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Climate change, a phenomenon put to the test by scientific debate

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Abstract
The warming of the climate system is unequivocal, and since the 1950s, many of the observed changes have been unprecedented for decades, even centuries or millennia. Consequently, the lives and livelihoods of especially vulnerable populations around the world are constantly threatened by this phenomenon. However, other voices are speaking out to the contrary. The objective of this work is to analyze the controversy over climate change by comparing the points of view of different currents. To conduct this research, the methodology used is based on documentary research. Indeed, we consulted documents on climate change in several documentation centers and libraries. Then, we compared the authors' points of view on this phenomenon. The authors are divided into three currents: climate alarmism, climate skepticism, and climate realism. The results of this research show that there is no scientific consensus on climate change. There is a divergence on the causes, consequences, and even the existence of this phenomenon. Indeed, climate alarmists defend anthropogenic climate change and warn of the immediate and future dangers it poses. Climate skeptics, on the other hand, question the significance or severity of climate change and its anthropogenic origin. The third group, climate realists, has a centrist perspective and advocates caution to avoid erroneous conclusions drawn from climate change studies.

Keywords: Climate change, climate alarmism, climate skepticism and climate realism

Introduction

The livelihoods and lives of vulnerable populations around the world are constantly threatened by natural disasters. The link between these and climate change has been established. Thus, the existence of this phenomenon is evident according to the Intergovernmental Panel on Climate Change - IPCC (2007) [8]. It added that the intensity and duration of the warming observed in the 20th century are unprecedented in the last thousand years. An increase in maximum temperatures, the number of hot days and the heat index were recorded in virtually all countries during the second half of the 20th century.

Furthermore, the outlook is worrying according to the IPCC (2014) [9], which concludes that projections based on all emissions scenarios considered indicate an increase in surface temperature during the 21st century. It is very likely that the frequency and duration of heat waves will increase, and that extreme precipitation will become more intense and more frequent in many regions. The oceans will continue to warm and acidify, and the average sea level will rise.

Africa emits fewer greenhouse gases. However, it is one of the regions of the world that is most affected by the harmful consequences of climate change. Indeed, according to Terdiman (2007) [10], Africa has already felt the impact of climate change and we can expect even more marked effects. Thus, in general, areas that have had rainfall, such as the equatorial and subpolar rain belts, will have even more, while dry areas, such as the subtropical arid zones, will have even less. As a result, the arid and semi-arid zones of North, West, East and partly South Africa have become drier while equatorial Africa and the rest of the South are becoming wetter. Worse, the IPCC (2014) [9] maintains that during the 21st century, global warming will be greater in Africa than at the global level. Indeed, according to ECOWAS and SWAC (2008) [2], the average temperature increases between 1980/99 and 2080/99 could reach between 3 and 4°C across the continent, 1.5 times higher than at the global level. This increase will be less marked in coastal and equatorial areas (+3°C) and higher in the western part of the Sahara up to +4°C.

In sub-Saharan Africa, climate change is also significant and disrupts economic, environmental, and social systems. For example, according to the IPCC (2014) [9], the example of rainfall is striking: after experiencing unprecedented drought worldwide since the 1970s, West Africa has benefited from increased rainfall since the early 1990s, but with strong interannual variability and more frequent episodes of violent rain. The duration of the rainy season has decreased, while the frequency of floods has increased.

As for Mali, according to the Ministry of Equipment and Transport –MET (2007) [13] in the PANA indicated that, for about thirty years, climatic conditions in Mali have only deteriorated with the consequences of the loss of soil, genetic material and species.

According to the IPCC (2007) [8], the scientific community unanimously agrees that climate change is a reality and is mainly due to human activities. However, other voices are raised to say the opposite. The authors are mainly divided into three currents: climate alarmism, climate skepticism and climate realism. The objective of this work is to analyze the controversy on climate change by comparing the points of view of the authors of the different currents.

Method and materials

To conduct this research, the methodology used is based on documentary research. Thus, the approach required several steps and tools. The steps are:

1. Scope of work

- **Objective**

First, the objective of the article was determined. It is the controversy over climate change.

- **Audience**

This research is aimed at the general public, academics, policy makers, etc. Then, the angle of approach from which it is placed is scientific.

2. Analysis techniques

The analytical grid used to distinguish the main schools of thought on climate change is based on the following variables

- **Causes of climate change:** the position of the authors causes a parameter of analysis. They are among others anthropogenic and natural;
- **Consequences of climate change:** this is a variable which allows us to distinguish between the negationist and alarmist position;
- **Proposed solutions:** The authors propose a variety of solutions. One of them is the ecological transition.

3. Analysis tools

The document was written using Microsoft Word software. Search engines such as Google Scholar were used.

4. Identification of the main schools of thought

At the end of the documentary research based on the analysis grid, we identified three main schools of thought on climate change: climate alarmism, climate skepticism and climate realism.

5. Structuring the article

This article is structured as follows: introduction; method and materials; results and discussion; conclusion and bibliographic references.

Results and discussion

1. Results

The increasing frequency and intensity of disasters and humanitarian crises, which pose a significant threat to peace, stability and economic growth, are most often associated with climate change.

While most scientists today agree that global warming is indeed occurring, it must be acknowledged that there is profound disagreement about the causes of this warming. Thus, proponents of anthropogenic climate change, and therefore of the IPCC, oppose climate skeptics who dispute the anthropogenic nature of climate change. A third group, called climate realists, is embroiled in the debate by advocatingcaution.

1.1. Climate alarmism

Climate alarmism is the current that defends anthropogenic climate change and warns of the immediate danger it represents. This idea is supported by a good number of authors often referred to as the entire scientific community (Fulchiron, 2011) [6]. According to these scientists, the climate is changing and man is largely responsible for it. Thus, Doukpolo (2014) [5] citing Bryant *et al*. (2008) wrote: "It is no longer a question of knowing if the climate is changing, but at what speed it is changing and how man will adapt to it."

For a number of authors described as climate skeptics, the current warming of the Earth is the consequence of the increase in greenhouse gases in the atmosphere due to human activity. For these scientists, the increase in temperature over the last hundred years cannot be explained by taking into account natural phenomena alone. Scientific studies clearly show that humans play a role in current climate change.

Thus, Kevin Trenberth and his colleagues (2009) [17] proposed an estimate of this radiation balance, by adding and subtracting all the energy exchanges estimated from observations and models: solar radiation reaching the atmosphere, the absorbed and reflected portion, heat release from the surface, etc. In the end, they estimate that the energy balance at the top of the atmosphere and at the surface is in excess of 0.9 (from 0.7 to 1) W/m2 (energy flow per square meter). According to these authors, this surplus energy, responsible for a warming of the Earth-atmosphere system, would come from the additional greenhouse effect: that which is caused by an excess of greenhouse gases released into the atmosphere by human activities.

Moreover, the IPCC (2014) [9] estimated that anthropogenic greenhouse gas emissions, which have increased since pre-industrial times mainly due to economic and population growth, are currently higher than ever before, resulting in atmospheric concentrations of carbon dioxide, methane and nitrous oxide not seen for at least 800,000 years. Their effects, combined with those of other anthropogenic factors, have been detected throughout the climate system and it is extremely likely that they have been the main cause of the warming observed since the mid-20th century.

Comparing observations of changes in gas content with those of the climate tend to confirm not only a causal relationship between the increase in greenhouse gases and climate change, but also that human activities are the cause of the increase in these gases.

Figure 1 illustrates that the CO2 content of the atmosphere and the average global temperature have always varied and are mostly correlated. The CO2 concentration in the atmosphere was already 394 ppm in May 2011. This is 114 ppm higher than the "natural" pre-industrial level (280 ppm). Since the beginning of the industrial revolution (+/- 1750), the CO2 concentration in the atmosphere has therefore increased by approximately 41%. Half of this increase has occurred in the last 50 years. In addition to an increase in the greenhouse gas CO2, human activities are responsible for an increase in many other greenhouse gases.

Human activities that release the most greenhouse gases are mainly the combustion of fossil fuels (coal, oil and natural gas) and massive deforestation is not a trivial factor. Thus, 49 billion tonnes of CO2 equivalent were emitted in 2010 by human activities, distributed as follows: 35% were produced by the energy sector, 24% by AFOLU (Agriculture, Forestry and Other Land Uses), 21% by industry, 14% by transport and 6.4% by construction (IPCC, 2014) [9].

Most greenhouse gases are of natural origin, but some of them are seeing their concentration in the atmosphere

increase due to human activities. This is particularly the case for ozone (O_3), carbon dioxide (CO_2) and methane (CH_4). On the other hand, other gases are exclusively the result of human activities and also contribute to the additional greenhouse effect. These are heavy halocarbons and other artificial fluorinated gases such as chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and sulfur hexafluoride (SF_6). Their contribution is recent and particularly effective.

However, proponents of anthropogenic climate change, in accordance with the IPCC definition of climate change, do not exclude natural internal processes leading to climate change. Thus, natural causes include solar activity, volcanic activity, meteorite impacts, Earth movements, the position of continents, and atmospheric circulation and ocean currents.

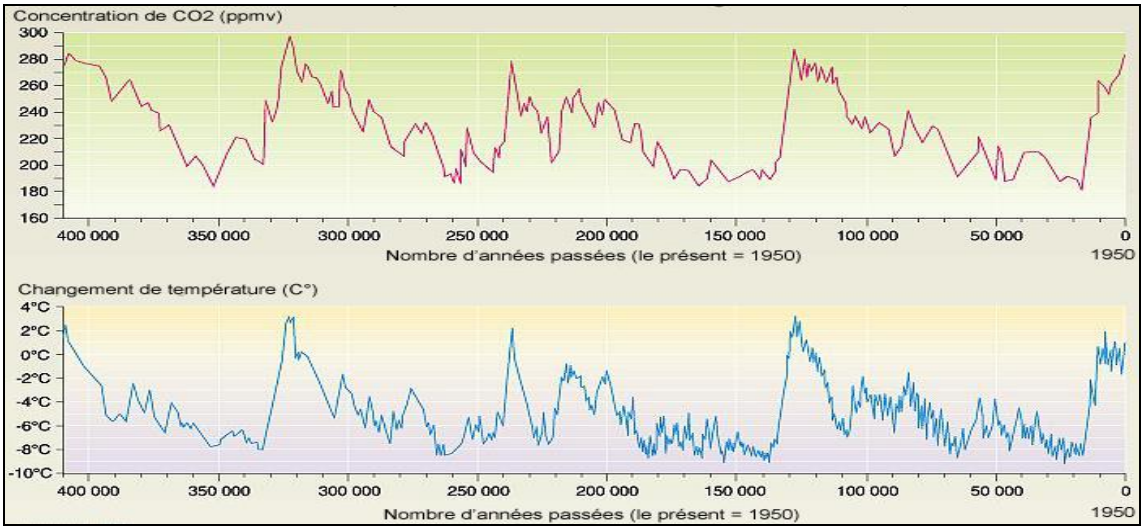

Fig 1: Temperature and CO^2 concentration in the atmosphere over the last 400,000 years. Source: Petit *et al*., 1999 [14].

1.2. Climate skepticism

Opponents of the diagnosis that global warming is primarily due to human activities have also mobilized. These are climate skeptics, referred to as "climate deniers" by some of their detractors. They question the significance or seriousness of climate change and its anthropogenic origin. They are becoming increasingly visible thanks to the publication of an article, column, or opinion piece in the mainstream press.

The argument of climate sceptics to deny human responsibility for climate change is made up of various elements, the main and most recurring of which are the following

- **natural phenomena as factors of global warming:** If the IPCC, in its review of scientific studies, takes into account the influence of the Sun but judges it to be only slightly responsible for current warming, some authors known as climate skeptics question not only the importance of the contribution of CO2 to current warming but also maintain that nature is responsible for it. Thus, Leroux (2003) [11] writes: "The greenhouse effect is not the cause of climate change. The probable causes are therefore: well-established orbital parameters on a paleo-climatic scale, with climatic consequences slowed down by the inertia effect of glacial accumulations; solar activity; volcanic activity and associated aerosols (particularly sulfates) whose effects (in the short term) are incontestable; and far after, the greenhouse effect, and in particular that caused by water vapor whose influence is unknown. These factors combine permanently and it seems difficult to establish the relative importance of these different factors on climate change. Similarly, it is biased to highlight the anthropogenic factor when it is clearly the least credible among all the other factors cited above.

- **Uncertainties in the IPCC's conclusions:** The IPCC, in its fifth report in 2014 [9], states that it is extremely likely (95-100%) that the influence of human activities on the climate system is the main cause of the warming observed since the middle of the 20th century. However, a number of authors identified as climate skeptics believe that uncertainties mark the IPCC's results. As a result, climate models are discussed.

Thus, Leroux (2003) [11] summarized his point of view on the theory of global warming as follows: "Global warming is a hypothesis derived from theoretical models and based on simplistic relationships, which announces a rise in temperature, proclaimed but not demonstrated. There are numerous contradictions between the predictions and the directly observed climatic facts, the deliberate ignorance of these flagrant distortions constituting a scientific imposture." In another study published in 2007, he concluded: "Climate changes are not summarized by a simple so-called "global" temperature curve. These changes are not "explained" by the greenhouse effect.

For Serge Galam (2007) [7], the cause of current climate change is still unknown and the only link between CO_2 and global warming is a temporal coincidence: "man has been declared guilty simply because for the moment no other culprit has been found and also because appearances are against him."

Furthermore, Michael Mann and Phil Jones are physicists whose work has been adopted by the IPCC, including the so-called hockey stick curve, which is said to prove the anthropogenic origin of global warming. Michael Mann is an American physicist and climatologist born in 1965, specializing in paleoclimatology. He is known for having developed in 1998 a curve reconstructing the average temperatures of the globe over the past 1000 years, which has the shape of a hockey stick, hence its name. Supposed to be irrefutable proof of human responsibility in global warming (Fulchiron, 2011) [6].

This curve shows that the climate has warmed abruptly since the beginning of the 20th century. Compared with the CO2 curves in the atmosphere, these increase simultaneously. The problem with this hockey stick curve is that the medieval optimum and the Little Ice Age that followed it do not appear (Allègre, 2010) [1]. There has therefore been a questioning of this curve, and there has been controversy, particularly around the methodology used by Michael Mann. For Claude Allègre, "he had wanted, without mastering the technique, to apply a sophisticated method to sparse data with random reliability." This curve was subsequently corrected to include the medieval climatic optimum and the Little Ice Age.

These corrections were notably developed with Phil Jones, the director of Climate Research Unit of the University of East Anglia in England, but do not remove the doubt about the models that made it possible to calculate it, since these models then appear to be modifiable at will to make facts appear or disappear. Now this model and this Mann curve were the subject of an investigation by the United States Committee on Science led by Edward Wegman, which submitted a report in 2006 highlighting methodological errors (Fulchiron, 2011) [6]. In addition, this author adds that Phil Jones and Michael Mann were also involved in the Climategate of November 2009. Climategate is the publication on the internet of emails exchanged by climatologists close to the IPCC over a period of ten years. Among these emails is an exchange between Michael Mann and Phil Jones where the latter asks Mann to delete data concerning an article included in the fourth report of the IPCC, following the request of Steve McIntyre of Climate Audit to access this data in order to verify the methodology used in their models which allowed them to arrive at their curves. Climategate also revolved around the "trick" used to hide conclusions which would go in the opposite direction of global and anthropogenic climate warming**.**

- **The whole climate:** according to Taithé (2011) [16] argues that climate skepticism would firstly benefit from a weariness with the omnipresence of climate issues. Apart from earthquakes, it might seem that all environmental issues can no longer be addressed except through the prism of global warming (water management, food, energy and health security, etc., or even crisis prevention). Actions against climate change are then perceived as long-term and poorly adapted to immediate problems (access to water). However, global warming is already a reality in the present and is becoming a dimension to be integrated into public policies related to the environment. Managing water, even within the framework of a plan lasting a few years, now requires taking climate dynamics into account, otherwise, for example, a country's hydroelectric potential or its food production could be overestimated. This rejection of the "all-climate" approach then becomes conflated with the phenomenon itself and its explanations. It is also maintained by the leadership that the broad climate science community has acquired on environmental issues. According to climate scientists, the disappearance of geology, a privileged discipline until the end of the 1980s (funding and outlets for oil exploration in particular), in favor of climate science would also be one of the explanations for the presence among skeptics of many geologists who also work on periods much longer than those of climate.

The dramatization of the consequences of climate change also contributes, through their exaggeration or their spectacular aspects, to a mistrust which also affects the scientific basis established by the IPCC (Taithé, 2011) [16].

However, climate sceptics are accused of evolving their arguments, in several stages, in the face of the glaring reality and the speed of global warming, something which undermines a certain credibility. Indeed

- **firstly, the original argument of the first climate sceptics:** " no, the Earth is not warming " (while we have our feet in water more and more.). Climate sceptics exploit the slightest flaw in the increase in temperatures to denounce the incoherence of the IPCC's forecasts, forgetting that the complex climate machine does not necessarily obey in a linear manner the increase in greenhouse gas concentrations;

- **Secondly, the first evolution of the climate-sceptic argument:** "the Earth is warming but Man is not responsible as evidenced by past climates". They no longer dispute the reality of this warming but they question the responsibility of man in this phenomenon. According to them, this warming would be "natural" and human activities would have nothing to do with it or would have a marginal responsibility in its acceleration. Consequently, it would be "urgent to wait" for the climate to regulate itself.

- **Thirdly, the second evolution of the climate-skeptic argument:** "Okay, the climate is warming and we are responsible, but it's only happiness in perspective!" Pushed into their last entrenchments, more and more climate-skeptics finally accept the idea of global warming of anthropogenic origin. However, always in a

spirit of contradiction, they will flaunt the multiple benefits that this implies, minimizing or dismissing the negative consequences, which are nevertheless very serious.

In addition to this climate skepticism, there is another trend called climate realism, which tries to stand out through its arguments and its organization.

1.3. Climato realism

Climate realists aim to promote open and free debate on climate change and related societal and environmental issues, by encouraging the expression of rigorous and reasoned opinions in all their forms. Their views on global warming are generally considered "centrist" in the opposition between climate alarmists and climate skeptics.

Thus, some of them advocate caution to avoid erroneous conclusions from studies on climate change. Indeed, Courtillot V. (2009) [4], geophysicist at the Institute of Globe Physics in Paris and the Academy of Sciences and member of the scientific committee of The Association of Climate Realists of France states: "Attributing a single cause to such a complex process is a risky statement. Moreover, current predictions are based on models that may still evolve. All our work over the past two years has shown the decisive impact of the Sun on the climate. Let's give ourselves more time before making definitive statements".

Furthermore, other authors denounce a stated scientific consensus around the IPCC's conclusions but propose a sought-after consensus. This search for consensus is sometimes long and difficult and requires a scientific debate that can be lively on questions where the scientific community is divided or expresses doubts about the relevance of certain theories or concepts. This explains, according to Merle *et al*. (2014) [12], the positions taken by an American meteorologist, Richard Lindzen, well known and highly respected by his peers in his field, who for a long time refuted the assertion of a majority of climatologists declaring that we were almost certain (95%) that GHG emissions produced by human activity were the cause of observed global warming. For Richard Lindzen, the lack of knowledge about the evolution of the water vapor content of the atmosphere, the main natural GHG, did not allow us to exclude that other phenomena still not understood, involving, among others, the water cycle and the formation of clouds, could be at the origin of this warming. These disagreements were debated in depth by the experts of Working Group I (the group that deals with scientific elements) of the IPCC, which advanced knowledge and ultimately contributed to refining the content of the expertise. This is what historians of science call: the "reflexive practice of expertise".

However, there are climate realists who are more inclined to the ideas of climate sceptics. Thus, for Benoît Rittaud, mathematician at the University of Paris-13**,** member of the scientific committee of the Association of Climate Realists), the climate realist position corresponds to the thesis according to which solar activity and cosmic radiation explain climate change. This is why, Rittaud (2010) [15] speaks of a "pseudo-science based on climatology" that he calls climato-mancy: "divinatory art aiming to deduce from human behavior the climatic future of the Earth, with the idea of prescribing penitential actions for each person." Defining himself as a climate realist, for Benoit Rittaud, predicting the "end of the world" is absurd.

Generally speaking, the position of climate realists ranges from caution to the denial of carbocentrism. It must be noted, however, that there is a porosity between climate realism and climate skepticism. Indeed, authors such as Benoît Rittaud and Vincent Courtillot who are members of the scientific committee of the Association of Climate Realists, are often cited in certain documents [1] as climate skeptics.

2. Discussion

This research shows that there is disagreement among scientists about the causes of climate change, which corroborates the results obtained by other authors such as Fulchiron (2011) [6] and Taithé (2011) [16].

Furthermore, our results also corroborate those obtained by Claude Kergomard (2012) [3] who goes further in his work "Climate change: certainties, uncertainties and controversies". Indeed, he speaks of the context of economic war and geopolitical confrontations which mark the debate on climate change.

Conclusion

This research aims to analyze the controversy over climate change by comparing the perspectives of authors from different schools of thought. To do this, a mixed methodology based on a literature review was used to compare the perspectives of the authors. The results of this research show that there is no scientific consensus on climate change. Indeed, authors are generally divided into three schools: climate alarmism, climate skepticism, and climate realism.

Considering the different points of view, it can be said that the current global warming is a natural process aggravated by man. What is certain is that this phenomenon is not without consequences.

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