and melting ice caps today is that these were on the continents and comprised of water coming from the oceans.

Louis Agassiz (1807 – 1873) introduced the idea that these ice ages had occurred in 1837 and met with violent opposition. It really wasn't until the 20th century that the idea of their occurrence gained any wide acceptance.

Slide 5

The son of Milutin Milankovitch claimed that his father died of a broken heart after his theory about changes in sun/earth relationships were a major factor in climate change. He proposed the idea in the 1930s and it was well received, however, before he died it was essentially rejected. The relationship is still little understood and rarely taught in schools. Again, the best coverage of this evolution of ideas is found in Imbrie and Imbrie.

A brief review is at; www.aa.usno.navy.mil/faq/docs/seasons_orbit.html.

A slightly better source because it gives credit to James Croll is at:

www.emporia.edu/earthsci/student/howard2/milan.htm.

Slide 6

This graph was included in the 1995 report of the Intergovernmental Panel on Climate Change (IPCC) and shows the variation in temperature of the last 1000 years compared to the average temperature of the Northern Hemisphere for the 20th century. It illustrates how much temperature has varied in that time, particularly the two significant periods of the Medieval warm Period (MWP) from 900 to 1200 and the Little Ice Age (LIA) from about 1450 to 1850. This graph is produced from a variety of sources including tree ring data pollen analysis and what is called proxy data. The latter are usually secondary evidences of climate conditions and climate change.

The other important point about this graph is that it was fully accepted in 1995 then suddenly was replaced in 1998 by a single study – the now totally discredited 'hockey stick' graph. It is hard to determine how a single piece of evidence could have been allowed to completely replace a mountain of evidence.

The reference to Dickens on the graph is about the weather conditions experienced by Charles Dickens that led to his portrayals of cold snowy conditions and difficult times. Harvest failures, harsh conditions created a poor economy and all the social hardships Dickens depicted and railed against so effectively.

Slide 7

This graph takes a portion of the preceding graph and presents it in a slightly different form. Changes are not explained by CO2 so something else must provide an answer. You can see that an overlay of changes in solar activity provides a very high correlation. This would be a good time to discuss the dangers of drawing conclusions from correlations. One reason supporters of the argument that human produced CO2 is causing the change reject this correlation is because they say we don't know the mechanism by which changes in the sun cause changes in climate.

Slide 8

Jan Griffier produced this painting titled "The Great Frost" in 1683. Griffier was Dutchman living in London during the period of the coldest temperatures of the Little Ice Age. Many paintings for this and the following century depict the cold and snowy weather.

Slide 9

The article I wrote associated with this slide is attached. It shows how much the tree line responded to the warming that has occurred since the 1680s. This refutes the argument that nature cannot adjust to a rapid rate of change – in this case the tree line advanced about one kilometre a year for approximately 200 years. The other point to note in the original article is Hearne's perception about the climate – it far exceeds most of today's so called experts.

Slide 10

There is a danger when bureaucrats become involved in research. It almost guarantees it will be political rather than scientific. By taking such a strong position and committing the government to that position they place themselves in the position of admitting they were wrong to their political bosses and possibly losing their jobs or blocking the truth and resorting to propaganda to keep pushing the message. That is precisely what this brochure is all about.

Slide 11

This is the now infamous 'hockey stick' graph compared to the results obtained by McIntyre and McKitrick when they tried to reproduce the results obtained by Mann, Bradley and Hughes. It is very disturbing because it shows how a data set was manipulated to achieve a certain result. More disturbing is how this graph then became the mainstay; it's referenced five times in the IPCC 2000 Summary, UN and government policy worldwide. You can read more about the research by the two Canadians at the following web site that then takes you to more information.

www.uoguelph.ca/~rmckitri/research/trc.html.

Slide 12

Perhaps the most disturbing aspect of the entire scientific debate is the focus on CO2 as a greenhouse gas (GHG). Water vapour is by far the most important GHG yet most people are unaware of that fact. Professor Fred Singer one of the leading authorities on atmospheric gases put the graph together. You can research his site at: www.sepp.org/

Slide 13

Notice that we can only estimate the amount of CO2 in the atmosphere to within 20 gigatons (a gigatons is one billion tons). Human production from all sources is 6 gigatons. Each year we attempt to measure the movement of CO2 through what is called the carbon cycle. There is a large portion unaccounted for in most years. Often this amount exceeds the total contribution from all human activities. It is called the missing sink and has puzzled scientists for many years. Some believe the boreal forest absorbs it and that underlines another problem. We only began measurement of gases in and out of the boreal forest a few years ago and the results are confusing. What this means is that we have very little idea what happens to CO2 in the atmosphere or anywhere else. Sherwood Idso and his son both of who have studied the interaction between plants and CO2 for many years maintain the best site for anything related to CO2 at,

www.co2science.org/scripts/Template/MainPage.jsp?MerchantCode=CO2ScienceB2C&Page=Index

(You have to pay a small fee for this site but it is well worth it since it has a wealth of information.)

Slide 14

The entire basis of the argument that human produced CO2 is causing climate change is the hypothesis that if CO2 in the atmosphere increases the temperature will rise. For many years the graph showing the relationship between temperature (blue line) and CO2 (red line) was used as proof of this relationship. In fact, the graph shows exactly the opposite. Temperature rises before CO. Also note: a) that the major temperature trends b) that the earth is in ice age conditions far more than in warm or interglacial conditions in this 420,000 year record. c) that we are in an interglacial right now and the long term pattern suggest another ice age. d) that we need to explain what causes the pattern of temperatures depicted by the graph.

Slide 15

This graph is considered the best representation of a region because of the density of weather stations. (see slide 16) It shows that most of the warming in the 20th century was in prior to 1940 while human production of CO_2 was low. After 1940 human production increased dramatically but the temperature went down.

Slide 16

There are serious problems with the surface weather record because of lack of global coverage. The oceans cover 70% of the world and we have very few stations. There is limited coverage in space and time. For example, Canada's record is only official from 1948 because the density of coverage is inadequate. So when we say we have a global average annual temperature of 15°C it is very open to question.

Slide 17

In 1978 a satellite was launched to provide temperature measurements over the entire globe. You can view the output of the satellite and discussion of its results at: www.ghcc.msfc.nasa.gov/MSU/msusci.html.

This slide shows that there is a growing difference between the surface and satellite record. It also shows that balloon data confirms the satellite data. This indicates something wrong with the surface data.

Slide 18

In 1952 Chandler measured temperature profiles across the London England and discovered that the city was warmer than the surrounding countryside. He had discovered what is now known as the Urban Heat island Effect (UHIE) This slide produced by Warwick Hughes in Australia shows temperature measurements for six cities. (web site www.warwickhughes.com/hoyt/climate-change.htm. Does not show the graphs but it does show Hoyt's score card for the computer models and their failure to make accurate predictions.)

Research shows that although temperature measurements are adjusted for the UHIE it is not adequate. In addition, even small towns can show such an effect. The change occurred after 1950 as the car allowed suburbs to surround airports the location of most weather stations.

Slide 19

The graph of 27 rural Australian stations for the same period showing a very different temperature pattern.

Slide 20

The UHIE is visible in almost all urban temperature records. This shows Central Park New York compared with Wes Point Academy about 48 miles away. An interesting site for more information on UHIE;
www.science.msfc.nasa.gov/headlines/y2000/essd16mar_1m.htm.

Slide 21

These studies were done in Winnipeg and show that Portage an Main is the warmest part of the city. The UHIE is maximum on cold winter nights with no wind. UHIE's exist for several Canadian cities including Montreal, Hamilton and Vancouver. A major researcher is Dr. Tim Oke at: www.geog.ubc.ca/~toke/ResearchProjects.htm.

Slide 22

During the recent Ice Age depicted in Slide 4 ice caps built up on land with water from the oceans. As a result sea level was lowered by about 150 m. As the ice melted sea level rose flooding large areas. For example, 6000 years ago England was connected to Europe but now it is separated by the North Sea.

A good exercise for the students is to determine which regions that are now separate were previously connected. A good web site for sea level changes is at;

www.greeningearthsociety.org/Articles/2000/sea.htm.

Also look at the work on sea levels in the Maldive Islands of Nils-Axel Morner.

Slide 23

Many examples of what are reported as sea level changes are in fact land level changes. David Suzuki did this in a programme on global warming when he used the gulf coast of Louisiana as an example. In fact that region is experiencing land level changes. The key words are eustasy, which are changes in sea level and isostasy, which are changes in land level. The best example in Canada exists around Hudson Bay where the land is rising after release from the weight of Pleistocene Ice. Sloops Cove on the west side of Churchill Harbour was used as an anchor by the Hudson's Bay company 200 years ago. Today it is above water even at high tide. The students can rese4arch the potential problems for Churchill as a port as the harbour gets shallower. A good start is *Life, Land and Water* by Mayer-Oakes and or the work of Jim Teller reviewed at;

www.und.nodak.edu/instruct/eng/fkarner/pages/agassiz.htm.

Slide 24

The opening slide talked about the lack of focus on water issues other than the general claim that droughts will increase. This is certainly the claim of Environment Canada. This slide shows evapotranspiration, that is the loss of moisture from direct evaporation and transpiration that is moisture exhaled by plants. The Prairies are the most severely affected and therefore it is the region where droughts are most recognized. Resource laws in Canada were part of the BNA Act and water although not specifically mentioned was simply another resource. A few years ago Alberta changed its water rights laws as it adjusted to the very different climate conditions. A major issue for Canada is that each region has such distinctly different climate conditions that universal policy for the entire country has become increasing difficult to encompass. Establishment of the Prairie Farm Rehabilitation Act that established the Prairie Farm Rehabilitation Administration (PFRA) to deal with the severe drought of the 1930s was nature forcing recognition of this fact. It is a rare example of a Federal agency for just one region and as such has been attacked as unconstitutional.

Slide 25

The best book on Palliser is by Irene Spry. A good web site is at;

www.ourheritage.net/index_page_stuff/Following_Trails/Palliser/Palliser_Rockies_1.html.

The British government sent Palliser to determine the agricultural potential of western Canada. His observations were remarkably accurate and prescient.

Slide 26

The Canadian government and the Canadian Pacific railway hired John Macoun to reassess the Prairies agricultural potential. A good web site is at;

www.geocities.com/craigavonhs/rev/mcgeownjohnmacoun.html.

Slide 27

This graph was produced in the 1970s to show the relationship between sunspots and drought cycles on the Great Plains of North America of which the Prairies are a northern extension. From a trough to a peak is the 11-year sunspot cycle. From a trough to a trough is the 22-year cycle. The global temperature varies with the 11-year cycle, but precipitation varies with the 22-year in that there is a drought in the middle latitudes These are averages and therefore the time from the middle of one drought to the middle of the next varies. A paper is attached explaining how the droughts alternate between 'hot' and 'cold' and how they are a significant factor in western Canadian history.

The student could do research on the influence of climate and climate change on history. A good book to start is by H.H. Lamb – *Climate History and the Modern World.*

Slides 28 and 29

These photos are part of a collection on Western Canadian agriculture available at the Western Canada Pictorial Index. I don't know if this is still available but information should be available through the University of Winnipeg. They also have a collection of photographs and images of women in western Canadian history.

Slide 30

A map produced by PFRA of the drought pattern in 1936. All prairie drought patterns vary somewhat, but this one set the pattern in people's minds. Match the direst region with the highest evapotranspiration region in slide 24. This was a 'hot' drought – that is with high temperatures, low precipitation and strong winds.

Slide 31

This is another 'hot' drought with essentially the same pattern as 1936.

Slide 32

This was a 'cold' drought with average temperatures, low precipitation and no strong winds. Notice that Manitoba is wet in this year.

Slide 33

This year was different because the drought was mostly in the northern part of the Prairie agricultural area. This meant that region had back-to back dry years, which is very hard especially since this is unusual for this region. Ironically the southern region was above average precipitation. This occurred because of the southerly position of the Polar Front (see Slide 36.)

Slide 34

The drought continues, but the end is near marked by the appearance of grasshoppers.

Slide 35

The drought is over with a vengeance. In fact, most of the Prairies had the coldest wettest summer in 100 years. This was aggravated by a crop-killing frost on August 20th. The reason is seen in the next slide.

Slide 36

This shows the general separation of cold polar air from warmer tropical air. The point of contact is known as the Polar Front. The contrast of temperature across this line can be quite dramatic. On January 22, 1943 at Spearfish South Dakota the temperature rose 27°C in 2 minutes from –20°C to 7°C.

Because of the temperature contrast across the front it is the location of storms and severe weather. As it moves north and south seasonally I brings the familiar fall and winter storms. When the cold air pushes south in the fall it confronts very warm tropical air and that triggers thunderstorms and tornadoes. The Jet Stream (more correctly called the circumpolar vortex in which the highest wind speed portions are called the Jet Stream) is also a result of the temperature contrast. Waves develop in this circumpolar cortex called Rossby Waves (see next slide). These waves move from west to east and bring different weather patterns on a 4 to 6 week basis.

Slide 37

The pattern of waves varies from the top pattern known as zonal flow to the bottom known as meridional flow. Each brings different wind directions and weather patterns. Zonal generally brings more stable weather patterns while meridional more extreme weather and temperatures. From 1940 to approximately 1980 (look at the temperature patterns for this period in Slide 15) we had zonal flow. From 1980 onward we had meridional flow with more dramatic swings of temperature.

Slide 38

Breughel was one of the first artists to paint what ordinary people were doing. This painting shows the cycle of life with parents harvesting the crop, the elderly playing with the children in the distant fields and the church through the trees implying moral values.

Teachers can use Breughel paintings to teach about ordinary people's lives. More important they can use them to illustrate children's activities. We rarely teach children about what it was like to be a child in history. Breughel produced one painting titled "Children's games" depicting at least 60 different games.

In this painting it shows the reality of the height of men in the 17th century and the height of European Spring Wheat. It is useful for students to relate body height to diet in medieval Europe, among the Viking settlements in Greenland and post war Japan. We are what we eat.

Student Exercises

The ideal exercise is to establish a weather station at the school. When I have helped schools do this I have had support from Parent Teachers groups and from local businesses: power utility companies are usually very willing to help. You can also get help and advice at least from the government at Environment Canada or the National Oceanographic and Atmospheric Administration (NOAA). Automatic instruments are not expensive and can be hooked directly into a computer preferably in the library where all the students have access.

1. The values of this project for students are;

2. They learn about quality, location and reliability of weather instruments.

3. They learn about official weather instruments and weather stations.

4. They learn about the collection of data; a fundamental part of all aspects of understanding the environment and society.

5. They can compare their results with local, national and international weather stations and with other schools who keep similar records.

6. They learn about the problems of maintaining long-term records and develop an obligation to those who went before them and those who will come after.

7. They will learn about local and microclimates as their record differs from other stations in their community or in neighbouring communities.

8. There are many exercises the students can do with their information, including providing the data for the local radio or TV stations.

A list of topics for students to investigate in a way the teacher can define depending on their particular location and resources available. Some of these topics will be unknown to most students but the questions will take them on a voyage of discovery.

1. Investigate paintings, drawing and photographs as evidence of previous climates.

2. Examine the changing western view of the world starting with Neptunism, through Uniformitarianism to Chaos theory.

3. Compare this view of the world with other cultures such as China and India.

4. How is sea level measured? How has it changed over time, especially since the last Ice Age? What is the difference between eustatic and isostatic changes?

5. Who was Milutin Milankovitch? How was his work a culmination of research from James Croll on? How did it explain the occurrence of Ice Ages?

6. Examine the scientific consensus of the 1970s that the earth was cooling with serious consequences for humanity.

7. What does the development of mapping tell us about our view of the world? Research the concept of mental maps.

8. Identify and explain the three types of ice in the Antarctic. Research the concept of towing icebergs as a source of water supply.

9. What is the relationship of trees to climate? Use the Køppen system of climate classification as a guide.

10. Abandoned Medieval villages in England are victims of climate change. Examine the demise of the Anaszi civilizations of the US southwest, the collapse of Mayan civilizations of Central American, the Khmer civilization of Southeast Asia, and the Inca of South America as possible examples of the impact of climate change.

11. Maps are essential to understanding the history, geography and climate of a country. Research the history of mapping in Canada.

12. What are ecozones? How are they related to climate? What are the Canadian ecozones?

13. Wind is one of the forgotten weather elements yet it determines the movement of weather systems and large amounts of energy. How are the general wind patterns of the world created? What are the general and local wind patterns for your area?

14. Explain the difference between Alpine and continental glaciers. How are glaciers formed and how are they related to temperature and precipitation.

15. What is the Urban Heat Island Effect? Is there one in your community? How does it affect temperature measurements locally and globally?

16. How are computer models of climate created? What are their limitations? Why can't they predict the weather beyond 10 days?

17. How is surface weather data collected? How many stations are there world wide? How have the number of stations changed over the years? What are the problems with these stations?

18. What are weather satellites? What information do they collect? How is temperature measured from space? How does the record compare with the surface data?
19. What is the Precautionary Principle? How reasonable is it? How would you set priorities?

20. Is there evidence of climate change in your area? Over what time period has the climate changed? How have flora and fauna changed with these climate changes?

21. What are sunspots? How are they related to Aurora? What is the Cosmic theory? Does it explain the relationship between Earth's temperature and sunspot numbers? What did native Canadians think about the relationship between the aurora and weather?

22. What are ice cores? How are they obtained? What do they tell us about the Earth's atmosphere? What are their limitations?

23. How many deaths occur each year from the following weather events? a) Heat. b) Cold. c) Flood. d) Drought. e) Tornados. f) Hurricanes. g) Blizzards.

24. How are food supply related to climate and history?

25. What are El Nino and La Nina? How did they influence South American civilizations like the Inca? What causes them?

26. How are plants a function of variations in atmospheric CO2? What is an optimum level and how is this used commercially?

27. What is the Circumpolar vortex? How is the Jet Stream related? How does it essentially dictate middle latitude (30 to 65° N and S) weather?

28. Find cartoons about weather and climate? How do they underscore people's concerns about weather and climate?

29. What are the major causes of famines? How have they devastated people through history? How have societies tried to deal with them in the past?

30. What are the major volcanic eruptions in history? How have they altered the climate? How have they altered history?

31. How much do we know about the climate of the Arctic and Antarctic?

32. What is proxy climate data? Find several examples and discuss their value.

33. What is Phenology? How does it help us understand climate change?