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QUESTIONS ABOUT CLIMATE CHANGE AND GLOBAL WARMING

(Shorter Version)

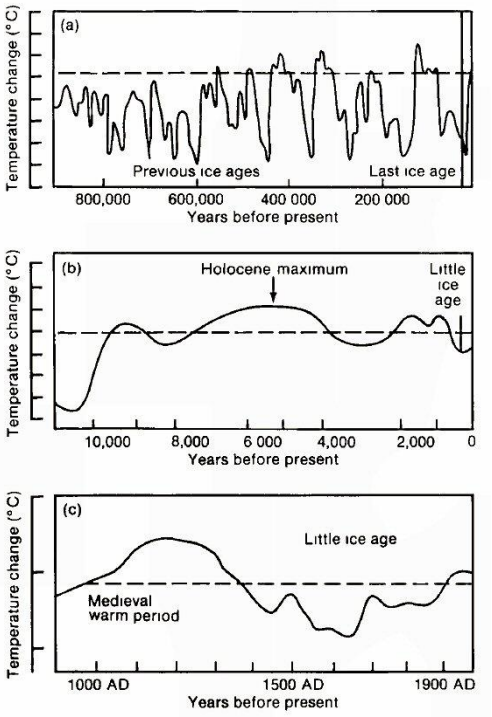
When a person speaks about "weather", they are referring to how the atmosphere is behaving over the short term (hours or days), and usually about how it directly affects them (in terms of temperature, precipitation, humidity, wind, etc.). The term "climate" refers to the statistics of weather over a 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." The global temperature is the average temperature at the surface of the entire earth, measured over a period of time.

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 from the IPCC's 1990 report [1], and show global temperature variations over three different time scales. 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. 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".

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*) has stubbornly postulated that recent changes are primarily the result of activities by humans.

2. What factors affect the earth's climate?

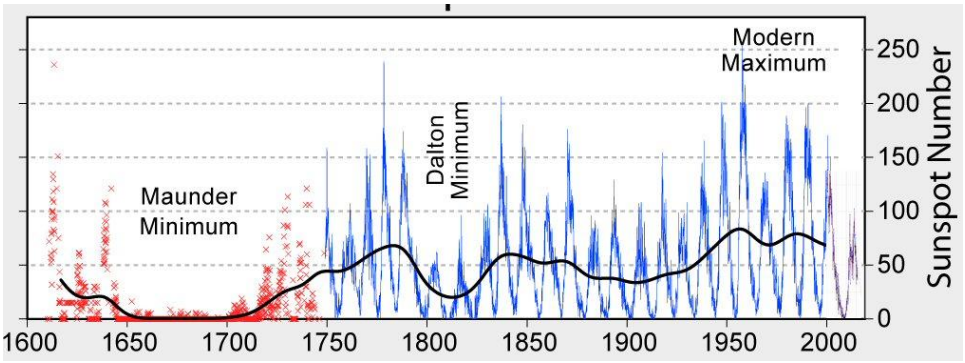
A -The earth has its own internal heat sources, such as its radioactive core, but these are very small. The earth's temperature is primarily a function of the electromagnetic energy received from the sun (so-called "solar radiation"). In the absence of the sun or any internal heat sources, the earth's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

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 [2]. 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).

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 (as summarized by Ray Tomes of Auckland, NZ in 2004 [3]) might be caused by "tides" on the sun's surface due to gravitational effects from the orbits of Jupiter, Saturn, Earth, Mercury, and Uranus. Other theories based on relativistic causes or inter-planetary electric fields 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 that eventually strikes the Earth's atmosphere.

These cycles also have a major effect (by at least a magnitude factor of 10) in extreme ultraviolet (EUV) radiation, which can strongly effect the chemistry and thermal characteristics of the earth's upper atmosphere. [4]

The amount of solar energy that actually reaches the earth's surface is affected by many atmospheric variables: clouds, water vapour, surface reflectivity, and the "**greenhouse effect**".

THE GREENHOUSE EFFECT

4. What is the "greenhouse effect"?

A - 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 energy and the longer-wavelength IR energy (in the range of 10μm) that is emitted by the earth's surface. 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 linearly proportional to the concentration of the greenhouse gases: it varies with the logarithm of the concentration. [5][6][7] 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.

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

A - 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! [8]

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 effect 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.

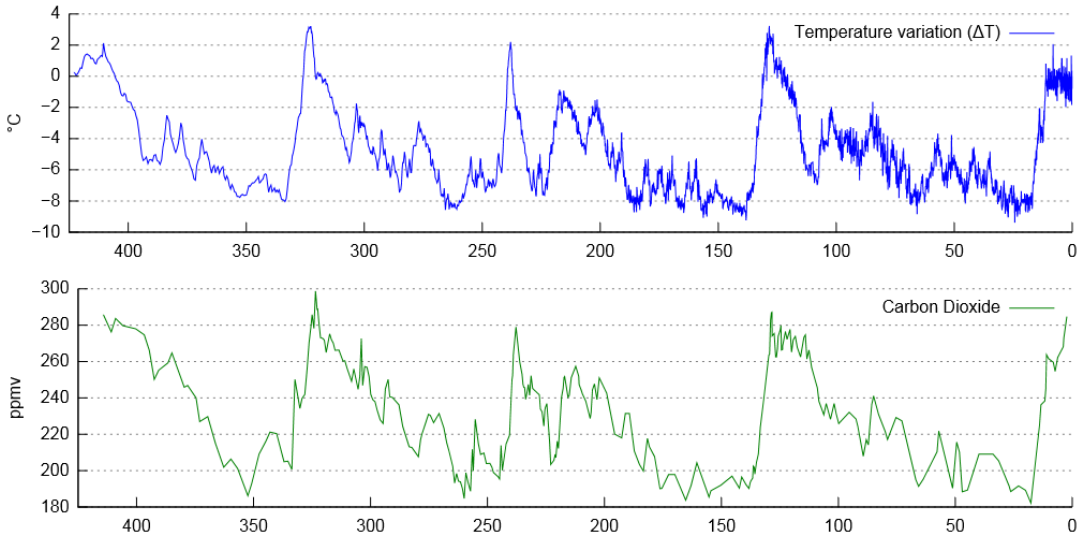
MORE ABOUT CO_2

6. Can global temperature changes be attributed to changes in CO_2 concentration 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, but the historical record (from sediment and ice core samples) does not support this.

The current concentration of atmosphere is approximately 400 parts per million (ppm) by volume. It has been much higher in the past during the Jurassic and Cambrian periods [9]. More recently, the concentration has been slowly rising from a low of approximately 260 ppm about 7,000 years ago [10].

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 [11]:



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 close examination of the data shows that CO_2 concentrations start to increase about 800 years **after** temperature starts 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 [10].

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! 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.

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.

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 [12]. 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 being the major mechanisms.

There is controversy over the lifetime of CO_2 in the atmosphere (estimates vary from 5 to 200 years, but analysis suggests it is probably in the range of 8 to 15 years) [13], and even more about how significant man's contribution is. Current estimates are that 3 to 4 percent of the 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 effect 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 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.

Data from climate models should be treated with a large degree of scepticism!

FLOODING POTENTIAL

10. What about melting ice and sea level changes?

A - 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 [14].

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 .

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 adjust to these changes.

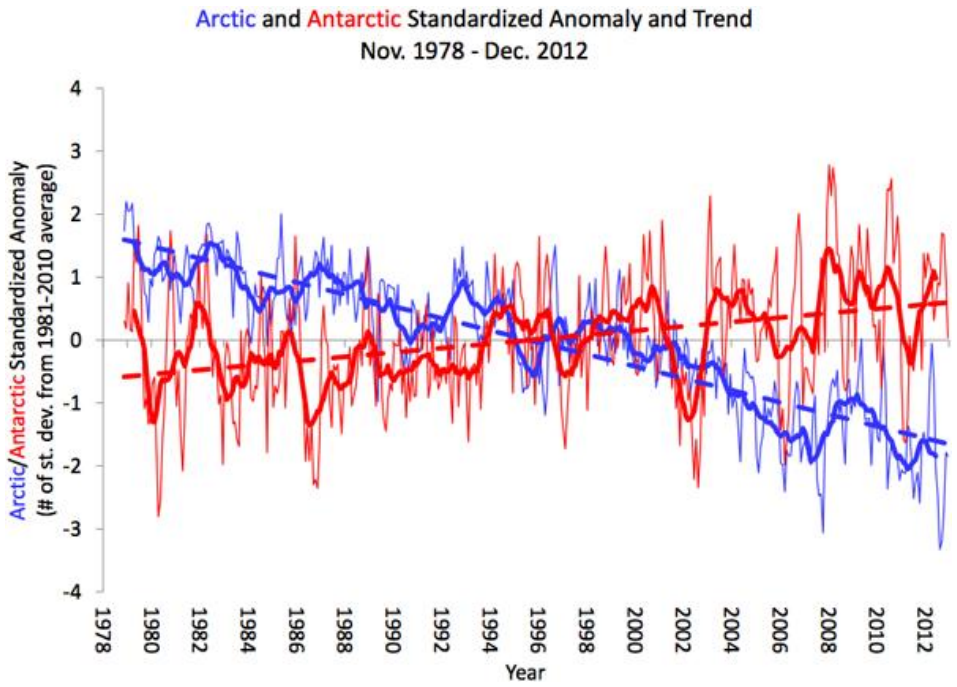
CORRECTIVE ACTION

11. 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 controversial) geoengineering efforts [15] 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 [16] 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. The best recommendation that can be given is that man must learn to adapt to the continually changing climate.

12. 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 "anti-nuclear" based on safety concerns or political views. Despite these concerns, nuclear power plants are widely used in some regions (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".

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 [12], it would be possible to reduce the total amount of man-made CO_2 emissions by over 50%, thereby reducing the atmosphere's CO_2 concentration by 6 to 8 ppm. This small decrease is unlikely to have any 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, and lubricants.

POLITICS

13. 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 [17] [18], and they fail to mention the 31,000 US scientists and engineers who have signed a petition urging the US government to reject the Kyoto agreement and its assumptions. [19]

The IPCC scientists have had a number of scandals where it has been proven 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" [20] [21] [22], and the scandal at East Anglia University when leaked e-mails revealed that data was being systematically manipulated [23] [24]. 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. [25]

14. 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": the conclusions can usually be predicted in advance. 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 documentary is also being widely shown in the schools.

Meanwhile, anyone who offers dissenting points of view is mercilessly hounded and deprived of funding. Climate Warming is turning into a religion! [26] Heretics are labelled as "deniers", or "sceptics", and are blacklisted.

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

15. 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).

c) The effect of atmospheric CO_2 on global temperature change is not major.

d) Man-made CO_2 is not a significant contributor to global temperature change.

e) There is very little that mankind can do to effect 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.

*f) 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 climate changes

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