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QUESTIONS ABOUT CLIMATE CHANGE AND GLOBAL WARMING

(Long Version)

PREFACE

When a person speaks about "weather", they are referring to how the atmosphere is behaving over the short term (hours or days), and usually about how it directly affects them (in terms of temperature, precipitation, humidity, wind, etc.). The term "climate" refers to the statistics of weather over a defined large region over a long period of time (decades or more). The difference between Climate and Weather is primarily a matter of time.

This document will frequently use the term "climate change", but it is primarily addressing "global temperature change."

TEMPERATURE AND ITS MEASUREMENT

All the discussion and concern about climate change seems to focus on one aspect of climate - *temperature.*

Temperature is a measure of how hot or cold something is, and it is measured with a thermometer. Most of the world uses the Celsius system of specifying temperature, where zero degrees is the temperature at which fresh water freezes, and 100 degrees C is the temperature at which fresh water boils at sea level. The scientific world often specifies temperature in terms of degrees Kelvin (K), where zero degrees is referred to as Absolute Zero, and is the coldest temperature possible, at which all molecules and atoms become motionless. A temperature expressed in degrees Kelvin can be converted to Celsius by adding 273.

Discussions of climate change focus on what is commonly referred to as the "Global Temperature", which is supposed to be the average temperature of the Earth. This temperature is intended to represent that of the atmosphere that is close to the earth's surface (at an altitude of 1.5 metres). There are actually a number of problems in coming up with a meaningful number for an average temperature for the Earth, and these are thoroughly outlined in a 2006 paper by Essex, McKitrick, and Andresen.[1] Most climate change papers ignore or downplay the issues raised in this paper as the studies then present inferred historical temperatures, extract trends, postulate causes, and try to project the future.

Reliable equipment for measuring temperature has been available since the early 1800's, and distributed networks of these devices have been used to record historical temperatures that are used in the study of Climate Change. Unfortunately, the number and placement of temperature recording stations has changed considerably over time, so it is often difficult to get a complete and consistent record for a specific area.

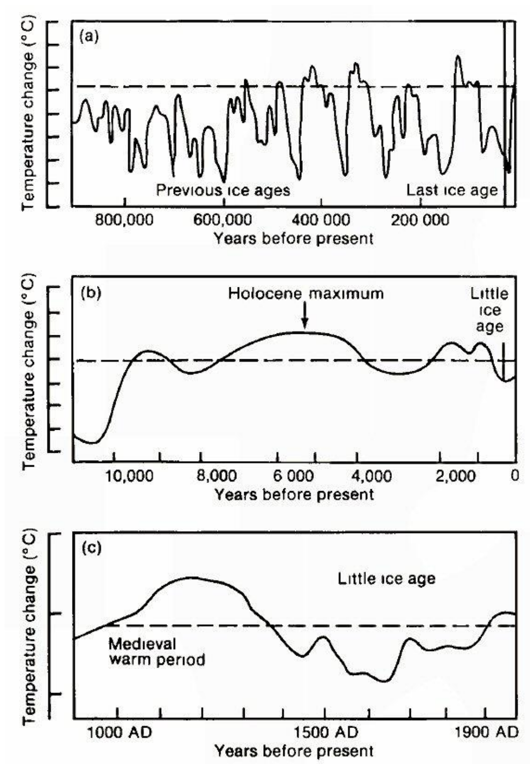
Temperature history for the period preceding the nineteenth century must be inferred by analyzing ice cores, tree growth rings, sediments, and corals. Ice cores (typically from Greenland, Antarctica, or the Arctic) are the most commonly-used "proxies", and it is possible to infer temperatures from thousands of years ago. It is also possible to estimate the historical composition of the atmosphere using ice cores, but diffusion effects may mask some of the inferred extremes (of both composition and temperature)

Although surface temperature is what humans actually "feel" on a day-to-day basis, that data can be contaminated by the "urban heat islands" that are caused by construction of roads, parking lots, and structures that change the localized reflectivity and thermal mass of the surface. Because of this, it is sometimes more meaningful to talk about the temperature of the troposphere, which is the lowest layer of the Earth's atmosphere (about 20 Km thick), and is where all weather takes place (clouds, precipitation, storms, winds). Temperatures in the troposphere can be directly measured by balloon-borne radiosondes, or inferred from satellite radiometry.

INTRODUCTION

1. Is Climate Change "Real", or is it a hoax?

A - Climate change is definitely not a hoax: the climate has always been changing, and it will continue to change in the future. Looking just at the temperature record, the earth has sometimes been much hotter than it is today, and sometimes much cooler. The following charts detail some of these historical changes:



These three charts are taken directly from the IPCC's 1990 report [2], and show global temperature variations over three different time scales. Note that the lower graph indicates actual dates, whereas the upper two graphs refer to years before the present time. The dotted line represents the average temperature near the beginning of the twentieth century.

For reference purposes, recall that the first appearance of Homo Sapiens was about 200,000 years ago. Archaeological research shows that a predecessor (Homo Erectus) first used tools about 2 million years ago.

Note that instrumentation to accurately measure temperature directly has only been available since the early nineteenth century. Earlier temperatures must be implied through a variety of "proxies" (ice cores, sea sediment, etc.)

The above three charts highlight the variability of the earth's surface temperature over time. The world was not industrialized over most of this period, but despite this fact, the IPCC (*Intergovernmental Panel on Climate Change*) continues to claim that recent changes are primarily the result of activities by humans.

2. What factors affect the earth's temperature?

A -The earth has its own internal heat sources, such as its radioactive core, but these are very small. The earth's temperature is primarily a function of the electromagnetic energy received from the sun (so-called "solar radiation"). In the absence of the sun or any internal heat sources, the earth's temperature would be close to absolute zero, which is -273°C, or 0°K.

Heat is just a form of energy, and it is commonly measured in units of Joules. It exists as a property that is contained within a material (solid, liquid, or gas), and can be thought of as the kinetic energy of the movement of the material's molecules and atoms. The term "temperature" relates to the amount of heat in an object.

Heat always flows from a hotter object to a cooler object. The rate of heat transfer is measured in Watts, which are defined as "Joules per Second".

The sun is the primary source of energy for the earth. A broad spectrum of wavelengths is emitted, but the peak wavelength is at about 502 nm, which corresponds to green-blue light.

The distance from the Earth to the Sun varies during a calendar year, but today has an average of 147 million Km. The black body radiation from the sun (across all wavelengths) therefore has an average illuminating power density of approximately 1367 Watts/m^2 at the top of the atmosphere.

Using basic geometry, it can easily be shown that (ignoring all atmospheric effects), this is equivalent to a <u>perpendicular</u> average flux across the surface of the Earth of 341.2 Watts/m^2.

Looking at just the major factors, Earth's temperature is dependent on four parameters:

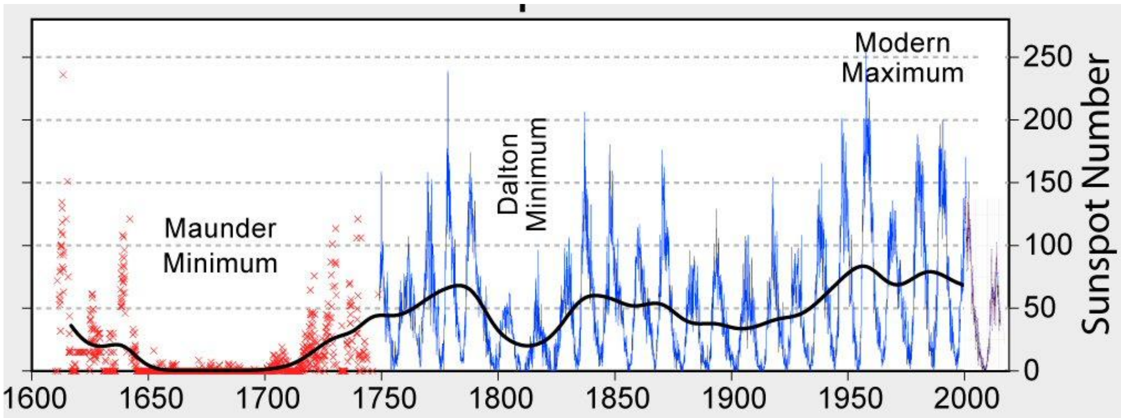
1. The energy being emitted by the sun. (both the total amount, and its spectral distribution)
2. The distance between the sun and the earth. (this affects the received energy in an inverse square law relationship)
3. Influences of the earth's atmosphere. (shading, reflection, absorption, radiation, etc.)
4. Characteristics of the surface of the earth (such as its reflectivity at various wavelengths) that determined how much total solar energy is absorbed, and how much is reflected. The term "Albedo" is used to measure this characteristic: albedo is defined as the ratio of irradiance reflected to the irradiance received by the surface. [3]

If it were not for the atmosphere, the earth would be a much colder place. Energy received from the sun would heat the earth's surface, but "black body radiation" would radiate much of this energy into space, resulting in an average global temperature of approximately -18°C. The atmosphere stops a significant portion of this heat loss by acting as a "greenhouse", thereby warming the earth to comfortable temperatures.

3. What causes the climate to change?

A - Mankind is still trying to understand all the possible causes of climate change, and their interactions and net effects. It appears that one of the largest drivers of climate change are "Milankovitch Cycles", which are based on long-term cyclic variations in the orbits of the Earth and planets, and changes in the earth's rotational axis.[4] These orbital variations cause corresponding changes in the amount of solar energy impinging on the earth's atmosphere. These changes in irradiance are significant, but the cycles have long periods (thousands of years).

The temperature of the sun's surface is approximately 5,800°K. Darker, cooler (about 3,800° K) areas on the surface of the Sun (so-called "sun spots") vary over an 11 year cycle. The magnitude of these spots also varies over a much longer cycle that is suspected [5] might be caused by "tides" on the sun's surface due to gravitational effects from the orbits of Jupiter, Saturn, Earth, Mercury, and Uranus. Continuing analysis of this has added credibility to this theory.[6] Other theories based on relativistic causes or inter-planetary electric fields [7] have also been proposed. Here is a historical record of observed sunspot numbers over the past 400 years:



The net effect of this is to change the outgoing radiation from the sun that eventually strikes the Earth's atmosphere.

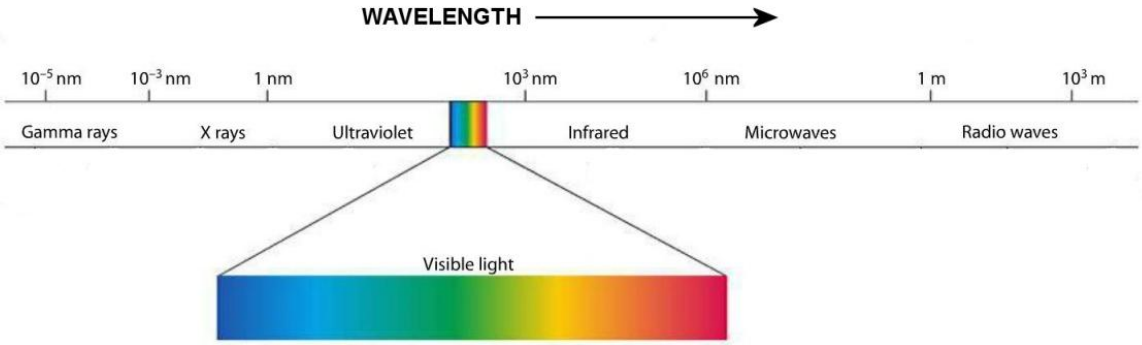
These cycles also have a major effect (by at least a magnitude factor of 10) in radiation of extreme ultraviolet (EUV), which can strongly effect the chemistry and thermal characteristics of the earth's upper atmosphere.[8]

The amount of incoming solar energy that actually reaches the earth's surface is affected by many atmospheric variables: clouds, scattering, absorption, water vapour, surface reflectivity, etc. The actual heating effect of this incoming solar radiation on the earth is influenced by the so-called "greenhouse effect", which will be described in detail in the next section of this paper.

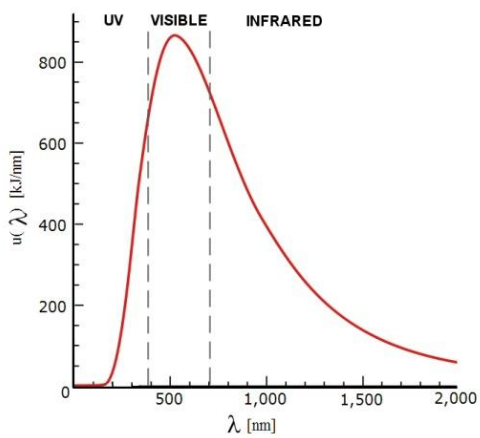
There are many other theories about possible causes of global temperature change. One of the more interesting theories focuses on the fact that the earth's magnetic poles are moving, and the magnetic field strength is weakening prior to an expected "flip" in the earth's magnetism within the next century. These changes have happened many times before, at a rate of about once every 100,000 to 1,000,000 years. The last "flip" of the poles occurred about 780,000 years ago.[9] The decreasing magnetic field strength of the earth reduces the effectiveness of the earth's magnetosphere, thereby offering lesser protection to the incoming solar wind, and this will definitely affect the earth's atmosphere. Cosmic particles that reach the atmosphere have a part to play in the "seeding" of clouds, and cloud cover has a strong effect on the amount of the sun's solar radiation that actually reaches the earth's surface.[10]

THE GREENHOUSE EFFECT

Background Tutorial - The sun emits energy in the form of electromagnetic radiation (EM radiation). In order to understand the greenhouse effect, we will first review this type of radiation. Depending on its wavelength, EM radiation can represent radio waves, visible light, ultraviolet (UV) light, infrared (IR) radiation, X-rays, etc. The following chart illustrates this:

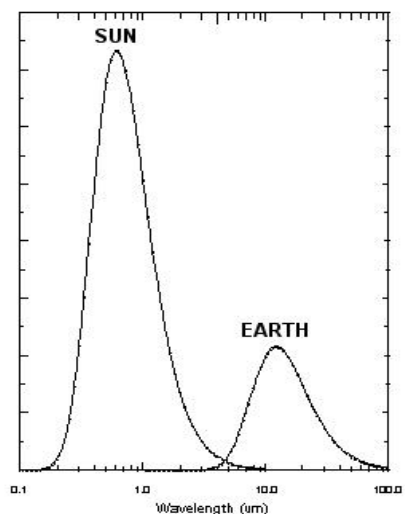


The sun does not emit a single wavelength: it is a so-called "black body emitter", and as such, emits a range of different wavelengths of EM radiation based on its surface temperature (about 5,800°K). Solar energy is distributed across this series of wavelengths as shown below:



The sun's EM radiation is distributed into three broad ranges: 7% in the UV portion of the spectrum, 44% in the visible spectrum, and 48% in the infrared region.

The earth also acts as a "black body emitter". Its average surface temperature is about 287°K, and its emitted spectrum is therefore centred in the IR range, as shown below:



This diagram plots the relative intensity of the black body radiation from the sun and the earth as a function of wavelength.

Black body radiation consists of a continuous spectrum of emitted wavelengths. The peak radiation is at a wavelength that is inversely proportional to surface temperature, and the total emitted energy varies as the fourth power of the surface temperature. These relationships are defined by the Stefan-Boltzman Law [11], Planck's Law [12], and Wein's Displacement Law.[13]

4. What is the "greenhouse effect"?

A - EM energy travelling from the sun to the surface of the earth, and then being re-emitted by the earth's surface, has to pass through the atmosphere on both trips. The atmosphere's gases have an effect on the energy: the dominant factor is absorption, which is often a function of wavelength. The amount of absorption varies with the concentration of the gas in accordance with the Beers-Lambert Law.[14] The greenhouse effect is caused by the fact that water vapour and other so-called "greenhouse gases" exhibit differing absorption and reflectivity characteristics between the shorter-wavelength incoming solar EM energy (centred at about 500 nm, as shown in the preceding diagrams) and the longer-wavelength IR energy (in the range of 10µm) that is emitted by the earth's surface. Some of the outbound IR energy from the earth's surface is absorbed by the greenhouse gases, causing heating, and this in turn sets up black body radiation both toward the earth and into space, as well as heating air in the lower troposphere. The net effect is that energy is "trapped" in the lower levels of the atmosphere, and as a result the earth's surface is much warmer than it would be in the absence of these greenhouse gases. Note that it is believed there are "escape holes" in the two polar regions (roughly coincident with the ozone holes) that potentially allow trapped heat energy to escape from the earth: more research is needed in this field.

Also note that the greenhouse effect is not <u>linearly</u> proportional to the concentration of the greenhouse gases: it varies with the <u>logarithm</u> of the concentration.[15] [16] [17] The temperature increase contribution caused by a rise of CO_2 concentration from 400 to 500 ppmv (parts per million by volume) is much less than that caused by a rise from 300 to 400 ppmv. This fact is seldom mentioned in popular literature which discusses the possible climactic danger of increasing CO_2 levels [18].

5. Is Carbon Dioxide (CO_2) the primary greenhouse gas?

A - No, water vapour is.. Major components of the atmosphere by volume are:

Nitrogen	78% or 780,000 parts per million by volume (ppmv)	
Oxygen	21% or 210,000 ppmv	
Argon	1% or 10,000 ppmv	
Water Vapour	0.001% to 5% or 10 to 50,000 ppmv	(*A Greenhouse Gas*)
Carbon Dioxide	400 ppmv	(*A Greenhouse Gas*)
Neon	18 ppmv	
Helium	5 ppmv	
Methane	2 ppmv	(*A Greenhouse Gas*)

Looking at the above list, Water Vapour (H_2O), Carbon Dioxide (CO_2), and Methane (CH_4) are all "greenhouse gases". Water vapour is not visible to the human eye, but when this vapour condenses to form small water droplets, the resulting clouds or fog are easily seen. Water vapour is the dominant greenhouse gas, but CO_2 receives most of the publicity! [19]

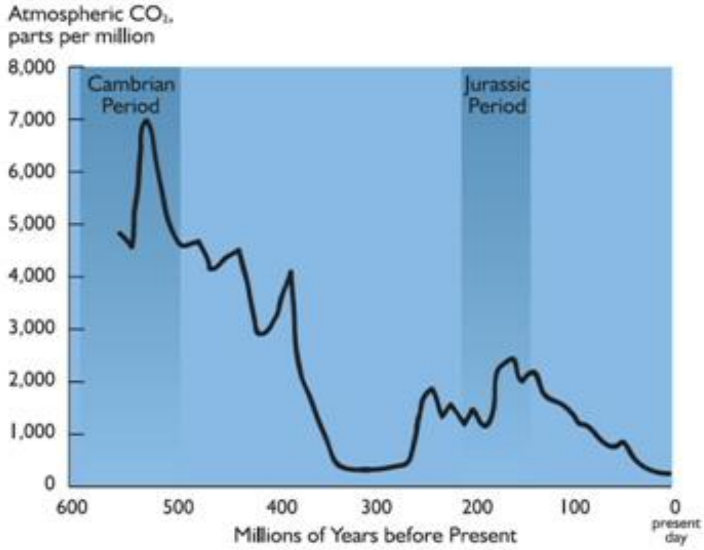
Water Vapour is the primary Greenhouse gas, representing up to 100 times the concentration of CO_2 in the atmosphere. The atmosphere's water vapour is primarily the result of evaporation of the earth's lakes and oceans. As the Earth's temperature rises, more evaporation will occur, increasing the level of atmospheric water vapour, thereby increasing its Greenhouse Effect, and therefore causing more warming. This "positive feedback" tends to increase the effect of other external factors that affect Global Temperature. Offsetting this, there is a "negative feedback" mechanism, whereby higher levels of water vapour result in more clouds which reflect solar energy back into space.

Other greenhouse gases include Nitrous Oxide (N_2O), and Ozone.

MORE ABOUT CO_2

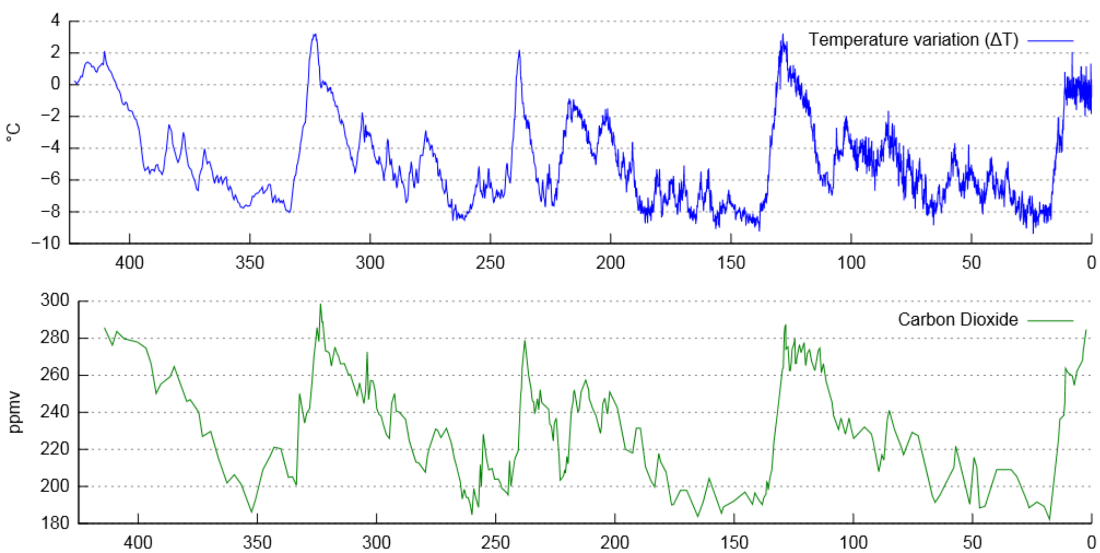
6. Can global temperature changes be attributed to changes in CO_2 levels in the atmosphere?

A - In modelling the flow of radiant energy from the sun, and the resultant earth surface temperature, it is clear that greenhouse gases have a strong influence. According to the models, the concentration of CO_2 in the atmosphere should have a meaningful effect, <u>but</u> the historical record (from sediment and ice core samples) <u>does not</u> support this.



The current concentration of atmospheric CO_2 is approximately 400 parts per million (ppm) by volume. It has been <u>much</u> higher in the past during the Jurassic and Cambrian periods (see chart above).[20] More recently, the concentration has been slowly rising from a low of approximately 260 ppm about 7,000 years ago.[21]

It is instructive to compare the plots of surface temperature and CO_2 concentration over the past few hundred thousand years, using Antarctic core sample data:[22]



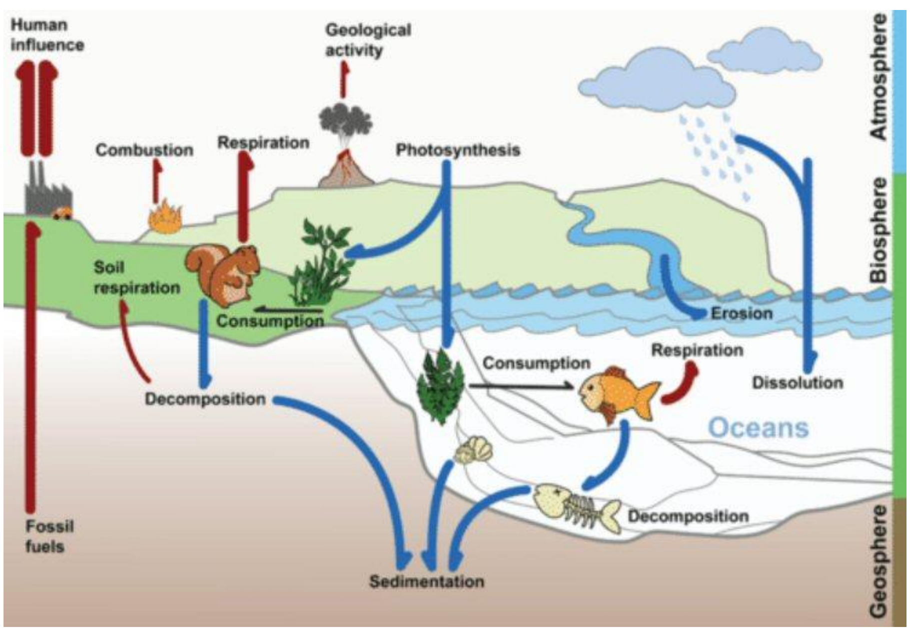
The horizontal scale represents thousands of years before the present. This appears to show a very strong correlation, but there is still much debate as to whether or not the temperature changes occur before or after (by several hundred years) changes to the CO_2 concentration. In other words, did changes to the CO_2 concentration cause changes **to** the global temperature, or were the CO_2 concentration changes caused **by** the changing temperature? A closer examination of the data shows that CO_2 concentrations actually start to increase about 800 years **after** temperatures start to rise. It is known that increasing temperatures cause CO_2 outgassing from soil and the oceans, so either hypothesis is possible.

Looking at just the past 3,000 years, analysis of Greenland ice core data suggests a remarkable lack of correlation between surface temperature and CO_2 concentration levels.[23]

7. Is CO_2 a pollutant, and should we try to eliminate it?

A - No, CO_2 is definitely **not** a pollutant: it is actually essential to life! [24] If the atmospheric concentration were to fall below about 150 ppm, plant life on earth would cease to exist. Many European greenhouses intentionally artificially increase the CO_2 concentration in order to stimulate the growth of the plants inside. Humans are quite tolerant of elevated CO_2 levels. Submariners routinely exist in atmospheres of several thousand ppm of CO_2.

Atmospheric CO_2 is part of the earth's "Carbon Cycle", whereby carbon is transformed between many different forms as part of naturally-occurring cyclical processes. The Carbon Cycle is a complex, much studied, but poorly understood process. Note that popular literature often talks about "Carbon" (a solid) when they are actually referring to CO_2 (a gas). Carbon is the sixth element in the periodic table, and the total number of Carbon atoms in, on, and around the earth is fixed (in the absence of nuclear reactions). Although the number of Carbon atoms is fixed, it can exist in combination with other elements to create the various forms that we are familiar with (vegetation, animal and human life forms, calcites, diamonds, hydrates, fossil fuels, Methane, CO_2, etc). A greatly simplified illustration of the carbon cycle is as follows:



In looking at this diagram, it is important to recognize that the amount of carbon remains constant, but it is just manifesting itself in different forms in a continuous, cyclic process.

MAN'S CONTRIBUTION

8. What about CO_2 produced by human activities?

A - Many human activities result in the release of CO_2 into the atmosphere.[25] The dominant ones are those involving the combustion of fossil fuels. Typical sources are heating, internal combustion engines, external combustion engines (thermal power plants), cement production, and industrial processes. There are also many natural mechanisms that release CO_2 into the atmosphere: the decay of organic material, respiration, dissolution, calcification, outgassing, fires, volcanoes, etc. CO_2 is taken out of the atmosphere by other natural "sink" phenomena: photosynthesis and absorption into water being the major mechanisms.

There is controversy over the lifetime of CO_2 in the atmosphere [26] (estimates vary from 5 to 200 years, but analysis suggests it is probably in the range of 8 to 15 years), and even more about how significant man's contribution is. Current estimates are that 3 to 4 percent of the current atmospheric CO_2 is due to human activities. This implies that the atmosphere contains 12 to 16 parts per million of man-made CO_2.

To put things in perspective, imagine a 1 litre volume of air. 780 mL of this volume would be occupied by Nitrogen, and 210 mL would be Oxygen. Naturally-occurring CO_2 would take up 0.4 mL, and man-made CO_2 would occupy 0.015 mL, which is 15 micro Litres (equivalent to a volume the size of 1/3 drop of water).

If all human activity were to cease, the effect on the earth's atmospheric CO_2 concentration would be small!

CLIMATE MODELS

9. Can we predict future climate changes?

A - Not very well! A number of attempts have been made to develop a scientific "model" of the various processes that can affect the earth's climate, so that predictions can be made for the future climate on the basis of known information. The IPCC has developed several different models over the years, but they keep changing them as new information or theories are unearthed. Back in the 1970's, climate models were actually predicting a global cooling period, and concerns were expressed about the "coming ice age"!

In order to truly believe a computer climate model, it must be possible to put historical data into it, and then examine predictions to see if they match what actually occurred. It must also be possible to "run the model backwards" (in other words, we need "backsight" as well as "foresight"), and see if it can predict the historical ice ages and warm periods. So far, there is no model that can do this!

A climate change model needs to include the effects of the various complex interactions between the atmosphere, biosphere, and hydrosphere. Looking very simplistically at just the flow of energy from the sun to the earth, the model needs to account for the various absorption and reflection mechanisms (all at different wavelengths) that are applicable, and then come up with a net "energy budget" that can be used to predict the earth's surface temperature. Although numerical estimates exist for most of these mechanisms, there are non-trivial uncertainties in all of these numbers. When the entire budget is summed up, the resultant total cumulative uncertainties mask much of the residual effect that the model is trying to quantify! Further complicating all this is the presence of many different "feedback mechanisms" (some positive, some negative) that can exacerbate or diminish the effect of certain parameter changes.

In their 2001 report, the IPCC itself stated (on page 78 of the section entitled "Summary For Policymakers"): "*In climate research and modelling, we should recognize that we are dealing with a coupled, non-linear, chaotic system, and therefore that the long-term prediction of future climate states is not possible*" [27] (my emphasis). Data from climate models should be treated with a **large degree of scepticism**!

10. What about "Climate Feedback", and "Tipping Points"?

A feedback path in a system is one that either increases (positive feedback), or decreases (negative feedback) the effect of an initial perturbation. Feedback loops are widely used in industrial control systems and electronic devices, but they also play a part in understanding climate changes.

An example of a positive feedback mechanism is the effect of water vapour in determining climate. If the earth's temperature has a small increase due to an increase in solar irradiance or some other factor, the higher temperature will cause more water to evaporate from lakes and oceans. As discussed earlier, water vapour is a greenhouse gas, and the increase in water vapour concentration in the atmosphere will then lead to a further increase in temperature. Similarly, an increase in the earth's temperature will ultimately result in a reduction in the amount of ice and snow cover on the surface of the earth, thereby decreasing the surface reflectivity, increasing solar energy absorption, and leading to a further increase in temperature.

As an example of a negative feedback mechanism, consider that an increase in atmospheric CO_2 will result in enhanced growth in trees and similar vegetation. This will then lead to an increased rate of removal of CO_2 from the atmosphere due to photosynthesis, thereby reducing the effect of the initial perturbation.

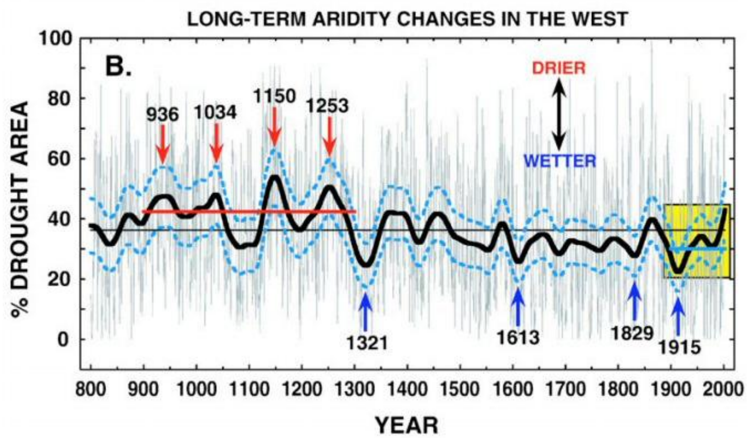
If positive feedback paths dominate and become excessive, it is possible that an initial perturbation will get magnified into a much larger change that continues to grow unabated. This form of excessive positive feedback is similar to that produced by a PA sound system when the system's gain is set too high, and the system breaks into a loud "howling" oscillation. In looking at the very long term temperature record, it is probable that this condition was encountered many times before over the millennia, and resulted in both high and low temperature extremes.

There is controversy over the magnitude and effectiveness of the multiple feedback paths (positive and negative) which affect the earth's climate, and whether any of them might ultimately lead to a "tipping point", whereby the temperature starts to climb or descend in an uncontrollable fashion. The oceans have a major effect on all of this, and are the subject of a great deal of ongoing research.

WEATHER EXTREMES AND FLOODING POTENTIAL

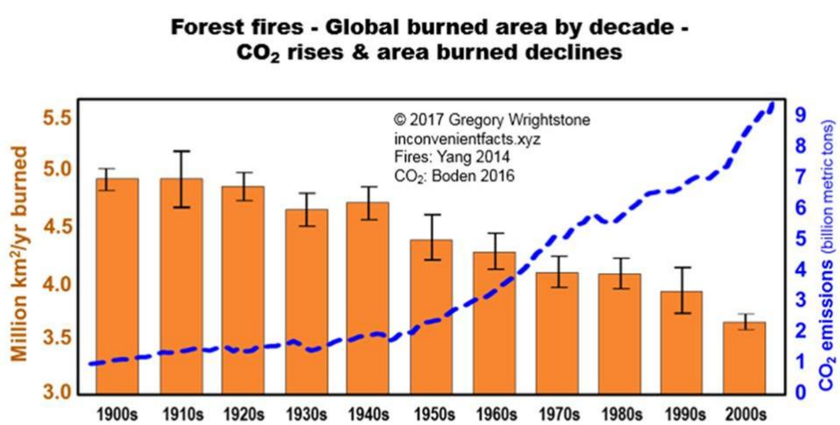
11. Are recent California wildfires caused by Climate Change? Is man to blame?

A - The 2017 devastating wildfires in California have been attributed to the a combination of extreme weather conditions: drought, strong winds, and low humidity. The state's governor has publically blamed "climate change" for this situation, and the continuing series of droughts that California has endured. As part of the messaging, these changes are attributed to man-made causes. However, scientific research has determined that the current droughts are not unique. [28] The following chart plots the percentage of Western US., and SW Canada that have been subject to droughts for the past twelve centuries:



The past century is highlighted in yellow, and the horizontal red line shows the average value during the period of AD 900 - 1300. Note that the horizontal blue line represents the average over the period 1900 - 2000, and it is significantly less than the red line from the earlier period. In other words, the droughts during the period of the recent Industrial Revolution are <u>not</u> worse than those in pre-industrial times.

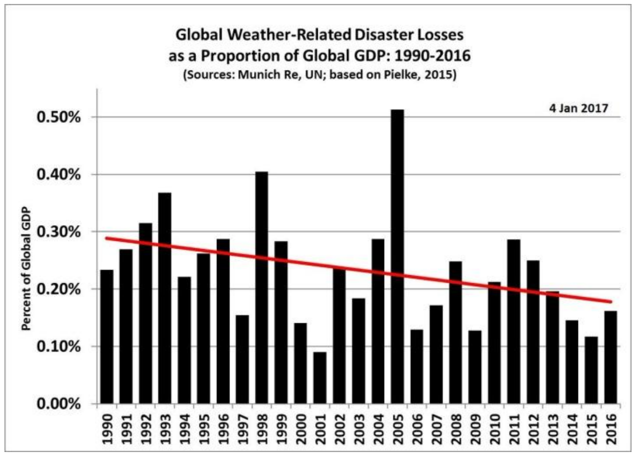
If man-made CO_2 emissions are plotted vs. time together with forest area burned by wildfires for the past century, [29] it is clear that there is no correlation:



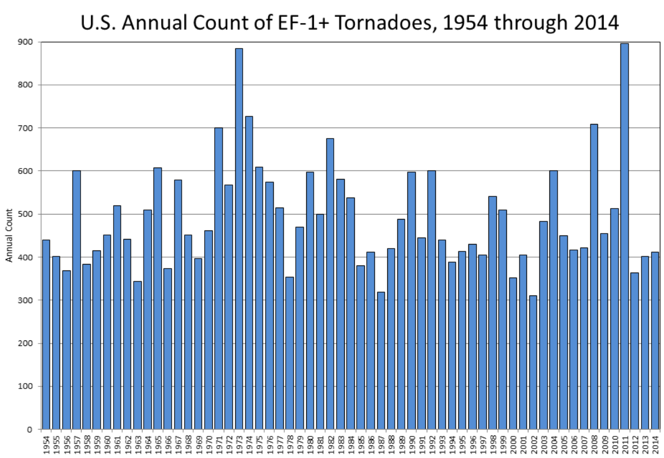
<u>Source area burned:</u> Yang, J, Tian H, Tao B, Ren W, Kush J, Liu Y, and Wang Y (2014) Spatial and temporal patterns of global burned area in response to anthropogenic and environmental factors: Reconstructing global fire history for the 20th and early 21st centuries, J Geophys Res Biogeosci, 119, 249 263
<u>Source CO2:</u> T.A. Boden G. Marland and R.J. Andres. 2016.Global Regional and National Fossil-Fuel CO2 Emissions. Carbon Dioxide Information Analysis Center

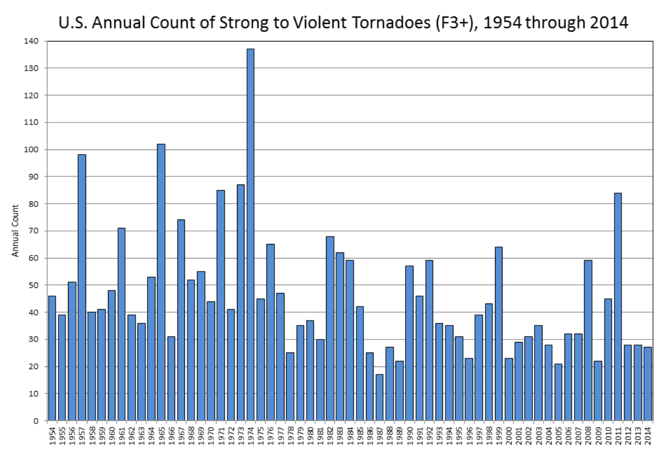
12. Is Climate Change causing more storm-related damage?

A - The popular press would have you believe that there are more severe storms than there used to be, they are more frequent, and they are causing more damage, but an analysis of the data suggests that this is not the case, [30] as shown in the following chart:



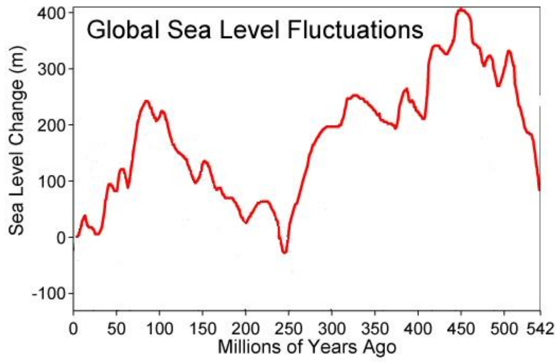
Looking specifically at NOAA data for US tornadoes, it appears that the frequency of weaker ones (category EF-1), has been fairly constant in recent years, but the frequency of stronger ones (category EF-3 and stronger) has actually been slightly declining, [31] as shown below:

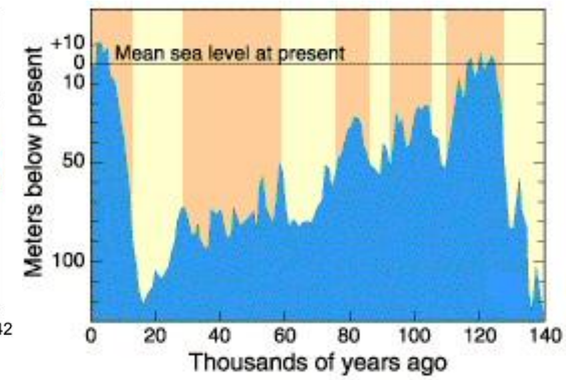




13. What about melting ice and sea level changes?

A - Sea level has varied considerably over time. The following two charts show historical average global sea level (with respect to the current level) over two different periods of time.[32]





There is a great deal of publicity (and in some cases, hysteria) surrounding predicted increases in sea level which will result in wide-spread flooding. If the earth maintains a constant vertical profile, the sea level is purely a function of the total volume of water in the oceans. As the earth's surface temperature increases, not only will the sea's volume and evaporation rates increase, but ultimately ice in the Arctic and Antarctic regions will melt, thereby increasing the volume of water in the oceans, and raising the sea level. Note that the melting of ice that is currently floating in the oceans will not result in an increase in sea level; it is only the ice that is presently on land that will have an effect if it melts.

The press has made much of the claim that "The Glaciers Are Melting", and concluded that this is being caused by man's recent contribution to atmospheric CO_2. However, records show that glacial retreat has been occurring for hundreds of years.[33]

If the mountain snowpacks and the icecaps on Greenland and Antarctica do melt, there is no doubt that the average sea level will rise. In our particular region, this is offset by the fact that the earth's surface is actually rising due to rebound from the ice ages, and (in the Victoria region) due to tilting of Vancouver Island from relative motion of the plates beneath it.

In South East Alaska, every year more land is actually being "reclaimed" from the ocean as the land rebounds from the heavy ice load it was previously subjected to.[34]

In Victoria, future sea level changes should not be a major concern. In other parts of the world, the average increase in sea level is a bit over 2 mm per year, and plans should be made to adapt to these changes.

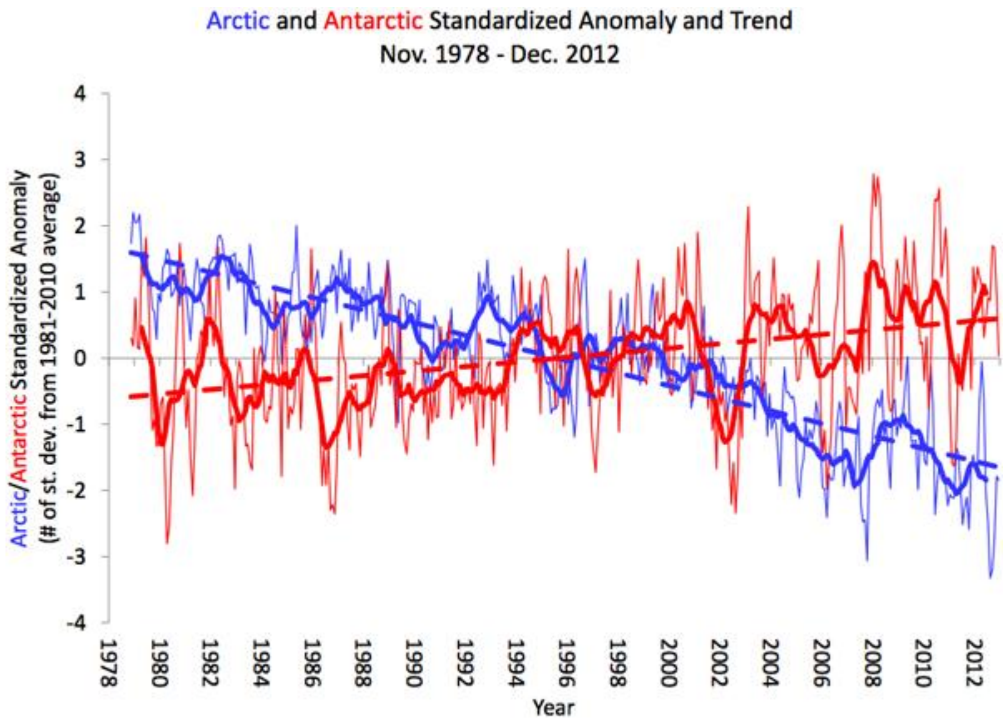
CORRECTIVE ACTION

14. What can man do about all this?

A - Very little! As discussed above, the predominant factors affecting future climate on the earth are natural; humans can do little about this unless large-scale (and very controversial) geoengineering efforts [35] are made to force climate change artificially (such as by putting reflective particles into orbit around the earth, thereby reducing the incoming solar flux).

However, throughout history, man has shown a remarkable ability to adapt to external events. As an example, the Netherlands has even adapted to having 25% of its surface area being beneath sea level by constructing dykes and flood control dams. London has adapted by building the Thames Barrier to protect the city from abnormally high sea levels under certain conditions.

Note that there is a difference in temperature trends between the Northern and Southern hemispheres. As an example, looking at records of polar sea ice extent [36] over the past 30 years, it can be seen that the Arctic ice is shrinking at the same time that Antarctic ice is slightly expanding:



If the earth warms up, there will be a general shift of the population to cooler regions of the planet.

Humans tend to abhor change. A lot of people like things "just the way they are now", and believe that the climate we have been enjoying for the past few decades is "perfect" for them. But it is the height of arrogance and selfishness to believe that present conditions are ideal for us, and that we have the ability to control the climate so that it stays this way! The best recommendation that can be given is that man must learn to adapt to the continually changing climate.

15. What about the switch from oil and coal to alternate energy sources?

A - Oil and coal have been major energy sources for over two centuries. It has a high energy density (ie: a small and light weight amount of the substance has the potential to create a large amount of energy). A few decades ago, there was worldwide concern that we were running out of these fossil fuels and only had a limited supply, but new exploration/extraction techniques, combined with more efficient energy use have allayed those concerns.

Fossil fuels are converted to energy by the process of combustion. Almost 40% of the material's potential energy is extracted in modern gasoline or diesel engines, and almost 55% in modern combined-cycle gas-fired power plants. The remaining energy is turned into waste heat. In building heating applications, the fossil fuel is burned to directly create heat: this process can have efficiencies of over 95%. All of these combustion processes generate CO_2, and this is the main focus of politicians, scientists, and environmentalists.

Electricity is a good way of moving energy between terrestrial locations. Thermal power plants convert fossil fuels (usually natural gas or coal) to mechanical energy that drives efficient generators, and the resulting electricity can travel long distances over power lines to operate motors, heaters, lights, and industrial processes in remote locations.

Hydro-electric power plants are an environment-friendly way to generate electricity. After a major capital outlay, the plant produces electricity quietly and efficiently over a long period of time, without emitting greenhouse gases. Unfortunately, suitable sites for new hydro-electric plants are becoming scarce.

Nuclear power plants are pollution-free ways of reliably producing electricity at low cost (other than the very large initial capital outlay), but there are disposal issues with the spent fuel, and certain segments of the public are vehemently "anti-nuclear" based on political views or supposed safety concerns. Despite these concerns, nuclear power plants are widely used in some parts of the world (Over 70% of France's electricity is produced by nuclear power plants).

Photo-voltaic cells ("solar cells") can produce electricity directly from the solar energy incident on the earth. The efficiency of the conversion process can be as high as 20%, but it degrades somewhat as the cells age. The biggest problem is that this is an intermittent source: it only produces electricity during the day time, and is affected by local weather conditions (clouds, fog, rain, etc).

Wind turbines produce electricity at any time of day if the wind is blowing, but their large, highly-visible profile means that they are usually located in remote areas or offshore.

Other so-called "sustainable energy sources" include waves, tidal power, and geothermal.

Wind turbines and solar cells have received most of the publicity in recent years as large arrays of these devices have been installed around the world. The biggest problem is the intermittent nature of their output. To compensate for this, excess generating capacity has to be installed, and very large energy storage devices (batteries, pumped water, etc) have to be included to ensure a reliable source of supply.

There has been much development in electrical technology for road vehicles, but the major problem has been the availability of electrical energy storage devices (primarily batteries) that are small and light enough to fit into the vehicle, and that have sufficient capacity to provide decent range between charges. The energy density (KW-h per Kg) of modern Li-ion batteries is about 2% that of gasoline or diesel fuel. Some specialty electric cars have met with market success, but battery technology needs to produce at least a doubling of battery energy density before they are considered viable for mainstream applications, and then the problem will be one of installing enough charging infrastructure to allow for unimpeded travel without the drivers suffering from "range anxiety".

Ships, highway trucks and airliners pose their own problems, and are unlikely to be weaned off of fossil fuels for some time to come.

If it were possible to convert all power generation, heating, and transportation applications to non-fossil fuel technology,[37] it would be possible to reduce the total amount of man-made CO_2 emissions by over 50%, thereby ultimately reducing the atmosphere's CO_2 concentration by 6 to 8 ppm. This small decrease is unlikely to have a major effect on climate change. It would of course still be required to extract oil and natural gas from the ground for the manufacture of synthetic materials, plastics, asphalt, lubricants, and pharmaceuticals.

POLITICS

16. What is the IPCC, and aren't they researching this?

The IPCC (Intergovernmental Panel on Climate Change) is a politicized technical organization that reviews and summarizes scientific papers related to climate change.[38] It does not do original research, nor does it conduct climate monitoring.

The IPCC was established in 1988 by the World Meteorological Association (WMO), and the United nations Environment Program (UNEP). It is specifically tasked with assessing published scientific information relevant to human-induced climate change.[39] In other words, the organization already believed that it was human activity that was causing climate change before they even started work.

Member are appointed to the IPCC by individual countries, presumably on the basis for their support of their country's adopted position on the topic. The IPCC generates "Assessment Reports" that are compilations of the technical material that has been reviewed. Five of these assessment reports have been produced so far. Before publication, wording of these assessment reports is reviewed on a line-by-line basis to ensure that the material is consistent with the position of each of the 195 countries that supplied members to the IPCC.

Although it has a scientific basis, the IPCC is heavily influenced by politics!

17. Is the "science settled"?

A - **No**! In the popular press, it is common to hear terms such as "The science is settled", or "97% of scientists agree". However, consensus is not a legitimate way to conduct science! If we allowed mere consensus to dictate scientific beliefs, we would still think that the earth was flat and the sun revolved around it, because Pythagorus, Socrates, Aristotle, and Galileo were not part of the "the scientific consensus" at the time.

The "97% of scientists" are often talked about in the media, but there is some doubt about the validity of this number,[40] [41] [42] [43], or their conviction[44] and they fail to mention the 31,000 US scientists and engineers who have signed a petition[45] [46] urging the US government to reject the Kyoto agreement and its assumptions.[47]

The IPCC scientists have had a number of scandals where it has been alleged that data was falsified in order to support the pre-ordained conclusions that were mandated to be produced. Examples include Mann's famous "Hockey Stick",[48] [49] [50] and the scandal at East Anglia University when leaked e-mails revealed that data was being systematically manipulated.[51] [52] It is claimed that the "East Anglia Data Manipulation" has now been satisfactorily explained, but there is still controversy surrounding the incident. There is considerable controversy and emotion surrounding the topic of "climate change", and both sides of the argument have resorted to less than professional tactics.[53]

18. Aren't the politicians, NGO's, and scientists working on this? Who can you trust?

A - Take everything with a grain of salt, and "follow the money". Ever since Al Gore (a former US politician) rejuvenated his career by producing a glossy, sensational, but wildly inaccurate and misleading documentary entitled "An Inconvenient Truth", politicians have been scrambling to climb on the bandwagon and hitch their stars to the climate/environmental movement. Meanwhile, universities, researchers, consultants and NGO's have been given easy access to funds for projects which will support the IPCC's "consensus viewpoint" that Global Warming is caused by man's activities, and that is bad for humanity. Left-leaning organizations are seizing on "climate change hysteria" as further evidence of capitalism's evil nature.

Unfortunately, Canada's school system has embraced the IPCC's position wholeheartedly, and is indoctrinating our children with their potentially incorrect conclusions, and teaching that "consensus" is now apparently a legitimate way to conduct scientific research. Al Gore's fear-mongering (but inaccurate) documentary is also being widely shown in the schools. throughout the world.

Meanwhile, anyone who offers dissenting points of view is mercilessly hounded and deprived of funding. Climate warming is turning into a religion! [54] [55] Heretics are labelled as "deniers", or "sceptics", and are blacklisted.

Much of this (both scientific and political) is reviewed in a documentary by John Robson entitled "The Environment: A true Story".[56]

And of course, don't believe anything you read in the popular press as they seek to retain or expand readership by printing more and more sensational headlines such as: "Highest Temperature Ever Recorded", "Global Warming Increasing Hurricane Threat", "The Glaciers Are Melting", "Unprecedented Warming", "Climate Change Is Destroying Fish Stocks", "Global Warming Is Worse Than Predicted", and "Polar Bears At Risk".

The best advice is : **QUESTION EVERYTHING**!

SUMMARY & CONCLUSIONS

19. Based on the above material, what should we believe, and what should we do?

A - A number of conclusions can be taken away from the information presented so far in this document:

a) *Climate change is a naturally-occurring, cyclic phenomena, and it has been going on for millions of years.*

b) *Climate change is primarily driven by changes in the energy of the sun that impinges on the earth. The dominant factors driving this are Milankovitch Cycles, and Sunspot variations (11 year cycle, planetary solar tides, EUV variations). Other factors include the effect of varying cosmic particle influx, causing changes in cloud cover.*

c) *The primary greenhouse gas is water vapour. The effect of atmospheric CO_2 on global temperature change is not major.*

d) *Man-made CO_2 has a small effect on global temperature changes, but it is not the dominant factor.*

e) *Climate models are not effective at forecasting future long-term global temperatures.*

f) *There is very little that mankind can do to affect global temperature change. It does not make sense to introduce regulations that will have a negative impact on Western economies in a pointless attempt to change the natural rate of global climate change.*

g) *Mankind will have to learn to **adapt** to future climate changes.*

Any legislative efforts to limit man-made carbon dioxide emissions at the local, regional, provincial, or federal levels may be well-intended, but are ultimately futile, and potentially dangerous. These efforts will harm the economy, waste resources, and not significantly affect the naturally-occurring cyclic climatic changes.

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