What Should We Make of the Assertions of Climate Change Skeptics ?

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Climate scientists widely agree with the claim that climate warming is under way ; this warming is mainly due to man-made greenhouse gas emissions ; it may have significant impacts that would be harmful to humanity. A large majority of the population believes that this triple diagnosis is true. However, the agreement is not unanimous; renowned individuals, usually working in fields other than climate science, argue that human activities have no impact on the climate, some going so far as to deny that there is any climate warming at all. These judgments and denials enjoy some success amongst the audiences and readers of these individuals. We purport to present synthetic answers to the arguments that are most often put forward. We have grouped them within four topics.

1. HUMAN ACTIVITY DOESN'T REALLY IMPACT THE CLIMATE

The earth has already experienced warm climates, with no human intervention whatsoever.

True, of course. Man is not the only entity capable of modifying the climate. The sun, volcanic activity, continental drift, greenhouse gases, … are all items that impact the climate.

The earth's average temperature follows CO2 variations only during the years 1970 – 2000. Therefore, CO2 concentrations are not responsible for the temperature rise.

Wrong. CO2 prevents heat from escaping but, taken the thermal inertia of the oceans, there is a large delay between CO2 accumulation and global warming. Moreover, CO2 is not the only climate player. Indeed, aerosols have significantly mitigated climate warming during the 20th century.

The earth was warmer around year 1000, at the medieval optimum, it was colder starting in the middle of the 15th century, with the little ice age. The present warming, which is very limited as compared to the medieval optimum, is nothing but the end of the little ice age.

Wrong. The medieval optimum involves only a part of the northern hemisphere, with a maximum near Greenland. The little ice age is totally unknown in the southern hemisphere. Both cases are due to climatic oscillations which warm some part of the globe, at the expense of another. On the contrary, the current warming involves the entire planet.

The alpine glaciers have started to melt in 1850, much before CO2 emissions could have brought on any kind of warming.

True. Glacier recession can have two causes: increased temperatures and a deficit of snow accumulation as compared to melting. The two inverse phenomena come into play when glaciers grow. Actually, the accelerated alpine glacier melt is not in itself a proof of global warming. But the fact that all the large continental glaciers worldwide are melting is indeed a proof of global warming, all the more where precipitations have increased.

The well known climate scientist, Richard Lindzen from MIT denies global warming as described by the IPCC.

While Richard Lindzen does not agree with the climate impact of global warming, he does not deny the existence of global warming, nor the effect of CO2 on the climate: in an article published in the April 12, 2006 issue of the Wall Street Journal (http://www.opinionjournal.com/extra/?id=110008220), he wrote: "Global temperature has risen about a degree since the late 19th century; levels of CO2 in the atmosphere have increased by

about 30% over the same period; and CO2 should contribute to future warming. These claims are true."

Man-made CO2 emissions represent only a few percent of natural emissions.

True. But they come as an add-on and break the equilibrium between what nature emits and what it absorbs from the atmosphere. Today, half of what man injects in the atmosphere stays there and builds up. If the atmospheric gases were to separate as a function of their density, CO2 would represent a 3 meter thick layer near the ground. 150 years ago, the layer would have been only 2.25 meters thick.

During natural variations, CO2 has never caused warming, it has accompanied it, as measurements from air bubbles trapped in ice cores have shown.

True concerning Quartenary glaciations but wrong for the history of earth's climate : there have been times when earth was entirely covered with ice: e.g. the "snow ball earth", 600 million years ago; the earth was able to warm up because of the accumulation of CO2 emitted by volcanoes, CO2 that was not consumed by photosynthetic activity. As for glacial and interglacial eras during the Quartenary period, we know that variations of solar radiation at high latitudes of the northern hemisphere were the triggering factor of these phenomena, that the albedo (reflective power) variations of the surface, when it is, or is not, covered with snow or ice, were necessary to reinforce the initial temperature variations. The warming or cooling of the oceans that ensued caused the variations we observe in CO2 concentrations, that in turn played fully its part as a climate amplifier. In the absence of the greenhouse effect, the amplitude of the glacial periods would have been far less.

Indeed, we are dealing with two different phenomena. On one hand, as a consequence of the greenhouse effect, an increased CO2 concentration induces a temperature rise. On the other hand, a temperature rise induces an increase of CO2 concentration in the atmosphere for reasons that are not all fully understood, one of them being identified as ocean degassing. Thus, increased CO2 concentration induces a temperature rise and a temperature rise induces a CO2 concentration increase. The two phenomena reinforce each other, regardless of which comes first - CO2 concentration today, the temperature rise during the glaciation cycles.

At the present time, it is CO2 accumulation which, because of the greenhouse effect, induces the warming. Note that the rate at which CO2 concentration in the atmosphere is increasing because of human activity is 100 times faster than the natural increase during the most recent deglaciation.

Atmospheric CO2 concentration has varied considerably and has often overshot the present value during the first half of the twentieth century as is established by numerous measurements performed by various laboratories.

Wrong. Before the measurements initiated by Keeling in 1958 in Hawaii and in the Antarctic, people measured CO2 concentrations in the vicinity of their laboratories, i.e. close to human activities such as industry, heating, transportation, all responsible for significant CO2 emissions. The variations they measured were, in fact, variations in the contribution of these various emitters in the local air composition . Keeling's great contribution is that he made his measurements far from any local polluting source.

The main greenhouse gas is water vapor, not CO2.

True. But, contrary to the added CO2 which remains in the atmosphere for several centuries, excess water vapor condenses and leaves the atmosphere in the form of precipitations. The problem with CO2 and other man-made greenhouse gases is that they remain in the atmosphere for a long time and thus have time to trap a great deal of heat near the earth's surface. However, the greenhouse effect due to water vapor is indeed there and it tends to add to the warming due to increased CO2 concentration : a higher temperature induces increased evaporation from the oceans and more accumulation in the atmosphere because the water vapor saturating pressure

increases; this supplementary water vapor in the atmosphere contributes to more warming. Obviously, climate models take this phenomenon into account.

Clouds are an essential component of the climate; their behavior is not well understood.

True. And that is the main source of uncertainty in climate models. Their physics takes place at a microscopic scale that is, and will be for decades to come, out of the reach of the climate models we run on our computers. And we don't know what will become of clouds with global warming: more thick clouds which protect earth from solar radiation and have a cooling effect, or more thin clouds which let solar radiation through but stop the infrared radiations emitted by the earth, providing a strong contribution to the greenhouse effect. The various IPCC models have different approaches to these issues, thus illustrating the uncertainties on our predictions.

All the blame is put on CO2 although it is not the only entity involved. The role of clouds and aerosols is not taken into account because they are poorly understood.

Wrong. Beyond CO2, the models take into account the other greenhouse gases, whether they are emitted by human activity or naturally, even if, sometimes, we realize that some have been omitted. Clouds are an essential component of all models (see above); aerosols are taken into account (with uncertainties on their indirect effects and on their future emissions) since the middle of the 1990's.

There is nothing to prove that the observed warming is connected to human-made CO2 emissions.

The isotopic composition of CO2 in the atmosphere (Carbon 14 ratio) shows unambiguously that the CO2 increase comes mainly (excluding deforestation), from very old carbonated materials. Moreover, the slight but clearly observed decrease in atmospheric oxygen concentration goes to prove that the additional CO2 has been made by burning carbon and is not due to CO2 degassing from some reserve.

According to our understanding of the climate, the natural conditions of the past 50 years would have produced a cooler climate in the absence of an excess of greenhouse gases, rather than the warming we observe.

While all the models reproduce the temperature variations observed at the global scale, separately for the continents and oceans, and separately for each continent, none of them is able to reproduce the variations observed without including the man-made excess greenhouse effect. The correlations observed between various climate parameters also point towards warming as a consequence of increased greenhouse effect.

2. In Fact, There Isn't Really an Ongoing Warming Process

The measured temperature increase is due to the fact that most meteorological stations are placed in urban areas, islands of increasing heat.

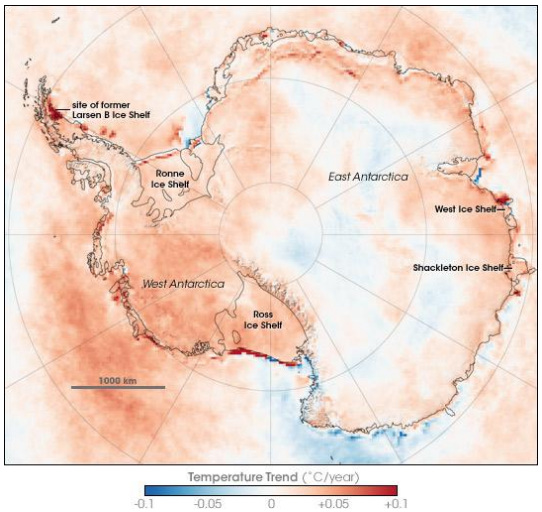
A number of ground stations are in urban or peri-urban areas. Meteorologists and climate scientists take that into account in their mean temperature calculations. The calculation procedures are not the same in the United States and in Europe leading to a few differences in the detail, but the results are the same and the tendencies found by one are found also by the other. Don't forget that 70% of earth's surface is ocean water (devoid of urban heat), that very large areas are not urban, and that the temperature is measured over the entire surface of the globe by satellites. Indeed, many areas where temperature increase is significantly higher than the average are very scarcely populated : the highest temperature increase is observed in the Arctic or in Siberia; high increase occurs also in African deserts and in tropical forests.

The fact that the global temperature has increased more on the continents than on the oceans proves that continental temperatures are biased by the urban hub effect.

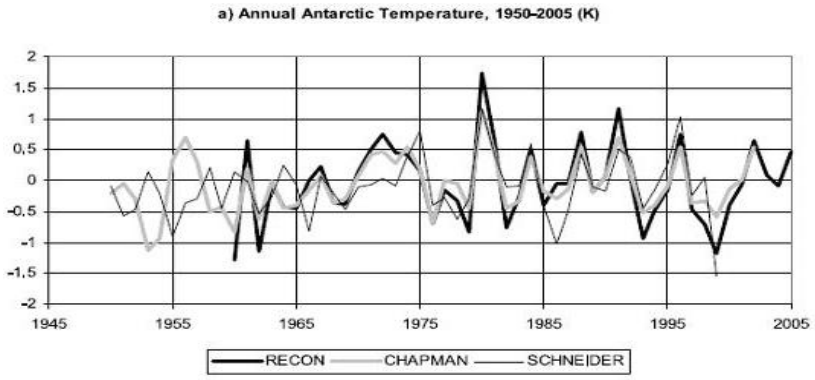
The thermal inertia of the oceans necessarily delays their warming as compared to that of continents.

Far from warming, Antarctica cooled down.

True in some areas and wrong on the average. As it is, the atmospheric circulation tends to isolate the Antarctic from the rest of the planet. In the coastal regions of this very large continent, the evolution of the temperature depends also on the ocean temperature. Thus, the West peninsula has undergone a very large temperature rise. The temperature of the rest of the Antarctic has not changed much, with perhaps a very slight increase from 1950 to 2006 and, for certain measurement points, a very slight cooling over the past 30 years. The "ozone hole" may have contributed to this cooling.



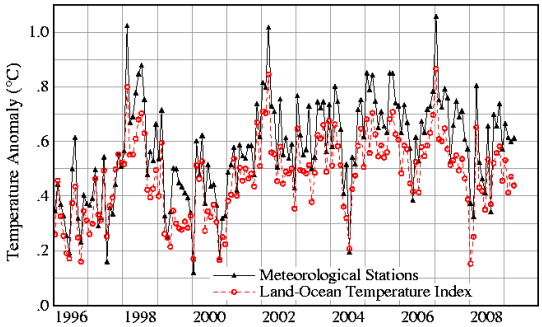
Temperature evolution over the past two decades (nov 2007)
http://earthobservatory.nasa.gov/IOTD/view.php?id=8239



Monaghan, A. J., D. H. Bromwich, W. Chapman, and J. C. Comiso (2008), Recent variability and trends of Antarctic near-surface temperature, *Journal of Geophysical Research*, **113**, D04105, doi:10.1029/2007JD009094.

Over the past 10 years, the climate has cooled.

Wrong. Climate change skeptics who make this claim start the decade from the 1998 extreme maximum which was due to a very strong El Niño event, and end it with the last available year temperature, that of 2008. Even if 2008 is the coldest year of the 21st century, it remains amongst the 10 warmest years after 1998 which are, in decreasing order 2005 (3 years ago and practically at a level with 1998), 2003, 2002, 2004, 2006, 2007, 2001, 1997, 2008 and then, only, the years prior to 1997.



Monthly Mean Global Surface Temperature
(http://data.giss.nasa.gov/gistemp/graphs/Fig.C.lrg.gif)

During the 21st century, the rapid temperature rise of the 1990's is not occurring, proving that there is no ongoing global warming.

Wrong. The climate cannot be quantified over a mere few years of observations, meteorological variations are too large. Observations over several decades are needed to describe a climate.

While the IPCC global warming models predict a general temperature increase of the lower atmosphere, the measurements in the tropical zone indicate decreasing temperatures.

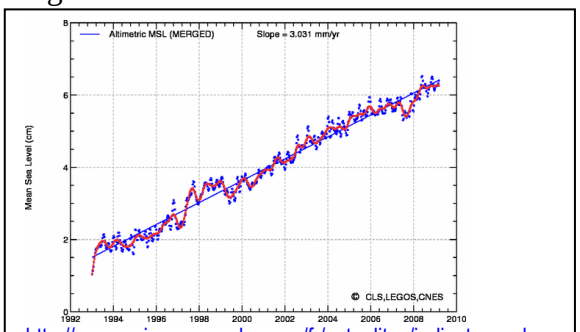
True. And this is triggering a great deal of research. The most recent conclusions point towards an erroneous evaluation of the measured temperatures. One should realize that measurements in the atmosphere are done either with balloon-borne instruments, or with satellites. With a satellite, a global view of an atmospheric column is obtained, from which the temperature at various altitudes must be inferred. With balloon-borne systems, which traverse layers of the atmosphere, the temperature and humidity measurements are not independent. In tropical zones, with significant damp, vertical convection movements, classical corrections could be mistaken. More refined corrections remove the discrepancies between the measurements and the models.

The temperature increase should be accompanied by increased relative humidity if the anticipated positive feedback is to contribute to global warming.

Wrong. It is the total amount of water vapor, i.e. the absolute humidity, that counts, not the relative humidity.

The sea level has stopped rising since 2006.

Wrong, as evidenced in the figure



http://www.aviso.oceanobs.com/fr/actualites/indicateurs-des-oceans/niveau-moyen-des-mers/images-et-donnees-altimetriques/

The variation of ocean surface temperatures explains, by itself, the warming of the continents, without involving greenhouse gases.

This statement is derived from an american paper (http://www.cdc.noaa.gov/people/gilbert.p.compo/CompoSardeshmukh2007a.pdf),and is totally unfair. The authors say that ocean warming is sufficient to induce warming of the continents without the greenhouse effect on the continents. But they do not conceal that the greenhouse effect can be the reason for ocean warming. Don't forget that the oceans cover 70% of earth's surface and that they absorb solar radiation much more efficiently than continental surfaces.

It is the sun that controls the climate

Solar irradiance variations are on the same order of magnitude as the forcing due to increased greenhouse gas effects.

True above the atmosphere but wrong at ground level. What reaches the vicinity of our planet in space is on a similar order of magnitude as the forcing at ground level due to the greenhouse effect. But what reaches ground level on the average represents only one eighth of what arrives

outside the atmosphere, because earth is a sphere and not a flat disk, and because the atmosphere and clouds send part of the radiation back into space.

Solar activity modulates the rate of cosmic rays that reach the earth. The latter induce cloud nucleation and thus control the climate via cloud albedo: (http://icecap.us/images/uploads/SvensmarkPaper.pdf***).***

The tropospheric mean temperature curve can be shown to be in phase with solar activity variations, at the price of data manipulations that obliterate the North-Atlantic oscillation, El Niño, and a linear trend over time. Strangely, surface temperatures, the ones that are most easily measured, don't fit well. Could it be that they are qualitatively poor?

3. And Even if CO2 Did Play a Role, It Could Not Have Troublesome Consequences.

When dinosaurs were around, there was 2.5 times as much CO2 as now and life (animals, plants) was lush.

True. But if dinosaurs and ferns were plentiful, today's fauna and flora were not present, with only few very small mammals. Of course, earth will adapt to a climate change, even if it is violent. It is not obvious that humanity, with its forthcoming 10 billion individuals, will fit nicely on it.

The oncoming sea level rise is presented as catastrophic and yet the rising rate is only a few mm per year whereas humanity has already experienced a 120 m rise during the last deglaciation.

Today, we are 6 billion human beings living on earth, a large number of whom are very poor and live near sea level. The 20th century water rise is already responsible for soil salinification in areas that were still yielding crops recently but have now become inappropriate for food crops. Sea level rise, even if small, renders storms even more hazardous for coastal populations. By destroying the mangrove and coral reefs, it deprives the coast of a protective barrier as well it deprives marine fauna of an environment suitable to its development. Ocean warming reinforces these phenomena. Finally, water acidification due to the CO2 dissolved in the ocean is loaded with threats to ecosystems.
A world population with less than 10 million individuals, all nomad hunter-gatherers, was able to adapt to the water rise of the last deglaciation. What of a population with nearly 10 billion mostly urbanized individuals living in cities near the ocean ?

The anticipated disappearance of polar bears, the emblem of threats to biodiversity, is a fable: there has been a threefold increase of their population in the past 40 years.

True but wrong: indeed polar bear populations have increased, for the simple reason that they are no longer hunted. But, in the past few years, with the shrinking ice sheet, their hunting territory, the females have been found to weigh significantly less because of the difficulty in finding food. The vanishing summer ice sheet will create a very tough pressure on the species.

4. The IPCC Is Submissive to Governments, It Is Incompetent. This Tale of Global Warming Is Just a Conspiracy.

The IPCC (Intergovernmental Panel on Climate Change) stems from governments and its reports say what governments suggest.

The IPCC was created by the World Meteorological Society and the United Nations Environment Program. While government representatives participate in plenary sessions, they contribute to the process that elaborates the assessment reports only twice: to communicate their comments after the report has been revised, taking into account the remarks made by the

scientific reviewers (any scientist may have access to the text and make comments), and in the writing of the final summary for policymakers.

The IPCC staff does not comprise many climate scientists. Its claim to being a group of experts is abusive.

The IPCC assessment reports comprise 3 parts: physical scientific aspects of climate change; vulnerability of socio-economic and natural systems to climate change; options for mitigating climate change or making its consequences bearable. Each of these 3 parts is under the responsibility of a Working Group. Obviously, climate experts belong only in the 1st group. And there is no reason for the IPCC president to belong to that particular group.

The IPCC claims to have reached consensus, and that is contradictory with scientific thinking which thrives on the confrontation of ideas.

Consensus is mandatory only in the summary for policymakers which the representatives of all states have to sign. The bulky text of the full reports details the divergence of views among specialists every time (and there are many) there is one, whether or not these specialists are members of the Working Group.

The allegations of man-made climate warming are due to "ecologists" who are convinced that man can only do harm to the environment, and they are taken up by scientists who see them as a good opportunity to attract research funding.

This claim to a conspiracy is unambiguously negated by the facts: the first signs of concern emanate from the scientific community, as far back as the 1950's. The first cries of alarm were aired to the public around 1960.

To conclude, we are facing a very real climate threat in which the role of human activities is established : stringent action is mandatory in order that humanity may be able to control the effects of the oncoming change. With Save the Climate, we warn the reader against counter-arguments that are often specious. We know, with the IPCC, that uncertainties remain in the modeling of the climate threat and in the scenarios for the future, but we acknowledge also that the conclusions of the IPCC rest on a considerable set of converging facts.