CLIMATE CHANGE CAUSED BY HUMAN ACTIVITY - I

Have the Mechanisms That Govern Climate Change Been Properly Identified?

The mechanisms that govern climate change have been known for almost two centuries, thanks to the work done by Joseph Fourier in 1824. The intensity of solar radiation (irradiance) reaching the Earth is 1.3 kW per m^2 on a surface perpendicular to the sun's rays. Roughly one-third of this radiation is reflected back into space by the atmosphere and the ground, while the remaining two-thirds are mainly absorbed by the Earth's landmasses and oceans. The Earth's surface thus absorbs solar energy day after day; it can only stop heating up indefinitely if an amount of energy that is equal to the absorbed energy is released into space. This is achieved by emitting waves of the same nature as the light waves of the sun, but which have a longer wavelength given the much lower temperature of the Earth's surface. These waves correspond to the color infrared, and are invisible to the human eye. This infrared radiation has to first pass through the atmosphere, where the greater the quantity of absorbing gases, the greater the ratio of energy emitted from the Earth's surface to energy released into space. The presence of such gases therefore tends to increase the temperature of the Earth. These gases are said to produce a greenhouse effect by analogy with one of the phenomena that occur in gardeners' greenhouses.

The Earth's atmosphere contains naturally occurring water vapor and carbon dioxide gas (CO2), both of which are greenhouse gases. Without their presence, the ground temperature would be around 30 degrees less than what it actually is. It is thus the greenhouse effect that has made life possible. Other planets are

governed by the same laws of physics. This is why the dense atmosphere of Venus, made up essentially of CO2, results in a very significant greenhouse effect and temperatures of 450°C.

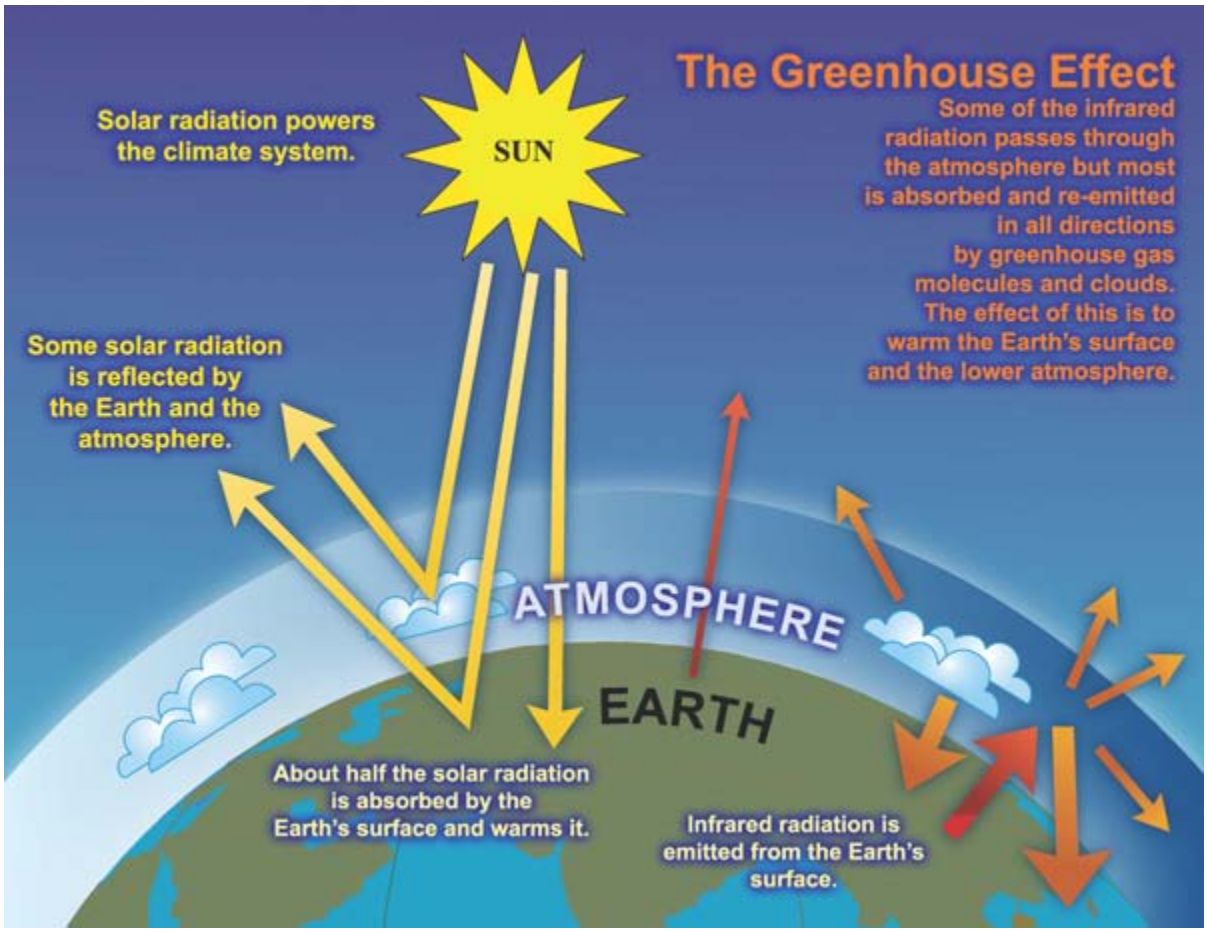


Figure 1: Diagram of the energy balance at the surface of the Earth. The greenhouse effect is as follows: a fraction of the infrared radiation passes through the atmosphere, but most of it is absorbed and reemitted in all directions by greenhouse gas molecules and clouds. This results in the warming of the Earth's surface and the lower layers of the atmosphere. (Source for this picture and the following ones : Intergovernmental Panel on Climate Change, www.ipcc.ch)

Does the Climate Evolve Naturally?

The position of the continents and the composition of the atmosphere have evolved considerably over the geological ages. The Earth's climate has thus inevitably been greatly affected by these major changes. More recently, over the last million years, the climate has developed in a fairly well-known way. This has occurred under the influence of natural causes that have always existed and that will continue to play a role in the next several millennia.

- Firstly, the orbit of the Earth around the sun undergoes variations because of the attraction of the moon and the other planets. These variations occur slowly over periods of time that are measured in tens of thousands of years. They bring about changes in the angles at which the sun's rays strike our planet and are at the origin of the large glacial and interglacial cycles with amplitudes of around 6°C for a period of 100,000 years. We are now 10,000 years into an interglacial and hence warm period.

- The sun is itself subject to variability, as revealed by the presence of sunspots that vary over a period of 11 years. However, this 11-year sunspot cycle affects the solar radiation mainly in the ultraviolet range. It thus has an impact on the behavior of the highest layers of the Earth's atmosphere: the ionosphere (altitudes of 100 km and above) and, to a lesser extent, the stratosphere (altitudes of approximately 30 km, see the ozone page). It has a very slight effect on the total energy radiated and although its influence on climatic phenomena has been detected, it is very small.

- Another factor that affects the surface temperature of the Earth is volcanic activity. During powerful volcanic eruptions, volcanic dust reaches the stratosphere (above 15 km) and may remain there for one or two years before falling back to the ground. These particles, essentially made up of sulfur oxides, act as a screen to

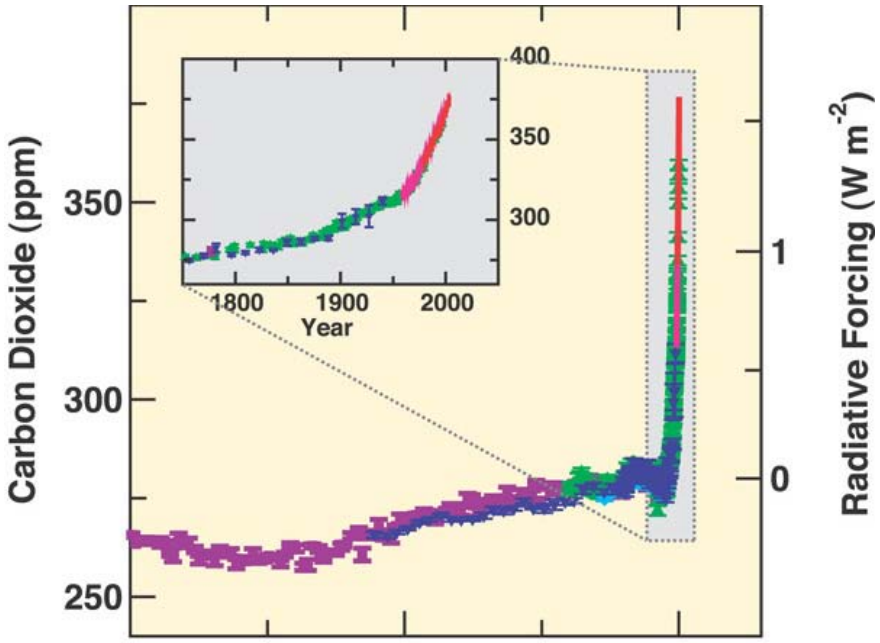
the incident solar flux (radiation), which has a cooling effect on the surface for a year or two.

Can Human Activity Modify Climate?

Since the beginning of the industrial era, human activities have added new sources of variation to the above natural causes, which bring about atmospheric change.

Can Human Activity Change the Composition of the Atmosphere?

Systematic observation of the atmosphere has indisputably shown an increase—for a little over a century—in the level of greenhouse gases such as CO2, methane, and nitrous oxide.



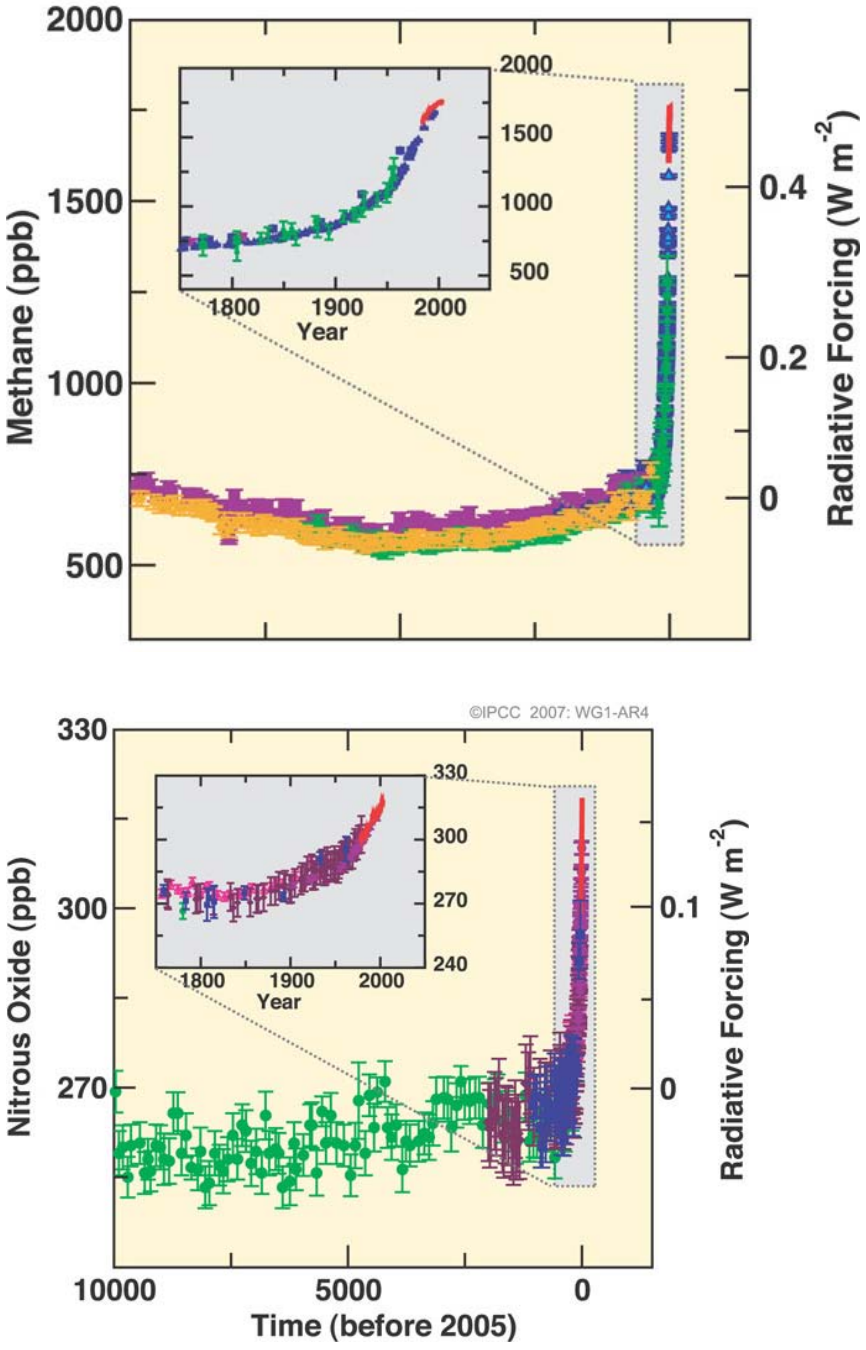


Figure 2: The current concentrations of the main greenhouse gases and their rate of increase are unprecedented.

Looking at the most important of them, CO2, we can see that the number of CO2 molecules found in one million molecules of air has risen from 280 in 1850—before the beginning of the industrial

era—to over 380 today. Here, we refer to 280 or 380 parts per million, or ppm. The annual increase in the concentration of CO2 is about half of what it would be if the atmosphere had retained all the CO2 that humanity produced by burning coal, oil, and natural gas. The other half is absorbed by the oceans and the biosphere. Moreover, we can also observe a very small decrease, in relative value, of the concentration of oxygen—oxygen that is necessary to produce additional CO2 that has been removed from the atmosphere. Finally, measurements of isotopic composition of atmospheric carbon complete the body of arguments that enable us to attribute, without any doubt, the changes in atmospheric CO2 concentrations to human activities.

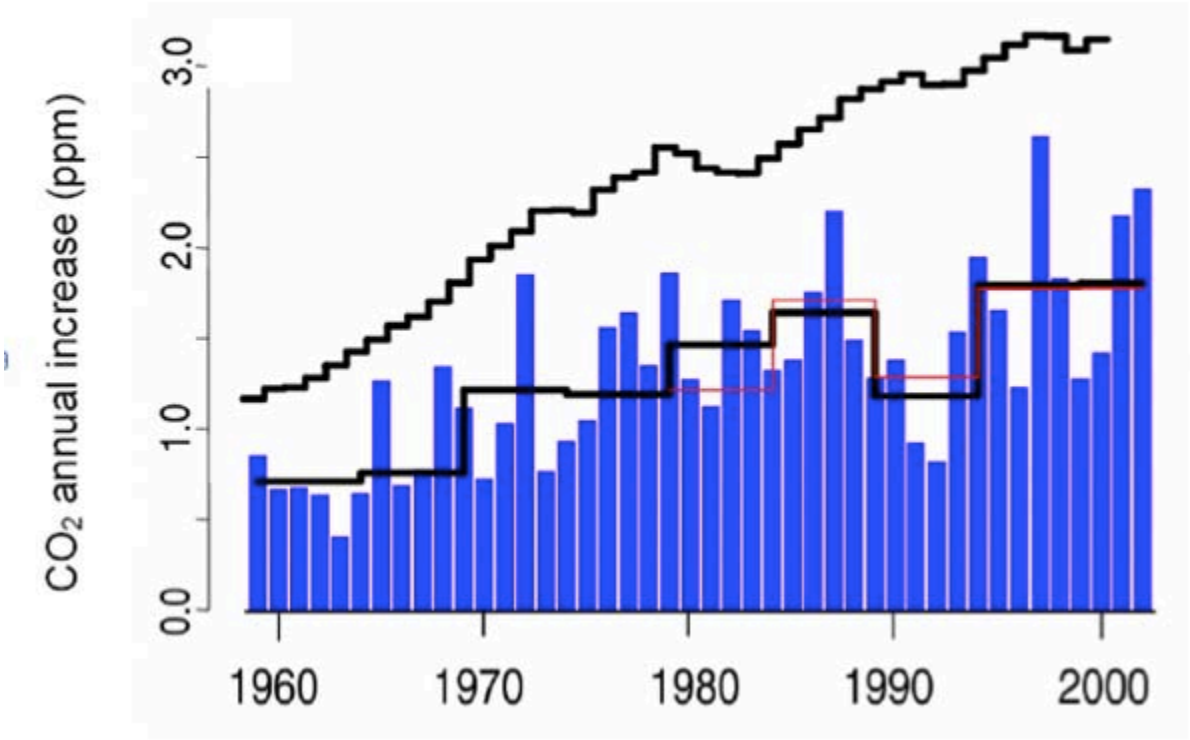


Figure 3: Use of fossil fuels and increase in atmospheric carbon dioxide (CO2) levels, between 1959 and 2002. The top black

stepladder curve shows the rise in the concentration of atmospheric CO2 gas that would have been seen had all the CO2 resulting from the combustion of fossil fuels remained in the atmosphere into which it was released. The blue vertical columns show the effective annual increase in concentration observed. The five-year average is given by the black and red curves that translate the uncertainties of this average.

Have We Recently Observed a Change in Climate? We have in fact observed an increase in the average temperature of the Earth of an estimated 0.8°C (plus or minus 0.2°C), for a little over a century. The average global temperature is not directly measurable and can only be estimated by compiling all the limited observations of local temperatures available around the world. This estimation is a parameter whose changes reflect, in summarized form, the general trend of temperature variations observed over the whole Earth. Several other indicators, apart from global temperatures, also confirm global warming: the melting of glaciers in all the continents and at all latitudes, the decrease in the snow cover in the Northern Hemisphere; the rise in sea level (3 mm per year), due in part to the thermal expansion of water and the addition of water to the oceans from the melting of continental ice sheets; and changes in the physical and biological systems consistent with local increases in temperature.

This warming is not uniformly distributed. Oceans, by their very nature, heat up less than land because of their well-known regulatory effect on temperatures. Continents are thus warmer than the average earth temperature. Furthermore, it is observed that the rise in temperatures is especially significant in the northernmost regions of America, Europe, and Asia.

Precipitation is also affected by climate change with some regions getting more rain and others less.

We sometimes come across the following statement: “Temperature has stopped rising since the beginning of the century.” In fact, the unpredictable variations from one year to the next do not allow any conclusions to be drawn based on a few years of study alone. Only the averages spread over several decades provide any real insight. The most recent study regarding the evolution of temperature, published in January 2010 by the U.S. National Aeronautics and Space Administration (NASA), concludes that the last decade was the hottest ever recorded; in terms of individual years, last year (2009) came in third place, after 2005 and 1998.

What is Mathematical Modeling of the Climate? Climatic models numerically simulate well-known physical processes that govern the dynamics and thermodynamics of the oceans and the atmosphere as well as the energy exchanges between infrared radiation and the molecules of certain gases (Laboratory experiments and quantum mechanics have enabled the precise determination of the corresponding absorption spectra.) Computers are indispensable tools for describing these complex phenomena that obey non-linear equations in a non-homogenous milieu that is stratified vertically and is horizontally variable. At the same time, their use is sometimes seen as a potential source of doubt. However, computers are not responsible for the success or failure of a mathematical model. What matters is good knowledge of the phenomena that one proposes to replicate numerically. The results of climate modeling are nevertheless affected by uncertainties, mostly related to the practical impossibility of simulating phenomena spread over small spatial scales (below 100 km), in realistic computing intervals. One has to therefore introduce parameters that describe them empirically. The uncertainty of results is evaluated by comparing the outputs of models for different possible parameterizations. It is in this way that the increase in average global temperatures caused by a doubling of greenhouse gas

concentrations has been estimated to be in the range of 1.5°C to 4.5°C. The credibility of climatic models is based on their ability to recreate large geographical structures and past climatic developments.

Models have sometimes been criticized for neglecting the role of water vapor, considered essential. This criticism is totally unfounded. It is true that water vapor is the most effective greenhouse gas present in the atmosphere. However, the introduction of water vapor into the atmosphere has no lasting effect on its concentration in the atmosphere, insofar as its atmospheric lifetime is only one or two weeks. This injection therefore does not modify climate. Yet, the atmospheric lifetime of CO2 is more than one century and its concentration is modified permanently by human waste, which has the capacity to bring about a change in the climate. Even though water vapor might not be directly responsible for climate change, it nevertheless plays a part. The increase in temperature causes an increase in the concentration of water vapor in the atmosphere. This in turn causes a complementary warming and thereby creates a feedback loop with an amplifier effect, which is taken into account by models. This increase in atmospheric water vapor has in fact been observed over the last twenty years.

Source :http://www.paristechreview.com/2010/10/15/climate-change-caused-human-activity/