600 MILLION YEARS OF CLIMATE CHANGE; A CRITIQUE OF THE ANTHROPOGENIC GLOBAL WARMING HYPOTHESIS FROM A TIME-SPACE PERSPECTIVE

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Abstract: The paper reviews the climatic changes that took place during the Quaternary, in particular those of the Holocene, including the historical time. The role of carbon dioxide, as a greenhouse gas, is emphasized since it is an important factor influencing the global climate. During the last century, a non-negligible increase in the atmospheric concentration of CO_2 brought about a rise in global temperature attributed by many scientists to a man-made cause and labeled "anthropogenic global warming". It is claimed that a rapid (even exponential) increase in the content of man-made greenhouse gases (of which CO_2 is the most important) in the atmosphere may have grave consequences for human society, such as a rise in the see level, desertification processes on a large scale, with ensuing water shortages, biological mass extinctions, many more violent meteorological phenomena, etc. A large group of scientists claimed that mathematical-statistical models predicted extremely alarming worldwide events and proceeded to popularize such consequences of global warming, emphasizing their catastrophic impact upon planet Earth and, especially, upon human society. Strong measures to counteract these man-made climatic changes were recommended. Against such alarmist point of view other scientists advocated more research, since climate and its variations represent the most complex natural phenomenon. They questioned many conclusions of the adepts of global warming, conclusions drawn from the climate-statistical models (Global Circulation Models). This paper agrees with the skeptical scientists and advocates that more research is necessary before reaching a definitive conclusion, that it is indeed only mankind which is responsible for the present and future climate change and that the so-called science of anthropogenic climate change is settled and no more doubts should be expressed. In particular, the role and accuracy of mathematical models and the influence of climate feedbacks need much more research to confirm or negate the process of global anthropogenic warming. It is concluded that skepticism is a healthy scientific position and that alarmist and confrontational view points are not helpful in an ongoing discussion and, thus, a moderate and reasonable approach is recommended.

Key words: Climate change, Global warming, Hierarchy of climate types, Greenhouse gases, the CO_2 cycle, Neogene ice age, Milankowitch theory, Keeling curve, Radiocarbon, Climate mathematical models, Climate feedback mechanisms, Rising sea levels, Desertification, Water shortages, El Niño and La Niña, Global warming alarmists and skeptics, Abrupt change

INTRODUCTION

Planet Earth has undergone major and long-lasting climate changes during the Phanerozoic eon (representing roughly the last 600 million years of Earth history). Shorter modifications also occurred and such differences in the life span of climate variations led to a ranking of such changes.

The longest time intervals are known as climate modifications which lasted between fifty and one hundred million years, sometimes longer. Climate oscillations cover a 30,000 to 150,000 years time span, the global and interglacial stages of the Plio-Pleistocene belonging to this category. Climatic fluctuations lasted between 5000 and 10,000 years, while climatic excursions' duration is between 100 and 1,000 years.

Climate regimens and the change from one to another depend on a multiplicity of factors, but it is acknowledged that the variation in the content of carbon dioxide in the atmosphere and, in some respects, in the hydrosphere and biosphere plays an important role in the modification of climatic regimens. Indeed, upsets in the CO_2 contents of the atmosphere did occur several times in Earth's history and were linked to a change in the global climate. Although representing a small percentage of all planetary gasses, CO_2 has a far from negligible role in generating, maintaining or ending a warm or even hot climate. Its ubiquity within Earth's 4 geospheres and its migration from one geosphere to another makes it a major player in climate variation.

In the case of climate modifications (lasting some 100,000,000 years), the CO_2 content of the atmosphere was a factor, together with the geographical position of land masses, closer or more distant to the poles, the pattern of marine currents, the average altitude of the continents, the location and altitude of mountain ranges in determining the nature and intensity of climatic factors.

The role of CO_2 in the heat balance of the planet is determined by the rates of emission and absorption of the gas by the geospheres, together with the time of migration from one geosphere to another, and the time of residence in each geosphere. When the rate of emission and that of absorption of CO_2 are roughly in balance, the global climate will be equable. But upsets in the CO_2 balance did indeed occur in Earth's history.

According to Fischer (1982) : "The variation in the CO_2 content of the atmosphere from deficit to surplus and back to deficit is responsible for the planet's climate to oscillate between two basic states, the greenhouse and the icehouse state. The greenhouse state is characterized by low latitudinal gradients, warmish and humid polar areas, lack of polar icecaps and of mountainous glaciers, warm oceans and extensive circulation of marine currents bringing warm waters to polar latitudes. The icehouse climate is associated with high latitude gradients, cold and dry polar areas covered by ice, rather cold oceans and reduced oceanic circulations, especially where land masses were emplaced around the poles."

The Earth went, in the last 600 millions years, through three icehouse states (Late Precambrian – Early Cambrian, Late Ordovician – Early Silurian, Late Carboniferous – Early Permian) and it is now in the throes of a fourth icehouse regimen which began in the Late Oligocene – Early Miocene.

Considering the duration of the previous glaciations (between 50 and 90 million years) (Crowell, 1982), the present icehouse state has some 20 – 30 million years to run its course, periods of glacial oscillations alternating with interglacial ones.

It has become obvious that there is a certain order in the succession of climates which form cycles of 150- 250 million years. Each cycle usually begins with a hot and dry regimen which gradually changes into a mild, moist and equable one. A slow and steady cooling follows, leading to a climate with well differentiated seasons over most of the planet. A continuous cooling leads to an ice age, closing the cycle. (Brooks, 1970)

The main conclusion to these introductory remarks is that the terrestrial globe has undergone repeated climate changes, including periods of excessive heat, when temperatures were much higher than the ones of our times over substantial parts of the planet. The consequences of the ending of an ice age, regardless of its duration, were a rising of the sea level (sometimes, exceeding 100 meters), a quite extensive process of desertification (deserts occupying over a third of the planet) and widespread biological mass extinctions (in some cases 70% -80% of all plants and animals perished). And yet, Terra recovered almost miraculously from all these ordeals and continued to evolve and prosper.

As already mentioned, the carbonic gas was involved in most of the drastic climatic changes the Earth underwent during the Phanerozoic. This is why the role it played deserves to be analyzed in more detail.

I. CONTRIBUTION OF CARBON DIOXIDE TO CLIMATE CHANGE

It has been known, since the XIXth century, that carbon dioxide is a greenhouse gas, absorbing and capturing a part of the solar infra-red radiation (basically, heat) reflected by the Earth, thus maintaining it around the planet, rather than let it dissipate in the outer space.

Studies showed complex processes in the CO_2 circulation within the four terrestrial geospheres, forming a rather complicated cycle of this gas. Many physical, chemical and biological processes are involved, beginning with the delivery of CO_2 from several sources, its circulation through the geospheres, its storage in sinks or reservoirs and its eventual return to the atmosphere.

Huge supplies were provided by the outpouring and degassing of basaltic magma along mid-oceanic rift valleys and by continental volcanoes. Both vegetal and animal kingdoms pumped millions of tons of CO_2 through the process of respiration. Finally, the decomposition of organic matter, especially during moist and warm climates, was the third important supplier of CO_2.

Plants not only supplied CO_2 through respiration, they also absorbed it through the process of photosynthesis which represents the first "storage room" for CO_2. The second CO_2 sink was the complex of carbonate-rich rocks resulted from the weathering of igneous rocks rich in calcium oxides which reacted with the available CO_2 in the atmosphere and hydrosphere resulting in carbonates.

Finally, the rapid burial of organic matter arrested quite large quantities of CO_2 in the subsoil.

This carbon cycle, including the circulation of CO_2 through all four geospheres, has been operating, not only on the grand scale of climate modifications, but also on the smaller scale of climate oscillations and fluctuations. In fact, from the viewpoint of the global warming hypothesis, these latter subdivisions are more interesting and more relevant.

II. PLEISTOCENE AND HOLOCENE CLIMATE VARIATIONS

For many years, the cause for an oscillating climate was not known. Detailed studies of the Pleistocene oscillations, materialized in glacial and interglacial epochs have reached the conclusion that such alternances are mainly the result of extra-terrestrial processes, but a contribution of greenhouse gases is almost certain (Hays *et al*., 1976).

A Yugoslav mathematician and physicist, Milutin Milankovitch, claimed to have found the explanation for the repeated glacial and interglacial oscillations. They were the result of astronomical phenomena associated with the Earth/Sun relations (Milankovitch,1920,1930). According to his calculations, three orbital parameters were instrumental in determining the alternance of glaciations (eccentricity of the Earth's orbit around the sun, the obliquity of the Earth's spinning axis, the precession of the equinoxes) (Fig. 1). It is the variation of these parameters which is time-dependent that allowed Milankovitch to construct radiations curves correlating the position of the Earth *vis-à-vis* the sun with the amount of insolation the planet was receiving. The radiation curves showed that ice-ages should occur roughly every 100,000 years, with smaller temperature swings every 41,000 and 21,000 years average, figures that correspond well with the actual dates and duration of glacial and interglacial oscillations.

In depth research has identified several advances and retreats of both continental glaciers and mountainous glaciers, so that each oscillation was, in fact, a composite of shorter fluctuations. Thus, it was concluded that during every glacial and interglacial episode, epochs of quite appreciable warming alternating with epochs of deep freezing were common.

Such fluctuations and excursions are recorded during the present interglacial all the way to historical times. For instance, after the initial warming which marked the beginning of the present-day interglacial oscillation, a period of cooling ensued between 8,800 and 8,200 BC, followed by a long-lasting warming, known as the Climatic Optimum (8,000 to 5,000 BC.)(Lamb, 1965). Then, at several times, temperatures exceeded by 2 °C to 3 °C those of today. Glaciers expanded again and long, harsh winters affected the northern hemisphere some 5,000 years ago.

According to Singer and Avery (2007), the last 3,000 years can be subdivided into several climate excursions, which were alternately cold (700-200 BC, 440-900 AD., the so-called Dark Ages and 1,300-1,850, the Little Ice Age) and warm (200 BC – 600 AD, the Roman Warming, 900-1,300 AD, the Medieval Warming and 1,850 AD to present, the New Warming).

Thus, looking over the climate of historical times, it becomes obvious that repeated swings between frigid and warm fluctuations and excursions did occur. There is no acceptable explanations for such alternations; they are certainly too short to fit into a Milankovitch cycle.

It is worth noticing that between 1,200 and 1,300 AD the concentration of atmospheric CO_2 "jumped by 10 parts/million, which stands out as an unusual, indeed unique natural fluctuation" (Gribbin,1990).

The climate became milder beginning with the XIX century, long before the industrial age started to produce significant amounts of man-made CO_2. Therefore, it is clear that, whatever cause (or causes) of the succession of cold and

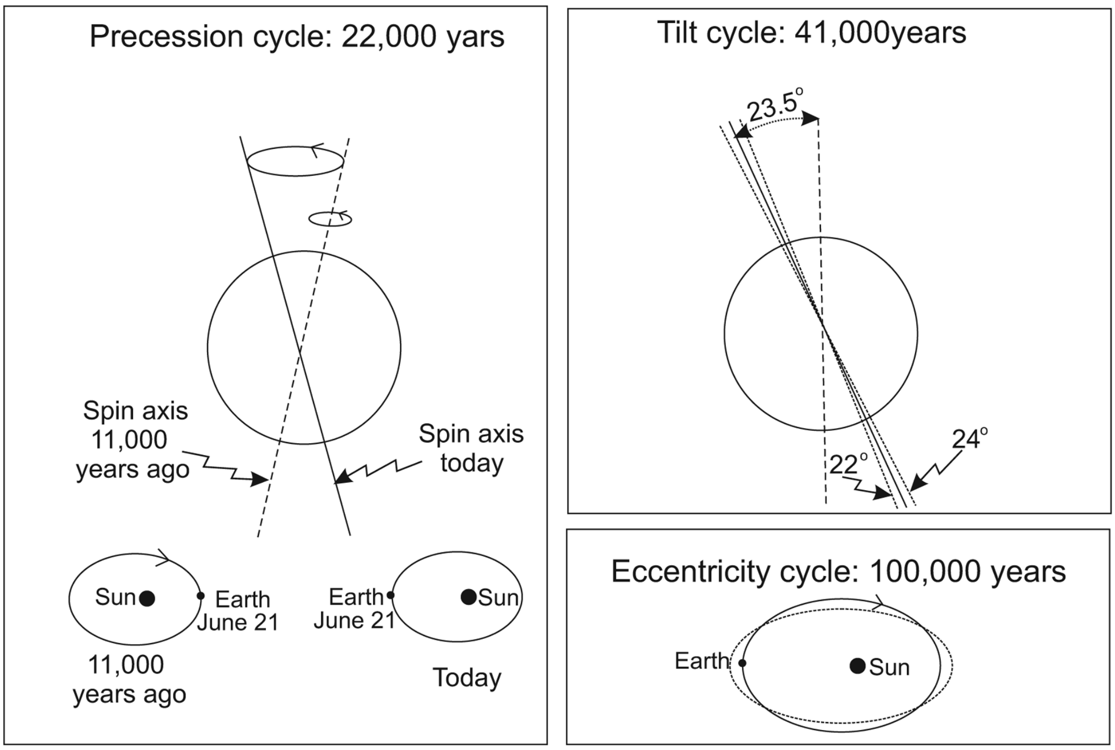

Fig. 1 The Milankovitch orbital cycles. Modified from Broecker and Kunzig "Fixing Climate", 2008.

warm episodes registered in the last 10 millenia, anthropogenic warming is not among them.

It is now time to analyze the causes, mechanisms and consequences of present and future climate changes in general, and of anthropogenic warming, in particular.

III. THE ANTHROPOGENIC GLOBAL WARMING HYPOTHESIS

As mentioned in the introduction, a group of scientists strongly advocated the concept of Anthropogenic Global Warming, forcefully claiming that the rising temperature all over the World was not a natural phenomenon, but a man-made one. The warming of the atmosphere (and, in the same measure, of the hydrosphere) was the result of the discharge into the air of vast amounts of greenhouse gases, CO_2 being the main culprit, generated mainly by society's industrial and agricultural activities through the burning of fossil fuels, primarily coal, but also petroleum, natural gas and old-fashioned wood. Continuing pouring into the air, exponentially increased amounts of CO_2 will soon lead to catastrophic climate change.

By far, most predictions were based on mathematical models, which in turn were predicated on temperature data collected from the present-day atmosphere, as well as from "fossil" or past temperatures obtained by indirect measures, the so-called proxies.

A. The question of the present and past temperatures

As far as contemporary direct measurements of temperature are concerned, they were provided by literally thousands and thousands of meteorological stations all over the World. They, indeed, showed a global increase in temperatures, especially starting in the last half of the XXth century. Yet, a group of scientists required more prudence in the interpretation of data. They were "the skeptics", though not categorical "deniers" of global warming. Their position was admirably defined by Dr. Ray W. Spencer, who put it in a nutshell: "None of us deny that global warming has taken place. What we are skeptical of is the theory that all (or even the most) of global warming is caused by mankind, or that we understand the climate system and our future technological state well enough to make predictions of global warming in the next fifty to one hundred years or that we need to reduce fossil fuel now" (Spencer, 2008).

It is true that temperatures are collected throughout the world, but this is not really a correct statement since 90% of the measuring stations are and were emplaced and located on land. Of these, a clear majority covered the territories of North America and Europe. Observations from Asia, South America and Africa were much sparser and the measuring stations were antiquated so that the information they provided was less reliable.

But the most important reservation concerning the accuracy of data from measuring stations is their emplacement in or near the cities or towns which are known as "urban heat islands". The buildings, the pavement, the buses and cars, are all traps of heat that they release later, distorting the temperature of the area. It is claimed that appropriate means and statistical measures were taken to clean and correct the data, but it is doubtful that such measures have been taken in all urban agglomerations, but the real large ones. Thus, some scientists are convinced that "Earth's surface thermometers are heavily skewed by urban heat islands and overstate surface warming by as much as 40%" (Singer and Avery, 2007).

C.C. Horner, one of the strongest opponents of global warming, points out that the 1990s, considered to be the hottest of the last century are an artefact due to the closing of many measuring stations in the former Soviet Union, closure resulting from lack of funds, but also from the chaos following the implosion of the USSR". It so happened that the majority of the closed stations were situated in Siberia, mainly in remote locations. Thus, many low temperatures located in the coldest area of the world were not registered, skewing the average global temperatures" (Horner, 2007)

Many violent meteorological phenomena were linked by "the alarmists" to global warming. As Spencer put it: "Floods? Global warming! Draughts? Global warming! Hurricanes? Global warming! Sea level rise? Global warming! (Spencer, 2008).

For instance, the heat waves of the previous years resulted from a drastic change in the jet stream path, which has retreated northward into Canada, leaving a large part of the USA open to an invasion of hot air from the Gulf of Mexico and the tropical-equatorial Central Atlantic, especially when a stationary front blocks the movement of cooler air from the west. If over such a pattern is superimposed an El Niño phenomenon (as it will be discussed later), then a really dreadful situation occurs. According to Silver (2008) "tropical storms are strongly influenced by an El Niño event, which also causes a movement of the jet stream closer to the poles". But there is no proof whatsoever that global warming has anything to do with it.

It must be noticed that many claims about the hottest year or decade or century come with a discrete disclaimer such as "on record", "in recent history", "ever recorded", etc. The fact is that the only credible figures are those of thermometer measurements. Still, given the rather primitive measurement instruments during the XIXth century and the sparse temperature data, even those must be regarded with prudence.

For almost all of the Holocene interglacial, one must rely on indirect data, quite credible when it comes to a larger picture (the Little Ice Age, the Medieval Warming) but not to specific numbers. It cannot be said that the year, say, 1472 was the hottest since the termination of the last glacial compared to the year 2005.

What is also known is that the temperature during the previous interglacial (125,000 years and beyond) were 2°C - 5°C higher than the present ones (Crowley and North, 1991; Silver, 2008).

Before examining the pros and cons of the anthropogenic cause of climate change, it is useful to put some facts (and numbers) into perspective.

Calculations have shown that natural processes discharge into the atmosphere circa 200 billion tons of CO_2 every year (produced by plant and animal respiration, volcanoes, geysers, fumaroles, hot springs, organic decomposition, etc.). The human contribution may be approximately 7 billion tons per year, 30 times less than the natural addition of CO_2 (Lee, 1993). Since 1859, human activities have released some 100 billion tons of CO_2 into the atmosphere which weighs 5 quadrillion tons (Spencer, 2008).

Put in a different way, anthropogenic CO_2 adds 1 molecule of CO_2 to 100,000 molecules of air every 5 years, representing a concentration of 38 molecules of CO_2 for each 100,000 molecules of air (that is nitrogen and oxygen) (Spencer, 2008).

But CO_2 is not the only greenhouse gas. First and foremost are the water vapors which account for 70% - 80% of the warmth of the atmosphere. Next important is methane (CH_4). Calculations show that one molecule of CH_4 absorbs 24 times the amount of solar energy of one molecule of CO_2. But since CH_4 concentration in the atmosphere is 165 times less than the concentration of CO_2, its warming effect appears to be less prevalent than that of CO_2. A modest part of methane is human contributed, mainly through agricultural endeavors (rice paddies where methane producing bacteria florish, burning of wood as fuel, burning of forests to make room for farm land). A non-negligible source of methane is represented by domestic ruminant animal flatulence.

Other greenhouse gases with a small contribution to the greenhouse effect are ozone, chloro-fluoro-carbons and nitrous oxide.

Finally, looking at the global temperature variations during the last 150 years or so, since the beginning of the industrial revolution, one notices that temperatures started rising, following the end of the Little Ice Age, reaching a high point in the 1930s. So, for instance, there was a dramatic increase in temperature of more than 1°6 C from 1920 to 1940, but a subsequent equally drastic fall, from 1940 to the mid-1970s, only to increase again since.

From all of the above, two conclusions can be drawn: First, that the climate oscillates quite often, including the XXth century; second, that most of the short fluctuations are not directly related to the alleged anthropogenic CO_2 input to the atmosphere.

With all the remarks mentioned so far, one can now get to the core of the problem of possible anthropogenic climate change.

There are three important aspects of the problem namely: the theoretical and physical basis of the hypothesis; the role of mathematical models and the contribution of feedback mechanisms.

B. The theoretical and physical basis of the hypothesis

The scientists skeptical of the claim that all or almost all of warming is a result of human activity, mainly by burning fossil fuels, agree that, indeed, the climate is getting warmer and that a part of the process may be man-made. But they ask three basic questions: (1) how much of the Earth's current warm up is a result of natural processes and how much is due to activities of mankind? (2) How bad will the process of global warming be, in the future? and (3) what can and should realistically be done about it?

To claim that there is no warming at all and that all warming (very modest) is exclusively a result of natural processes is quite sure not correct. It should be admitted that human society has an input in the process of climate change, besides the natural warming - a normal consequence of the deglaciation process - which has not yet reached its maximum.

Thus, the crucial problem is to try to disentangle what is natural warming from what is man-made.

The measurement of the atmospheric CO_2 began with Svante Arrhenius who proved that its content in the atmosphere was increasing and determined an increase in the global temperature. He based his conclusions on the discovery of the "greenhouse effect" made by Joseph Fourier and later by John Tyndall. Probably, Guy Stewart Callendar was the first to attribute in 1938, the rise of atmospheric CO_2 and the associated increase of global temperature to the burning of fossil fuels.

But it was in the 1970s that the concept of anthropogenic global warming and its consequences took flight, mainly through the research of Wallace Broecker and his collaborators (1979), following the ideas of Roger Revelle and Hans Suess (1957). He was soon joined by a plethora of meteorologists, climatologists, physicists and biologists, among whom James Hansen was the most determined and the most vocal (1981).

Ronald Bracewell concluded that periodical solar activity plays an important part in the alternating periods of cold and warm episodes. According to his calculations the 1970s should have been on a decreasing trend, started early in the 1950s. Broecker compared the actual average global temperature with the one predicted by the cycling of solar activities and found out that during the time interval when the world should have experienced a cooling condition, a warming trend was actually recorded. He explained such a rise by addition of anthropogenic CO_2 nullifying the cooling trend. He then calculated the greenhouse human effect measuring the quantity of CO_2 produced by industrial emissions and human activities.

Of course, the numbers he came with were approximate, but nonetheless he claimed that "the exponential rise in the atmospheric CO_2 content will tend to become a significant factor, and by early in the next century (XXI) will have driven the mean temperature of the globe beyond the limits experienced during the last thousand years" (Broecker, 1975; Broecker *et al*., 1979).

What was needed were some numbers to buttress the only qualitative data. They were provided by Charles David Keeling who started measuring year after year the quantity of CO_2 in the atmosphere, from his laboratory situated in Hawaii at the astronomical observatory of Mount Mauna Loa, chosen because the absence there of any significant air pollution. He started his measurements by the mid fifties and observed that practically every year the CO_2 concentration was increasing. The graph known as the Keeling curve (Fig.2) is more or less a straight diagonal line across the graph, documenting a gradual and steady increase in the atmospheric CO_2. What is intriguing is precisely the path of the curve, which shows the increase to be basically the same, year after year. One should expect, if most of the added CO_2 was indeed anthropogenic a much more ragged path, with some years standing out as much stronger producers of gas and others with a more moderate addition. It was as if the "polluting bad guys" have conspired to pour into the atmosphere almost exactly the same amount of CO_2 every year. It looks more credible that the cause of this homogenous trajectory of the CO_2 content is a natural release of it, as a consequence of a normal process of deglaciation. Anyway, the measurements tell us only that the total amount of CO_2 is increasing, but do not differentiate between natural and anthropogenic CO_2.

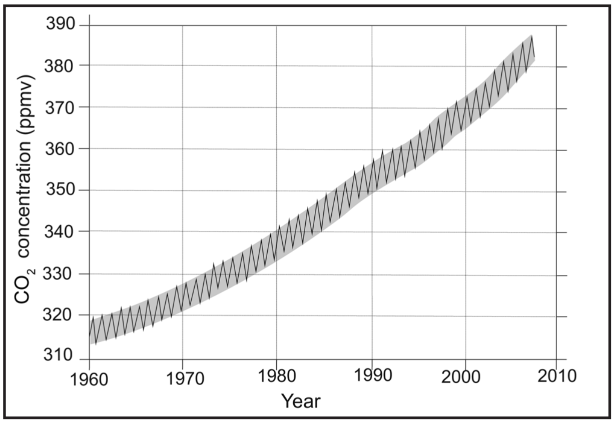

Fig. 2 The Keeling Curve.
Modified from Broecker and Kunzig "Fixing Climate", 2008.

Finally, the almost straight path of the "curve" does not reflect the claimed exponential increase of the amount of anthropogenic CO_2 in the atmosphere. The curve should have been a genuine hyperbolic curve with an increasingly steep ascending branch.

Keeling made two important but questionable, assumptions. The first was that the baseline of the CO_2 concentration was pretty much the same everywhere in the World. He concluded that the carbon dioxide gas was well mixed throughout the atmosphere. His second assumption, based on the first, was that there was no need to check the CO_2 content in several points of the globe and that the data obtained only from the Mauna Loa observatory and in Antartica were sufficient to draw conclusions for all atmospheric CO_2.

It is hard to believe, however, that the carbon dioxide (billions of tons emitted annually) could mix so thoroughly in just one year, over the entire atmosphere. Surely, there must be more CO_2 over volcanic areas or even huge industrial concentrations which did not have enough time in one year to become part of a homogenized layer of CO_2.

Since a substantial part of the gas is absorbed by the oceans, it must be summarized that the absorption coefficient is also practically the same, regardless of the geographical position (mainly latitudinal) of the body of water and its characteristics (density, temperature, salinity, depth, etc).

The same must be admitted concerning CO_2 absorption by plants, despite the fact that the distribution of the vegetal cover varies greatly and is highly diverse all over the planet.

Yet, the most important question had still to be answered. How to separate the two genetically different types of CO_2 since the Keeling and the other data did not explicitly segregate the anthropogenic CO_2 from the one produced naturally. The answer comes from observations and measurements made by Hans Suess (the son of the renowned geologist)

The key according to Suess was to differentiate among the three isotopes of Carbon, part of the CO_2 molecule. Unlike Carbon 12 and Carbon 13, which are stable, Carbon 14 is radioactive, so it decays in time, having a half life of 5,730 years. Because of this decay rate, radioactive carbon can be identified only in rather recent vegetal matter. It can be found in all living plants, especially trees, where it can be measured in their tree rings. In older organic matter, such as coal, there is no radiocarbon, since it has long decayed.

Carbon 14 is manufactured in the atmosphere by the interaction between nitrogen atoms and cosmic rays. Radiocarbon is then incorporated in the molecules of CO_2 and ends up in the bodies of organisms, such as trees and their annual rings.

By measuring the amount of Carbon 14 in different growth rings from the same trees, Suess wanted to know if the amount of CO_2 in the atmosphere was changing over time, an important element in allowing him to use radiocarbon as a dating method. He found out that since the XIXth century, radiocarbon has decreased by several percentages. Assuming that the supply of Carbon 14 has not changed, it meant that the atmospheric CO_2 pool was diluted by a source of CO_2 free of radiocarbon (Broecker and Kunzig, 2008). Since the percentage of all CO_2 has increased in the last century by approximately 20%, Suess assumed that this extra 20% of CO_2 devoid of Carbon 14 was the result of fossil fuels burning, whose very old carbon had lost all of the radioactive isotopes.

In Suess's reasoning there is a weak spot, namely the assumption that the quality and quantity of the cosmic rays intercepted by the Earth has always been the same, and consequently that the amount of radiocarbon stayed unchanged in the atmosphere. However, it is known today that solar activity can modify the amount of radiocarbon. When the Sun is more active, the solar wind is also stronger and acts as a shield for the incoming cosmic rays, thus decreasing the quantity of Carbon 14. The opposite is true when solar activity is at its weakest, allowing cosmic rays to penetrate the atmosphere and producing more radiocarbon.

The analysis of the tree rings sheds also some light over the relationship of temperature and the content of CO_2 of the air. It is obvious that the thicker the rings are, the more heat was involved for a longer period of time. What is important is that the Carbon 14 variation in the rings closely matched the sun's energy variation and thus the production of radiocarbon, linked in turn to more or less screening of cosmic rays by the solar winds. Two solar cycles were identified, one, at 80 and the other, at 180 years, in step with the size of the tree rings. According to Gribbin (1990) "the small amount of solar heat and possibly a more complex interaction, involving the way cosmic rays affect the production of clouds, causes, the Earth's climate to march in step with solar variation. Although nobody has satisfactorily explained just how this link works, the evidence is too strong to be dismissed".

Therefore, the assumption that the cosmic rays represent a constant in the calculation of the amount and impact of the cosmic rays intercepting the Earth is highly questionable. A consequence of the variability of the cosmic rays reaching the planet is that the amount of C_{14} is not unchangeable and can be much less in some years or decades than the one taken into calculations to determine the percentage of C_{12} and C_{13} resulting from burning fossil fuels.

The tree rings are a so-called proxy, letting scientists, through indirect methods to get information about the past history of the Earth, which could serve to make predictions for future climate behavior. Other proxies are the data collected from ice-core samples, ocean sediment samples and coral reefs. Those indirect methods became the main tool used to prove climate change in the past and present and, more importantly, to predict future modifications. To the proxies were added projected figures of the quantity of CO_2 in the atmosphere at different stages of the history of the planet, figures which are only rough estimates since it is practically impossible to measure, in weight, the actual amount of natural and anthropogenic CO_2, let aside the quantities of the past.

As for projections for the future history of the atmosphere, the concept of model came into the picture. Models become a powerful tool to advocate global warming and its consequences (almost all of them bad), so it is necessary to delve into the concept, as well as into its predictions and trustworthiness.

C. The role of mathematical-statistical models in predicting future climate change

According to the definition of Silver (2008), "a model is a mathematical description that relates the physical, chemical and biological properties of a system. Models address cause-and-effect relationships and include the impact of feedbacks".

The most complex (and it is inferred, the most reliable) models concerning climate are the so-called Global Circulation Models (GCMs). They are three-dimensional models collecting all the data possibly related to the climate and projecting the results into the future. "If they are fed with a set of numbers, they will calculate how the pattern of temperature, humidity, wind speed and direction, sea-ice, soil moisture and other climatic variables will change, as time passes" (Gribbin, 1990).

The GCM climate models include, for example, solar intensity, temperature of air and water, water salinity, relative humidity of the air, precipitation, greenhouse gas concentration, absorption properties for those gases, albedo for all exposed surfaces, aerosols, clouds, dynamic of atmospheric and ocean circulation, biochemical cycles, etc. The result is a series of equations that define the energy balance, the climate sensitivity, the impact of positive and negative feedbacks, etc. Even more sophisticated models take into consideration the conservation of mass, the conservation of momentum, the thermodynamic laws about the state of gas, etc.

In other words, a series of parameters related to climate are chosen. Their possible relationships are analyzed and then both parameters and relationships are subjected to variations, resulting in different outcomes and scenarios.

The most important thing to bear in mind is that the results coming out of complex calculations are "a direct function of assumptions plugged in" (Horner, 2007). So, most assumptions and choices have a certain degree (low or high) of subjectivity which can never be eliminated by any computer program. As Silver put it: "the scenarios and their results are valid only to the extent that the assumptions on which they are based are realistic, and there is not necessarily a single correct answer" (Silver, 2008).

Many models also include social, cultural and economic parameters, at least as difficult to prognosticate as the climate change conditions (population growth, economic development, cultural habits, etc.). As Nigel Lawson (2008) ironically stated: "you start with uncertainties of long-range weather, add to these the uncertainties of long-range economic forecasting plus the uncertainties of long-range population forecasting, feed them into a powerful computer and supposedly arrive at a sound basis for serious long-term policy decisions".

Dr. S. H. Schneider (1988) explained the mechanism for conceiving a climate model when he wrote: "Since no laboratory experiment can be built that remotely captures the complexity of Earth's climate system, scientists instead build mathematical models. Equations are written down, to represent the basic physical laws that govern the motions of the atmosphere, oceans and ice, etc. However, these equations cannot be solved exactly, so techniques were developed that included creating a discrete number of points or "grids" around the globe at which solutions to the equations are approximated".

The study of climate and climate behavior, in the past and present, but also in the future has shown how complicated and complex it is. Indeed, as Solomon (2008) mentioned, "the mathematics involved in climate modeling is a system of strongly coupled non-linear differential equations, where the solution can only be arrived at by a series of numerical approximations". "In short, the climate system is by far the most complex system known so far with many variables and many factors poorly understood or even barely known. And, too often, many or even all assumptions on which models are based are negative, neglecting natural forces which stabilize the climate system and do exist in nature and help to restore it close to a state of equilibrium" (Spencer, 2008).

And what are those theoretical models telling mankind? (keep in mind that they are all predicted on some uncertain or questionable premises). They predict that: a) global warming is all too real; b) it is dangerous; c) it is all the result of man-produced greenhouse gases obliterating the naturally produced ones; d) the warmest years on record (since 1880) are the most recent; e) the rate of global warming is increasing exponentially; f) the warming trend for the last 25 years is more than double of that of the past century; g) at no time during the last 11,000 years have temperatures as higher as today's been registered; h) the carbon dioxide level in the atmosphere is at levels unprecedented in recorded history.

Many models take as a baseline what will happen if the CO_2 levels in the atmosphere will double. Depending on the assumptions made by different scientists and the number and type of feedback mechanisms, a range of estimate temperature increases resulted. The accepted range is of 0.5°C - 1°C to be reached by mid-century, although some estimates consider the 3.5°C - 4°C more probable.

Scenarios were constructed linking each range of temperature increase with the impact on planet's life and with the consequences for humans (see Table 1). As it is obvious from Table 1, all of the forecasts present a dim picture of the near future and a much worse one for the second half of the XXI century, with a range of predictions from dangerous to cataclysmic.

Yet, one must keep in mind that the present interglacial is probably half way to its end, so that in a couple of millennia the warming trend should reverse itself and the cooling of the planet on its way to a full blown glacial fluctuation should begin.

As a result from the above discussion, there are so many uncertain or barely known data, that the level of certainty is quite low. However, many persons in the climate modeling business appear to be sure of what the climate of this century and even the next will be, so that they have concocted a chart on statistical confidence range which they linked to the likelihood of events which will happen till the end of the century (and possibly beyond) (see Table 2).

Table 1 Likely Climate Impact of Various Increased Temperature Ranges (modified after Silver, 2008)

Range of Temperature Increase	Impact
+ 2°C (+ 3.6°F)	Risk of extinction for 20-30% of the known species Millions of people subjected to flood risk
+ 3°C (+ 5.4°F)	Widespread destruction of coral reefs About 30% of global coastal wetlands lost
+ 4°C (+ 7.2°F)	Global food production decreases Increased extinction risk Partial melting of Greenland ice sheet and West Antarctic sheet raising sea level by 4-6m (13-20 ft)

Table 2 Likelihood of Variation Trends (modified after Silver, 2008)

Trend	Likelihood of Human Contribution to Observed Trend	Likelihood of Future Trends in the XXI Century
Warmer and fewer cold days and nights (over land areas)	Likely	Virtually Certain
Warmer and more frequent hot days (over land areas)	Likely	Virtually Certain
Warmer spells/heat waves becoming more frequent	More likely than not	Very likely
Heavy precipitation events becoming more frequent	More likely than not	Very likely
More areas affected by droughts	More likely than not	Likely
Intense tropical cyclones activity increases	More likely than not	Likely
Increased incidence of extreme high sea level	More likely than not	Likely

The trouble is that weather phenomena were linked to the warming of the climate for which there is scant evidence or no evidence. For example, it is stated that "it is more likely than not (more than 66% confidence) that intense tropical cyclone activity will increase", when the linkage between global warming and the frequency and the intensity of hurricanes and typhoons is tenuous at best. The same is true for the "increased incidence of extreme high sea levels which is considered to be likely, in general, and very likely (more than 90%) due to human contribution" (Silver, 2008). Most of the estimates vary between 20 and 60 cm for this century far from an extreme event.

The biggest problem with all the models is the influence of the feedback processes over the evolution of climate. Feedbacks form an intricate and complex web of phenomena which put their imprint on the climate variations. Quite a few of them are still poorly understood and their impact is still not completely known. Without a quantitative knowledge of their imprint upon the climatic process, any claim of how they would evolve is questionable. This is why it is crucial to delve into the most complicated aspect on the impact on climate of these processes and phenomena.

D. The contribution of feedback mechanisms

According to Silver's (2008) rather tortured definition, "a climate feedback occurs when an initial change triggers a second change that, in turn, influences the first process". For example, a change in the atmospheric CO_2 is responsible for increasing the temperature of the air and this change will increase evaporation and the resulting water vapors, a greenhouse gas, will absorb more heat and thus the atmosphere will get even warmer. This is an example of feedback, a feedback which intensifies the effect of the original change. A negative feedback reduces the input of initial change. Staying with the previous example of feedback, evaporation will also generate a cooling effect, which will facilitate precipitation, thus cooling the atmosphere. It remains to be seen which of the two opposite feedbacks will prevail. This shows how difficult is to introduce such contrary data into the equation to obtain a credible model for atmospheric behavior.

In short, positive feedbacks are destabilizing factors that amplify the original change. Negative feedbacks reduce the impact of the change and thus tend to stabilize the process.

Thus, the study of feedbacks in the case of global warming tries to answer the question whether the atmosphere will respond to a change in its CO_2 content in ways that amplify or dampen the amount of warming produced by the extra, allegedly anthropogenic CO_2.

In fact, the feedbacks, both positive and negative substantially modify the simple cause-and-effect of the CO_2 variation, whether natural or anthropogenic.

Here are examples of positive feedbacks:

1. Albedo: Snow and ice are powerful reflectors of solar radiation which keep the surface cooler. When temperature rises, a good part of this natural reflector melts and exposes the darker surface of rock and soil, which reflect less sunlight and therefore the air gets warmer.
2. Plant decay: A warmer atmosphere leads to increased plant decay which releases CO_2 into the atmosphere.
3. Melting permafrost: A warmer air will melt a part of the permafrost, which traps large amounts of methane and other greenhouse gases. Being set free they are added to the atmosphere, heating it up.

More important negative feedbacks are:

4. Photosynthesis: Increased heat means more CO_2 into the atmosphere, which favors plant growth since most plants are heat-loving. More plant growth intensifies the process of photosynthesis which removes CO_2 from the atmosphere, traps the gas into the plants and thus cools the atmosphere.
5. Increased air moisture: The greenhouse effect produces a moister atmosphere which increases the rate of precipitations with a double result. First, it cools the atmosphere and, when and where it falls as snow rather than rain, it increases the albedo effect and helps build up glaciers.

But the more scientists delved into the nature and consequences of feedbacks, the more complicated things became. Secondary effects were identified, sort of feedbacks of feedbacks and as a consequence, calculations, equations and algorithms became extremely complex.

According to Solomon (2008) "global climate models have reached a level of complexity so great that the predictions they can issue can no longer be called scientific propositions. So many simplifications are required that many models quickly become useless as predictive devices. The computers of today are nowhere fast enough to run a climate model with all known processes, let aside the assumptions necessary, which might be less than objective".

A review of the most important feedback factors and their relationships will show how complex their action is, how little about their positive or negative impact is known and how much more research is required before claiming that the science of anthropogenic warming has all the answers.

The carbon cycle is not a continuous, homogenous one; it involves times of transfer from one geosphere to another, times of residency in each of the four geospheres and times when a critical concentration of CO_2 in one of the geospheres is reached; that means that it is necessary to know the saturation point beyond which the given form of carbon (especially, CO_2) cannot be held anymore and must migrate to another medium.

So far, neither the times of residence, nor the points of saturation are precisely known. Moreover, they depend on several parameters such as temperature, pressure, density, salinity and chemical composition of sea water (mainly its content in carbonate and bicarbonate of calcium).

On land, chemical weathering depends on the humidity of the atmosphere, the acidity (or alkalinity) of the rainwater and groundwater and of the soils and surface runoff. A rather high level of CO_2 in the atmosphere will lead to more acidic rainfall, which, in turn, will acidify the soils and the ground water, producing more weathering and more CO_2 (positive feedback).

Yet, weathering of silicate rocks rich in Ca and Mg will result in oxides which readily react with CO_2 producing calcium and magnesium carbonates, an efficient negative feedback, impoverishing the atmosphere in CO_2.

A part of Ca^{++} and Mg^{++} will be discharged by rivers into the seas and oceans as bicarbonates. A cooler climate due to the capture of CO_2 from the atmosphere and a decrease in water salinity, due to the addition of rivers runoff will keep Ca^{++} and Mg^{++} as bicarbonates and thus keep a significant amount of CO_2 arrested in the ocean. However, a part of the bicarbonates will precipitate as solid carbonates of Ca and Mg if the temperature and the pressure (dependent on depth) are right, with the concurrent release of CO_2 which will return to the atmosphere as a result of this positive feedback. It is also known that cold (and thus deeper) water will keep calcium as bicarbonate solution, this mobilizing an extra amount of CO_2 and serving as a buffering mechanism for atmospheric CO_2 and therefore acting as a negative feedback.

This deep, cold, dense and more saline water will gradually rise to the surface after approximately 1200 years of residence at depth of thousands of meters, becoming warmer and lighter, being replaced by colder masses. This rate of overturn controls the rate of delivery of CO_2 into the air once the deep water reaches the surface (being warmer it cannot hold anymore the amount of CO_2 it had absorbed when it was colder) (Arthur, 1982).

The CO_2 transfer from air to water and vice-versa is also strongly influenced by biological factors. Organisms both absorb and release CO_2 through photosynthesis, feeding and elimination of waste. It depends on the ratio of absorption and elimination of CO_2 by the marine biosphere what ultimately will happen to the carbon dioxide in the hydrosphere. In turn, this ratio is controlled by nutrient availability, the rate of oxygenation, of the shallow and deeper layers of water and the rate of mortality of the organisms. One may conclude with M.A. Arthur (1982) that "at present, all these parameters allow only a speculative and, at best, qualitative approach to the relationship between climate and atmospheric CO_2".

Moving onto the land, buried organic matter (mainly by plant remains) also represents a sink for atmospheric CO_2. Like in the hydrosphere, the quantity depends on organic productivity and the rate of burial (the faster, the better). Once buried and insulated from air and water, it will take a long time for the carbonic acid to return to the surface and the atmosphere, function of the rate of uplift and erosion. But once exposed, the organic carbon rapidly combines with oxygen and adds to the atmospheric CO_2 as a positive feedback. In fact, it all depends on the rate of erosion and the rate of oxidation. These numbers are very difficult to arrive at.

To add to the complexity of an already complicated system, there is also a relationship between biosphere and biosphere. Indeed, the forests are the main sink of CO_2 through the process of photosynthesis, but they also release CO_2 through the process of burning (a process both natural and man-made). The problem to solve is to calculate which was the biggest number: the one related to the absorption or the one related to the release of CO_2 through fire.

In the last decades, five more factors entered the picture of the feedback process: the albedo and the permafrost on land, aerosols, precipitations and clouds in the atmosphere.

Aerosols are mainly suspended particles of soot, ash, dust and chemicals such as sulfates and nitrates. They are also good reflectors of sunlight. However, the same aerosols will reduce the reflectance of ice and snow when their particulates will settle over the snow-covered areas.

The layers of permanently frozen soil are covered mainly by the tundra vegetation all over North America and Eurasia. The thickness of the permafrost layer varies between 1-2 meters and 1.5 kilometers. When temperatures increase above zero, the upper part of the permafrost layer becomes a semi-frozen, slushy mix of decayed vegetation, soil and melt water, rich in methane. A substantial part of the methane is thus set free, and joins the atmosphere, contributing to its warming, serving as positive feedback. Besides the permafrost land reservoir of methane, there is another one at the bottom of oceans. Here, methane forms compounds called clathrates, located in the abyssal mud. The clathrates are stable as long as the temperature is low and the pressure is high. When there is a change in both, clathrates decompose and liberate methane which may reach the atmosphere.

The precipitation factor seems to be quite important, but it is poorly known. It is clear that greenhouse gases, cloudiness and air temperature range are closely associated with the process of precipitation. Spencer (2008) starts with an obvious observation: "despite the continuous evaporation of water from the Earth's surface, the atmosphere never fills with water vapors. Theoretically, nature could allow water vapors to accumulate causing a runaway greenhouse effect, much more than it actually does. Why doesn't it happen? Because the vapor is continuously kept in check by the only atmospheric process that depletes it, precipitation. Precipitation processes act as a natural thermostat, adjusting how much water vapor will be allowed to remain in the atmosphere, thereby controlling most of Earth's greenhouse effect". In other words precipitation acts as a strong negative feedback.

Unfortunately, its thermostatic role is so complex that the information available on precipitation efficiency is scanty and cannot be quantified so far. As a result it is practically not possible to include this important feedback into a climate model.

Clouds come also into the picture of a warming Earth. It was believed that their role was to cool the climate, because they reflect more solar energy into the space, than they trap the infrared radiation. Yet, the more the clouds were studied, the more complex their role played in the heat balance of the atmosphere seems to be. Now it is accepted that especially the low clouds keep the atmosphere cooler and thus are a negative feedback. But the thin cirrus clouds, located in the higher reaches of the atmosphere have a contrary effect, trapping more solar radiation than reflecting it. And, according to Spencer (2008), even two clouds having identical thickness and water content, and situated at the same altitude, have different effect on the climate. This is because the water droplets building the clouds have different sizes: small droplets reflect much more sunlight than larger ones.

Right now, these processes in the interior of the clouds and their relationship with other meteorological phenomena are so complex, that apparently the present-day computers cannot deal with them. That means that clouds are a serious source of uncertainty in modeling climate change.

Spencer concludes that: "the reaction of clouds to increasing atmospheric CO_2 is the largest source of uncertainty in climate model prediction of the future. Everyone agrees that clouds are a wild card in global warming predictions" (Spencer, 2008).

Even the IPCC reports (strongly advocating global warming) admit that: "clouds feedback remains the largest source of uncertainty since their feedback is not fully understood".

Finally, it is necessary to discuss the existence of the so-called climate oscillations, since they may play an important role in the global warming controversy. The oscillations were discovered in the 1920s, but their importance was noticed only during the second half of the XX century. There are several such climate oscillations, but the best known is the El Niño Southern Oscillation or ENSO active in the Pacific Ocean.

The mechanism responsible for ENSO is still not well understood, but it represents a complex interplay between atmosphere and hydrosphere. The Pacific Ocean ENSO is in fact, a dual system, El Niño and La Niña, the two extreme conditions of this recurring cycle oscillation.

During the time when the El Niño conditions prevail, the weather patterns are changed, sometimes substantially. In North America, El Niño brings milder conditions, higher temperatures (an increase of 1°- 2° C in average) and higher humidity. La Niña is the mirror image of El Niño, meaning lower temperatures (sometimes 4°C lower than average) and reduced humidity. ENSO affects not only the Pacific realm, but the climate worldwide.

The ENSO occurs at intervals of 7-11 years (sometimes longer sometimes shorter) and varies in intensity, in some cases leading to drastic changes in the weather patterns (heat waves, intense drought, storms, etc.).

It appears that the very warm decade of the 1980s was a result of an unusually strong El Niño and "nobody knows if this strength of El Niño is related to the build-up of CO_2 in the air" (Gribbin, 1990). Moreover there was no intervening La Niña, between the strong El Niño of 1982 and the following one. The first La Niña occurred only in the 1988 to counteract the strong warming of the preceding years. Therefore, the much touted "warmest years in history" or something to that effect, are mostly the results of El Niño and not of global warming.

By the same token, La Niña has mitigated several years later the increased temperature and humidity of El Niño. An additional effect of the La Niña phenomenon is that it also cools the ocean surface layer. Knowing that CO_2 dissolves more easily and faster in cold waters, it is possible that the lower temperature during La Niña, will influence the trend of global temperature, by absorbing more CO_2 from the air.

Summing up the data concerning the theoretical and experimental basis for global warming, the process of mathematical-statistical modeling of future climate change and the complexity of the feedback mechanisms, there are quite convincing arguments against the definitive sentence that "the science of anthropogenic climate change is settled, once and for all" (Broecker and Kunzig, 2008). There are many facts contradicting the categorical affirmation that practically all the warming and its consequences are the result of human activity.

Even a strong advocate of climate change is objective enough to list a rather long catalogue of unsettled questions related to the reality of global anthropogenic warming. Here are the most important basic uncertainties (to put it mildly), according to Silver (2008):

"(1) The effect of solar intensity variability for the past centuries is not clear because instruments to precisely make this measurement were not available.

(2) Information on hurricane frequency and intensity is limited to recently acquired data, making it difficult to determine whether there is a trend toward more severe weather.

(3) There is insufficient evidence to determine whether tornadoes and other severe weather phenomena are intensifying.

(4) Prior to 1960 there were no global measurements of snow cover, so no quantitative data on the impact of albedo are known,

(5) There is not enough information to draw a conclusion about trends in the thickness of Antarctica sea ice.

(6) Mechanisms for past abrupt change in climate are not well understood, including the thresholds for when abrupt changes may occur.

(7) Historical records are available for the northern hemisphere, but fewer records exist for the southern hemisphere.

(8) Factors affecting temperature change are much better understood than those influencing precipitation.

(9) Processes taking place in the ocean depths that influence climate are more difficult to model.

(10) The ENSO is only partially understood and is not modeled the same way by all scientists.

(11) There is very limited correlation between climate variables and the incidence of extreme events.

(12) During the past ice ages the carbon dioxide levels in the atmosphere dropped … and the precise mechanisms causing this drop have not been determined.

Crowley and North (1991) added another uncertainty to the list: "the causes of decadal, centennial and millennial-scale climate variations are not well understood and may have nothing to do with anthropogenic warming".

Most unsettling is the fact that data show quite clearly that during glacial-interglacial intervals the rise in temperature has preceded the increase in atmospheric CO_2 and not the other way around (Lee Ray, 1993; Solomon, 2008). Indeed, the analysis of Antarctica ice cores determined that temperatures over the continent started to rise centuries (more precisely some 800 years) before the atmospheric CO_2 levels began to increase.

It is interesting to note that for some scientists most of the uncertainties mentioned above will become certainties in just several years from now. It will be, therefore, interesting to examine the assesments and proofs of this group, convinced that short of drastic and fast measures impending environmental and societal doom is unavoidable.

Generally, the cries of alarm pertain to at least 5 dangerous possibilities: (1) unstoppable rise in sea level; (2) extensive desertification followed by water shortages; (3) increasing and more frequent violent meteorological phenomena (hurricanes and typhoons, tornadoes, etc); (4) rapid and massive extinction of plant and animal species; (5) drastic change in the pattern of winds and wind-driven marine currents.

These predictions were published and submitted to the governments by the International Panel for Climate Change (IPCC), but it is not clear how the climate trends, their likelihood and their consequences (mainly dire ones) have been established during the discussions among the panel members. Were the scenarios a result of a general unanimous consensus? Were they adopted by majority? (and in this case was there a minority report?) Maybe a sort of golden mean was chosen? Or on the contrary, from several scenarios, only one was chosen? (with the worst outcomes one suspects!), and the alternative scenarios were simply eliminated?

From the above-mentioned possible frightening outcomes, three are really significant and their consequences quite possible for the future (the next hundred years or so).

(1) Unstoppable rising sea levels

It is claimed by the advocates of global warming that the process will result in a substantial melting of both ice-caps and mountainous glaciers and all of the meltdown will end up, sooner or later, in the seas and oceans of the globe.

A secondary effect of climate warming on sea water will be its thermal expansion: a warmed up marine water will expand its volume and thus its level will be higher. It has been calculated that 25% of the sea level rise will result from such thermal expansion. Things are more complicated because different layers of marine water have different temperatures and densities which will impact on the final result. It is estimated, with all these complications, that a global warming of 4°5 C (a maximum rise for a doubling of atmospheric CO_2) would increase sea level by at least 30 cm, besides the rise resulting from the addition of melt water.

For the latter, the figures are quite different, according to the model chosen to obtain them, varying from a modest 10-20 cm to a catastrophic 5-6 m, number mentioned by Al Gore in his book (2006). Even the official predictions of IPCC have varied from decade to decade. In its 1990 assessment the numbers were 30-100 cm rise by 2100. But by 2001, the prediction was lowered to 9-88 cm and in its following report it was still lower (18-59 cm). Other computations consider a rising sea level by 10-15 cm (Singer and Avery, 2007), 20-60 cm (Silver, 2008), 30 cm (Broecker, 2008), all predicated on a doubling of the CO_2 in the atmosphere by the end of this century.

Here again, several feedback phenomena must be considered. If the global temperature will continue to rise, more sea water will evaporate, lowering the sea level, while the same rise will produce a heat-induced expansion of ocean. So far it is not realistically possible to estimate which phenomenon will prevail. It is quite possible that they will each other cancel out. And the process of latent heat of evaporation, which is a cooling process, will also come into play.

Moreover, continuous evaporation will produce clouds, which might or might not be positive feedbacks depending on their make-up and their altitude. A consequence of cloud formation will eventually be precipitation which in the polar areas will take the form of snow.

It is important to take into consideration that an opposite phenomenon is still taking place. It is the isostatic rebound of the land, which results from the melting ice from both ice caps, but especially from the Arctic one. The weight of this enormous volume of melting ice has depressed the Earth's crust by 700-800 meters. Once the ice weight is removed, the crust is rebounding to reach its normal isostatic level. Such isostatic adjustment will simultaneously lower the water level, especially in the northern hemisphere.

On the other hand, there are areas which are naturally subsiding or are sinking due to human works.

So, what is the prognosis for the XXI century? Keeping in mind that, for comparison, it was determined that during the previous interglacial the sea level was 4-7 meters higher than it is today for a temperature average of 3°C higher than the present one, and since the beginning of the present interglacial temperature has quite consistently increased, sea level has risen accordingly to a fairly steady 1.7 mm/year and in recent times by 1,8 mm/year, it is fair to assume that at the end of this century the sea level will rise with 30-50 cm (for a doubling of the atmospheric CO_2).

This, of course, contradicts the doomsday predictions which are based on the catastrophic melting of the Arctic ice cap and of the glaciers of the Antarctic Peninsula (Overpeck *et al*., 2006).

So, for example, John Mercer (1978) wrote that: "a major disaster – a rapid 5 meter rise in the sea-level-caused by the deglaciation of west Antarctica may be imminent or in progress after the atmosphere content of CO_2 has doubled, an event that will happen in the next 50 years, if fossil fuels continue to be consumed at an accelerating rate". 35 years later, deglaciation of the Antarctic peninsula has not happened, the atmospheric CO_2 content has not doubled and the level has not risen by 5 meters.

Finally, what will be the damages produced by a rising sea level of even 50-80 cm? First, practically all flooding will affect only the low-lying areas along the coasts, such as much of some territories of Bangladesh, Florida, the North Sea shores, as well as estuaries and deltas of large rivers (Mississippi, Thames, Rhine, Niles, Ganges and Brahmaputra, etc). Many of these territories are often flooded right now, but not because of the sea encroaching their shores, but because of river flow during the monsoon period or strong storm (Lawson, 2008).

But as the Dutch and the other people have shown, there are successful means to combat an increase in the sea level, which is a slow process, with the exception of sudden surges. The nations of the XXI century have the technical means, the funds and, hopefully, the will to cope with such a phenomenon.

Plant and animal species populating marshes, swamps and mangrove forests will have time to migrate together with their environment to higher grounds without major disturbances and adapt to their new habitat, not different from the old one.

In conclusion, the sea level rise will not be of biblical proportions, will not have a worldwide destructive effect and will allow the biosphere (including humans) to adapt successfully.

(2) Extensive desertification and acute water shortages

For planet Earth, desertification is nothing new. It has experienced widespread and long-lasting desertification in its past history. For example, during the Late Permian and Early Triassic about 2/3 of the Pangea supercontinent was covered by deserts and semi-deserts.

Closer to our time, California and the western United States have "experienced phenomenal drought periods" (Broecker and Kunzig, 2008). A massive drought started around 900 AD, lasting some 300 years. A second one, followed quite quickly (1200 – 1350 AD) affecting more than 40% - 50% of western and southwestern North America (the average desert territory is around 30% for the same area during the XX century) (Stine, 1994).

The first thing to be noticed is that territories affected by a shortage of rain fall in the past are basically the same as of today. Computer models do not show any new desert territories, but only an extension of the existing ones.

Such variability of wet and dry periods is known in most parts of the world, even in relatively recent times (historically speaking). During the Roman empire period, Egypt and the Maghreb were the granary of Rome. A good portion of the Sahara desert was green, but gradually the desert conditions started to advance, both northward and southward resulting in the picture of today's Sahara desert.

Obviously, the drying climate and the associated desertification process were not the result of anthropogenic warming produced by hideous coal-firing plants and despicable gas-guzzling automobiles.

The ENSO phenomenon appears to be quite closely related to the weather in western North America. According to Seager *et al*., (2007), a staunch proponent of anthropogenic global warming, "all six major Western droughts in recorded history, including the Dust Bowl of the 1930s and the severe drought of the 1950s were all caused by La Niña". The team found that tropical Pacific temperatures alone were enough to generate all recorded drought in the American West.

So far, there is no correlation between ENSO and anthropogenic global warming. However, the advocates of man-made climate change maintain that the real desertification (present and future) is man-made. They accentuated the fact that there is a tendency of the dry regions to become even drier and to gradually expand. However, there is no evidence that these events would not have happened but for human modification of climate.

On the contrary, both phenomena (increased drying of desertic areas and the migration of climatic zones) happened several times in the past, probably a result of natural warming of the earth. Seager's team (2007) had to admit that the proven cause of increased desertification was La Niña. Yet it claimed (without proof) that it only strengthened an anthropogenic warming ignoring the fact it was La

Niña alone which was responsible for catastrophic droughts when anthropogenic warming was non-existent. They reached a frightening conclusion that "a pronounced long-term drying may already have begun and that by 2050 the normal climate of the American southwest will be as dry as the Dust Bowl of the 1930s. The drying is unlike any climate state we have seen in the instrumental record" (Seager *et al*., 2007). However, Seager and his colleagues admit that "the most severe future droughts will still occur during persistent La Niña events, but they will be worse than any since the Medieval period because the La Niña conditions will be perturbing a base state that is drier than any experienced recently". It happens that the reverse is closer to reality, *i.e.* that La Niña is by far the most important element of desertification on which is grafted an increased warming (mostly natural) of the atmosphere.

Gribbin (1990) goes much further in claiming that "a northward shift of climatic belts will bring Dust Bowl conditions to North America, so that the U.S. will have to go cap in hand to purchase food to keep its people for going hungry". Such a reversal of fortune! The migration of climatic zones means that the breadbasket of the U.S., Canada and Russia will move northward, so that the future granary of North America and Eurasia will become the northern states of the U.S., the Central-Northern part of Canada and Central Russia (including Siberia). It is true that the quality of the soils of the new cereal belt is poorer (podzol soils instead of chernozem), but it will make in quantity what it looses in quality (the territory is double in size to the actual cereal-growing area).

Closely related to the alleged rate of desertification and atmospheric warming is the problem of fresh water availability.

Indeed, a non-negligible quantity of fresh water is supplied by ice melting from mountainous glaciers. Sizeable populations, mainly in Europe and Asia depend on the melt water from high mountain ranges such as the Alps, the Caucasus, Hindu Kush, Kunlun, Pamir, Himalaya, etc. which feed major rivers like the Rhine, Rhône, the Po, Indus, Ganges, Brahmaputra, Mekong, Irrawaddy, Huang Ho, Yangtze, etc. If, as it is alleged, the mountain ice is gone a major disaster will affect over 2 billion people.

In an article, the year 2035 was given as the year of complete melting of the Himalaya and Alpine glaciers. Only after the paper was published in a prestigious scientific journal, and only after the panic it created, a careful examination of the manuscript revealed that a typographical error was responsible and that the year of the alleged catastrophe was 2235! Quite surprisingly, none of the peer reviewers and the publication staff could pinpoint this massive error, making some to suspect that the mistake was deliberately left to be printed.

Combined with the advance from the south of desert areas half of mankind would be in great danger dying of hunger and thirst. The doomsayers completed the pictures with high probability of soil erosion, forest and prairie fires and frequent crop failure (mainly of rice which needs lots of water). According to Flohn and his collaborators (1980) "by the 1990s serious water shortages and population migration will be experienced in areas of high level standards" (that is North America and Europe). Flohn also predicted (according to Gribbin, 1990) "that a person twenty years old in 1980 will witness such crises when he will be at his forties" (that is the beginning of the XXI century). Some 20 years later the populations on both continents are still waiting with trepidation for such calamities to happen!

The same Herman Flohn predicted in one of his computer models (1980) that by the 1990s the storm path will shift to the latitudes of 60°-65° latitude north and that a global warming of 4° which should happen by 2030s will melt all ice floating on the Arctic Ocean. Such a migration of the rain-bearing cyclonic system "will bring serious shortages of fresh water in California, Texas, Spain and the Middle East".

According to Gribbin (1990), a planetary warming of 4° will be very rapid producing the disaster mentioned above "when the Arctic ice cap will melt, the world will change so drastically that … civilization will collapse".

In short, a cataclysm of unimaginable proportions is just waiting to happen in the next 50-100 years (if mankind is lucky, so to speak!).

However, even if many of the high altitude ranges glaciers will indeed melt, there still be left enough sources of fresh water to supply the threatened population. After all, not all American and Eurasiatic rivers collect their waters from melting snow and ice. Then there is the summer monsoon bringing heavy rains over South Asia and supplying rivers with plenty of water. Ground water is also in plentiful supply in the wet areas of America and Eurasia. So, for the foreseeable future there is no dramatic crisis in sight.

It must also be taken into account a chain of meteorological processes generated by the warming of the atmosphere. Such warming will intensify evaporation. In turn, water vapors reaching the upper atmosphere will condense and form clouds. Notwithstanding the uncertain role of the clouds themselves, they will condense and therefore increase the chances of precipitation. The result will be a double one: a cooling of the air and abundant precipitation mitigating the shortage of fresh water.

Since desertification will affect mainly the territories which are already arid, the populations living there have learned to cope with a dry climate. Adaptability and coping are not and cannot be included even in the most sophisticated computer models.

(3) World-wide mass extinction of plants and animals

No catastrophic predictions produced by global warming can leave out the calamity which will befall the biosphere. The main premise on which the world of plants and animals will be gravely endangered is that genera and species and even families will be unable to adapt to the rapid change in temperature and humidity with the accelerated migration northward (in the northern hemisphere) of the climatic zones, which control the biological zones. The result of this inability to cope, to migrate fast enough will lead to massive extinctions within both the vegetal and animal kingdoms (Thomas *et al*., 2004).

Gribbin (1990) claims that for a warming of 0°4 C per decade forests will have to move at a rate of 600 km per century. This compares to the rate of migration at the beginning of present interglacial of 200 km per century (for spruce trees). "By the middle the XXI century, in order to survive, the forests of birch, maple, spruce, beech will have to find a new home 500-1,000 km north of the present location". "Dieback will begin by the end of the 1990s, with forests full of aging trees and no new saplings taking their place" (Gribbin, 1990). Useless to remark that such dieback has not been signaled on a large scale so far, 20 years later than it was predicted.

The Thomas *et al*. model (2004) is even more frightening. It predicts that if the average temperature of the planet will increase by 0°8C in the next 50 years, roughly 20% of the world wild species, perhaps 1 million of them will disappear. If so happens that the Thomas model can be compared to a reality check: the Earth's temperature has already increased by 0°8C in the past 50-100 years and no important species (let aside genera) extinction has been recorded. True, some large species of animals have become extinct (mammoths, mastodons, saber teeth tigers), but that happened long before anthropogenic warming started.

And no sad story about extinction could be complete without the one about the adorable, cuddly Arctic bear which will be the innocent victim of the ice melting process. Nowadays the population of Arctic bears "is reckoned to be 20,000-25,000 individuals, living in 19 discrete populations" ("The Melting North", The Economist, 2012). Some of them are decreasing, some of them are increasing, some of them are stable. To claim they will soon be extinct is preposterous. It must be kept in mind that the species is at least 600,000 years old, so that it survived two previous interglacial periods, when temperatures were at least as high as today, probably higher, in fact.

The same biological disaster, it is claimed, will befall the marine organisms as well. Callum Roberts warns us that without dramatic actions (which ones?) to reverse the process, a catastrophe comparable to the mass extinction of the Paleocene - Eocene thermal maximum will occur, when CO_2 levels, temperature and ocean acidity will all rocket. "Not for 55 million years has there been an oceanic disruption of comparable severity than the calamity that lies ahead just a hundred years from now" (Roberts, 2012).

Apparently, Mr. Roberts needs some more knowledge in Historical Geology, Paleontology and Paleoclimatology, since no mass extinction took place during the Paleocene-Eocene. Mass extinctions were indeed recorded and documented but at the Cretaceous/Paleogene boundary a measly 10-15 m.y. earlier. Interestingly enough, the thermal maximum of the Paleocene-Early Eocene did really exist and brought about some extinction. But, as mentioned before, some tentative calculations showed that the concentration of CO_2 in the atmosphere reached 1000 p.p.m. (*versus* 400 p.p.m. today) without producing any biological cataclysms, compared with the genuine mass extinctions of the end of the Paleozoic and Mesozoic eras.

The same author is very worried about the fate of the corals. He mentioned that "during 1998 a rise in sea temperatures … caused a mass bleaching of the world's coral reefs. Up to 90% of the Indian Ocean technicolored coral reefs turned to skeletal wastes, largely devoid of life". Was it a consequence of anthropogenic global warming? Apparently not, since Callum Roberts mentions that "the harm of the corals was caused by a surge of El Niño". Moreover, it appears that "corals are returning to life, but there is a fair chance that just in a few decades they will be all destroyed as ocean temperatures rise owing to global warming", that is if not another El Niño will do the job before humans kill them! Notwithstanding the fact that corals are among the oldest organisms on Earth and that they successfully survived many more serious threats during their long life in the oceans.

The truth is that most of the disappeared species since the last glacial were wiped out by the human species. Hunting, farming, destruction of their natural habitat, invasion by alien species brought by man, all contributed to either direct killing or crowding into smaller and smaller territories.

The other side of the coin shows that climate warming has also important favorable effects, mostly on plants and indirectly on animals that feed on the plants.

Studies concluded that the most feared doubling of the atmospheric CO_2 will increase the productivity of herbs by 30%-50% and of trees by 50%-80%. Many plants will grow faster and healthier during a warmer climate (Idso *et al*., 2003), and produce more offsprings.

It also appears that plants can survive quite well when climatic conditions change, even when change is rapid. For instance, cold-adapted trees can still grow to maturity (though slower) even 100-150 km north of their natural range, and they also grow as well as much as 1,000 km south of their southern boundaries.

Shifting climate boundaries will also generate competition among species of grasses and trees, leading to the selection of those most adaptable to changing conditions.

The conclusion that can be drawn from the above considerations is that both the vegetal and animal kingdoms are far more resilient and adaptable even for relatively fast environmental modifications. If a species becomes extinct, a biological niche becoming thus empty, it will be quickly occupied by another species better adapted to the new ecological conditions, as bio-ecological history of the planet has demonstrated time and again.

As said before, the catastrophist scenarios make no provisions - and cannot make them - of three essential characteristics of all forms of life, namely adaptation, migration and selection, characteristics that are very difficult or even impossible to include in any computer model.

Finally, there is also a problem of terminology which can lead to unintentional (or possibly intentional) misunderstanding. The term "locally extinct" has been used quite often, but what it really means is that a certain population of plants or animals has abandoned its habitat and migrated somewhere else. But, by any means does it mean that the species died out everywhere on the planet.

IV. THE GLOBAL WARMING CONTROVERSY: ALARMISTS VERSUS SKEPTICS

To answer the many questions related to possible climate change, in general, and global warming, in particular, a special group, known as The Intergovernmental Panel for Climate Change (IPCC) was created under the aegis of the United Nations. The group, organized in 1988, had to release reports every 5 years or so.

The main result, so far, is the proliferation of committees, commissions, working groups, on the one hand, and, on the other hand, the convening of international meetings and conferences (Rio de Janeiro,1992, Buenos Aires, 1998, etc.). The most important meeting was held in Kyoto, Japan (1997), where the so-called Kyoto Protocol was signed and subsequently ratified by 141 countries (at that time, the U.S. government did not ratify the protocol for some good and not so good reasons).

The signatary countries accepted concrete (more or less) numbers in reducing emissions of greenhouse gases to be accomplished by 2012, when a new treaty should have been written and signed. Several conferences followed, the most important being held in Copenhagen, in 2009. It ended in disarray, and was a big disappointment for the global warming adepts. Thus, the negotiations toward a more ambitious, more comprehensive and more binding treaty failed.

Subsequent meetings in Cancun (Mexico) and Durban (South Africa) did not make any significant progress. Worse still, Russia, Japan, and Canada have pulled out of the Kyoto Protocol. Funding for poor countries to pay for the cost of pollution is in dire straits, and no countries has made more pledges to cut greenhouse – gas emissions.

The only concrete resolution taken in Durban was that negotiations for a new treaty to follow the Kyoto Protocol should be finished by 2015 and the new treaty should be fully operational by 2020.

The negotiations have begun this year in Doha (U.A.E.), the 18th United Nations climate –change conference, which, so far, has little to show as concrete results.

Unfortunately, one of the few results of the Kyoto Protocol was a negative one, the split of the scientists' IPCC group in two groups, those who are convinced adepts of the global warming hypothesis and those who are rather skeptical, and, therefore dissent from some or all of the conclusions and recommendations of the "pro warming" majority.

The position of the dissenting group and also of the adepts of global anthropogenic warming has been perfectly defined by Owen McShane, director for Resource Management Studies and cofounder of the New Zeeland Climate Science Coalition. "There are two main camps on global warming: "the true believers" and "the skeptics". The "true believers" are committed to a global warming creed … on the other hand global warming skeptics may reject all, some, or just one of the beliefs. Some … may acknowledge that the Earth is warming, but insist that such warming … is nothing unusual and is not catastrophic. The end result is that the skeptics tend to be tolerant of disputes and dissent … while the believers are not only intolerant of dissent, they are convinced that all skeptics must be motivated by greed or other evil forces. They are angry because it undermines their belief that skeptics are all stooges of Big Oil."

However, looking more objectively to the controversy, it is clear that there is an entire spectrum of opinions in this regard. The most extremists on one side of the picture are those who claim that all warming is man-made and that if the process is not stopped immediately it will lead to worldwide calamity in a very short time span (Hansen *et al*., 1981). The other side of the coin is represented by those who deny even the existence of anthropogenic warming (and of any kind of warming), claiming that all the numbers and models are a fraud (Horner, 2007).

Of course, each extreme finds its enemies: the alarmist side finds them among the big corporations, the financial institutions and the adepts of economic growth. The deniers have found them among the environmentalists, the anti-growth and new lifestyles organizations and the liberal media.

There are also many scientists who advocate middle-of-the-road approach (Lomborg, 2007), but in most cases their opinions have been drowned by the extremists, especially those of the alarmists side, attacking the others as a tiny fringe minority which carps from the sides against overwhelming evidence in favor of anthropogenic warming.

The skeptics said "not so fast" because quite a few important questions remain opened and should be answered.

It is true that some of the advocates of warming dialed back and claimed that they were misunderstood, mainly due to the media. S.N. Schneider an "unabashed" advocate of the reality of global warming, mentioned in an article published in the World Monitor of December 1988 that "no honest scientist can claim that the 1988 or any of the heat waves of the 1980s were certainly, absolutely attributable to the greenhouse effect". He added that "even though most scientists did not directly link the 1988 drought to global warming trends, an impression of cause and effect had been conveyed" and he concluded that scientists "simply have to spend more time making clear the distinction among (1) what is well known and accepted; (2) what is known with a degree of reliability and (3) what is highly speculative". Therefore "an awareness of just what simulation models are and what they can do and can't do is probably the best we can ask the public, journalists and leaders". Broecker and Kunzig (2008) agree: "There is no proof that global warming will cause a mega-drought or a sudden sea level rise. There is only a reasonable argument based on common sense".

If only some alarmists researchers should have heeded this advice! Unfortunately, this was not the case. They decided that the strategy to combat skeptics and deniers of the global warming should be based on fear and even panic, "which will replace reason as a motivating factor for changing opinions" (Spencer, 2008). As mentioned by Gribbin (1990) "there was a lack of the dread factor where the greenhouse effect is concerned and this has to be changed".

Thus, all possible (but not necessarily probable) large scale disasters are predicted, based on all sort of climate models and on catastrophic events of the past, none of them caused by anthropogenic warming. Thus, while the goals to reduce anthropogenic warming were honorable, the means to do so were execrable. To justify both means and ends, Dr. Schneider declared: "The problem scientists face in trying to communicate complex and controversial issues with governmental policy implication is formidable. On the one hand, our loyalty to the scientific method requires that we tell the truth, the whole truth and nothing but the truth, meaning all the caveats, ifs, ands and buts. On the other hand, as human beings we would like to see the world a better place, which to many of us means reducing the risks of unprecedented rapid climate change. That means offering scary scenarios, inserting few caveats and getting lots of media coverage. To me the prospect of global warming has been sufficiently compelling to deserve everyone's attention, even with the uncertainties admitted upfront" (Schneider, 1990). Unfortunately the scary scenarios were many, the caveats almost non-existent and the media coverage for doomsday scenarios too many.

The so-called "deniers" (most of them did not deny the warming of the air and water but doubted that the process is solely a product of human society) were vilified while their arguments and reservations were ignored. Climate change was absolutely undeniable and there was no point of expressing reservations, objections or doubts. Thus,the disccussion should be closed,since allegedly a consensus was reached among scientists. As Broecker stated : „And so the debate on the reality of global warming is pretty much over now" (Broecker and Kunzig, 2008}. Quite possible, but not about anthropogenic warming !

Surprisingly, the U.S. Environmental Protection Agency which, in general, sides with the supporters of global warming, issued a report in 2004 which cautions indiscriminate use of climate models. It states: "Virtually all published estimates of how the climate could change in the United States are the result of computer models known as General Circulation Models. These complicated models are able to simulate many features of the climate, but they are still not accurate enough to provide reliable forecasts of how climate may change… Given the unreliability of these models, researches trying to understand the future impact of climate change, generally analyze scenarios for different climate models. The hope is that, by using a wide variety of climate models, one's analysis can include the entire range of scientific uncertainty" (U.S. EPA Global warming climate report, October, 2004).

Needless to say that the adepts of rapid anthropogenic climate change riposted that the data were outdated or skewed, and that the report published during the Republican Administration of George H. Bush was biased to curry favors from the skeptical Administration.

It is interesting to note that in the not so distant past, similar warming of impending societal disaster to happen in the near future were also largely publicized. Two of them deserve attention because one was based on computer modeling and the other because it regarded climate change.

The first set of predictions regarded the consequences of an alleged economic exponential growth, which computer models proved to be unsustainable and lead to societal collapse. This attempt at prognosticating the fate of mankind in the upcoming XXI century was made in the 1970s by the so-called Club of Rome which claimed and tried to prove it mathematically that economic growth, especially exponential growth as it appeared to be during the second half of the XX century may lead to social, economic and cultural catastrophe. In the book the group published in 1972 "The Limits to Growth" they concluded that short of a drastic curtailment of economic development, civilizational collapse is inevitable and would lead to "a world where industrial production has sunk to zero, where population has suffered a catastrophic decline, where the air, the water, the sea and the land are polluted beyond redemption, where civilization will be a distant memory" (Meadows *et al*., 1972).

Such somber conclusions were based on computer models analyzing the rapid depletion of natural mineral resources due to exponential growth. The models indicated that "present reserves of all but a few metals and coal will be exhausted within 50 years" (that is 2020). At an exponential rate of usage, by 2010, Al, Cu, Au, Ag, Pb, Sn, Zn should already have been exhausted and the same for petroleum and natural gas. Obviously the predictions were patently wrong. It is also true that the economic growth did not reach uninterrupted exponential growth.

To the crisis of economic growth was added the crisis of population continuous growth. In an article published in the magazine "Ramparts" in 1969, Dr. Paul Ehrlich "the guru" of population problems, claimed that explosive increases in population will lead to "hundreds of millions of people perishing soon in smog disasters … the oceans will die of DDT poisoning by 1979, the US life expectancy will drop to 42 years by 1980…". He also published a book "The Population Bomb" in which he predicted that "in 1970s or 1980s hundreds of millions of people will starve to death so that failure of food supplies combined with the exhaustion of resources will produce the collapse of society" – Ehrlich went a step further in his book "The End of Affluence" when he predicted "Nutritional disaster seems likely to overtake the humanity in the 1970s or at the latest in the 1980s. A situation has been created that could lead to a billion or more people starving to death". Malthus should be happy in his grave for having such a brilliant student. And all this predicted by smart computers!

The pessimist movement went so far as to question the survival of the entire human species during the XXI century (Rees, 2004).

The second scary scenario regarded the fast return of the ice age. In the 1970s quite a few papers and articles in the media tried to convince the public that it is only a question of (short) time till mankind will freeze to death, unless drastic measures were taken fast to counteract the impending glaciations which will produce world famine, world chaos and probably world war, possibly by the year 2000. Nigel Calder* (1976) claimed that "Facts have emerged in recent years and months from research into the past ice ages. They imply that the threat of a new ice-age must stand now alongside nuclear war as a likely source of wholesale death and misery for mankind". Calder believed that "the new snow age is upon us, that the thousand year warm period has run out, that the odds are only twenty to one against an ice age beginning in the next 100 years". If his calculation should have been accurate, more than half of the Earth's inhabitants could die of hunger and cold and more than a dozen countries could be wiped out from the face of the Earth. He predicted that "the onset (of a glaciation – *author's note*) could still be gradual… but it could be disastrously rapid. The evidence is, though, for the episode of the sudden cooling and for the mechanism of the snowblitz favoring a catastrophic view of the threat of the ice age".

Finally, discussing the aerosols role in modifying climate it was stated that "An increase by only a factor of four may be sufficient to reduce the surface temperature by as much as 3º5 Kelvin; sustained over a period of several years, such a temperature decrease over the whole globe is believed to be sufficient to trigger an ice age". The article was signed by Dr. S.I. Rasool and Dr. S.H. Schneider. It appears that Dr. Schneider is the same who is today an "unabashedly" strong advocate of global warming.

This flurry of papers resulted from meteorological data showing a cooling of the climate over large parts of the World. The predictions of a freezing planet, uncannily resemble those of a boiling globe predicted by the warming alarmists.

So much for past predictions of climate change. The excuse is that the computers of the 1960s and 1970s were not powerful and sophisticated enough to crunch all the data loaded into them. Would it be also possible that if the predictions of today will not be confirmed twenty or thirty years from now, the same lame excuse will be invoked again?

The latest mantra of the alarmists is "abrupt change" (Alley, 2004; Crowley and North, 1988). For example, Crowley mentions that "the melting of the great ice sheets represents one of the most rapid and extreme example of climate change in the geological record. The deglaciation occurred in two steps: an abrupt warming (circa 13,000 years ago) followed by a climate reversal (at about 11,000 years ago), then another abrupt warming (10,000 years ago). The warm steps may have occurred in a short time of 200-300 years".

According to Broecker and Kunzig (2008) "violent shifts took place during the last ice age. In less than a millennium the temperature seemed to climb halfway out of its deep global cellar, only to plunge back as abruptly as several centuries".

In historical times, periods of drought are also mentioned as an example of abrupt change: a draught which ended around 1110 AD returned with a vengeance 100 years later, lasting a century and a half (Broeker and Kunzig, 2008).

Another example of "abrupt change" is given by Silver (2008) who wrote regarding the last glaciation that "the onset of glaciation is marked by two stages of volume growth at 115,000 and 75,000 BP" and that the start of both "may have occurred in a short time as 3,000-4,000 years".

In conclusion, Broecker stated that "the existence of abrupt climate change is by now more often of an observational fact than a theory. It is the most important thing we have learned about climate in the half past century".

It is quite possible that Broecker is right, but where he (and all the others advocates of abrupt change) is wrong is in the appreciation of the time scale of an event labeled as "abrupt change".

For a layman, reading this scary information, abrupt change means dramatic climatic events, taking place within the year or at most during the decade. He does not realize that it is a geological time-scale that is used for which centuries, millennia and several millennia is small change. Therefore the public should have been informed that abrupt change for geologists, glaciologists or climatologists is a change requiring in most cases centuries or millennia. Unfortunately, the alarmist group did not clarify this important

* The quotations related to an incoming glaciation are taken from Anna J. Bray's article "The Ice Age Cometh. Remembering the Scare of Global Cooling" (1991)

difference between annual and millennial change even if the latter is labeled as "abrupt".

The adepts of catastrophic events based on mathematical models rely on the presumption of phenomena which either happened in the distant past having nothing to do with anthropogenic global warming (sea level rising, desertification, extinction) or on phenomena which are not known to have occurred and, ironically, cannot be modeled for this reason. Thus Broecker (2008) maintains that "huge events are happening on Earth that we are totally unaware of" and that "we are witnessing the beginning of a sequence of events in Greenland and Antarctica that is outside our historical experience … These events may take centuries, but they might happen much faster" (abrupt change!). Just how fast and what those events may be the computer models apparently cannot determine.

One wonders, therefore, why so many millions of dollars are spent, why so many teams of scientists and why so many bureaucrats are feverishly concocting models when unknown, unpredictable and unpredicted climate events may happen, some of them allegedly overnight, taking those people by surprise. All events, processes and phenomena yet undetected will quite possibly nullify the efforts and costs of model making."

Most of the scenarios forecasting disasters are predicated on the premise that the weather system is nowadays lacking in equilibrium, mainly due to anthropogenic heating. As a result, the system will become increasingly unstable, hurtling toward a "tipping point" beyond which all cataclysmic events are imaginable. Nobody knows what exactly this tipping point is and when it will be reached.

A more optimistic view sustains that the atmosphere has an in-built system of balancing its diverse components. Spencer (2008) believes that "nature appears to operate with built-in checks and balances (Spencer, 2008)". "When the system veers too far from normal, complex processes react in ways that pushes the system back into the opposite direction". According to the same author, it is the precipitation process that acts "as the nature's thermostat, adjusting how much water vapors (the main greenhouse gas) will be allowed to remain in the atmosphere, thereby controlling most of the Earth's greenhouse effect. Unfortunately, it so happens that precipitation is the atmosphere process the least understood, because its thermostatic control is so complex that it is simply ignored" (Spencer, 2008).

CONCLUSIONS

It should be clear by now, that there is no unanimous view concerning the role of anthropogenic greenhouse gasses in heating the atmosphere. So many questions are still left unanswered, poorly understood processes are yet to be studied, feedbacks, unbelievably complex are yet to be untangled, that claims that there is no doubt about the overwhelming role greenhouse gases play in deteriorating climate makes this statement not too convincing. Indeed, many natural processes are intricately linked and influence the warming process (whether natural or man-made) in its length and potency. Some of these physical and chemical processes have also a strong buffering effect keeping Earth's CO_2 balance in check. To take, as an example, the science of physics, the physicists (and astronomers and other scientists) could have claimed that after each of the epochal discoveries which they made, everything was known and solved and therefore the science of physics was closed. The discovery of the atomic structure of the matter, the orderly arrangement of elements, the tie between electricity and magnetism, the relationship between mass, energy and time, the discovery of the principles of quantum mechanics, the role of the black holes in the death and birth of stars and of the Hicks boson, all might have qualified, in their time, as the ultimate finding necessary to settle everything in physics.

Fortunately, bright minds never pretended that their discoveries meant the end of the road for their science. Rutherford, Mendeleev, Maxwell, Borg, Heisenberg, Fermi, de Broglie, Hawking, Hicks and above all Einstein were prudent and modest enough to admit that there was much more to be known and understand before claiming victory.

It must be emphasized that the greenhouse effect of rising global temperature is nothing new for the planet, though it is so for contemporary human beings. But we must not forget that our ancestors outlived several glacial and interglacial fluctuations with infinitely less knowledge and fewer tools to combat their effects.

The Earth itself has gone through far bigger cataclysmic events, some of them of climatic origin lasting millions of years without suffering irreparable damage. Life processes continued uninterrupted and were not hurt by warm, even hot periods in Earth history. If anything, most organisms prefer warm and moist weather. It is the frigid epochs, some of them of a duration of millions of years which are dangerous to biotic processes, although life has successfully navigated such unfavorable, even dangerous times.

Compared to the long time spans of natural excessive warming or cooling, of huge ice caps and extensive deserts, a man-induced genuine greenhouse effect looks like a blip on the screen of Earth's history. It is true that this view is from a Terracentric perspective, but, seen from an anthropocentric view point. it is quite serious, especially if some of the frightening consequences of a warmer planet prove to be correct.

Certainly, the consequences of an anthropogenic effect (though not so strong and alarming as it is claimed to be) should be taken seriously, resulting in a realistic and feasible set of measures which will be approved by a majority of nations. Unfortunately, the most important decision so far, the Kyoto Protocol, proposed unrealistic goals and means to achieve them which were not accepted by the people.

What is necessary now is for all groups to come together. They must objectively and without a sense of passionate crusaders admit the undeniable facts, pour over the many still unanswered questions such as the physico-chemical cycles of most atmospheric and hydrospheric compounds, their precise times of residency within each geosphere, the exact saturation points (function of the changing characteristics of the medium), the self-regulating mechanisms of the planet, the complex feed-back loops, etc.

Furthermore, all models should be compared and choice among them should be made, which should allow to establish a hierarchy of problems to be studied or re-studied according to their urgency. Finally a realistic time frame should be agreed upon for implementing the measures already agreed upon, so a measures already established to a cost-analysis should become possible.

There should be an agreement that hasty conclusions about the inevitability of a catastrophic greenhouse warming effect just about to happen or already in progress is not a constructive approach especially when powerful interests like the media and the environmental movements try to sensationalize the alleged events.

Regarding the proposed solutions for lowering the amounts of CO_2 discharged into the air, some of them might prove realistic (CO_2 sequestration), but others (screening the solar radiation or other fancy ideas) are almost literally pie in the sky.

However, important decisions should be taken to reach the root of the problem that is to replace the finite fossil fuels as sources of energy with non-warming, non-polluting and inexhaustible ones. The future energy sources fulfilling all these requirements are nuclear fusion energy and hydrogen-based energy. This is where governments and private industry should concentrate their efforts, invest sizeable funds for research and plan for such a clean energy future. Indeed, such investments will not only cool the atmosphere, but also, in the long run, prove to be far more efficient than any other kind of energy. The accent put today on developing wind, solar, wave and underground heat energy should be regarded only a stop-gap measure, since, although non-polluting, they are far from reliable and demand huge spaces for the installations capturing the wind or solar energy.

As a conclusion, it is highly recommended that the scientific community and the political decision-makers act prudently and not contribute to the actions of panic-mongering groups interested mainly in obtaining more power, money and prestige for whom the global warming hypothesis is an excellent tool.

It is hoped that this rather long discussion about the climate history of our planet will put things into perspective, will alleviate some feelings of anxiety and, at the same time, will give foresight into possible outcomes of climate change, so as to make better informed and more rational decisions.

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