CLIMATE CHANGE CAUSED BY HUMAN ACTIVITY - II

Do Mathematical Models Replicate Recent Observations?

Thanks to mathematical climate simulation models, it is possible to assess whether or not the warming that is actually observed is quantitatively consistent with the models' results. When these models take into account the totality of known phenomena—of either natural or human origin—their results match up satisfactorily with observations. This holds true when dealing with average global temperatures, average land temperatures, or average ocean temperatures. Even though the potential for error increases when you focus on more localized regions, the agreement remains significant for individual continents.

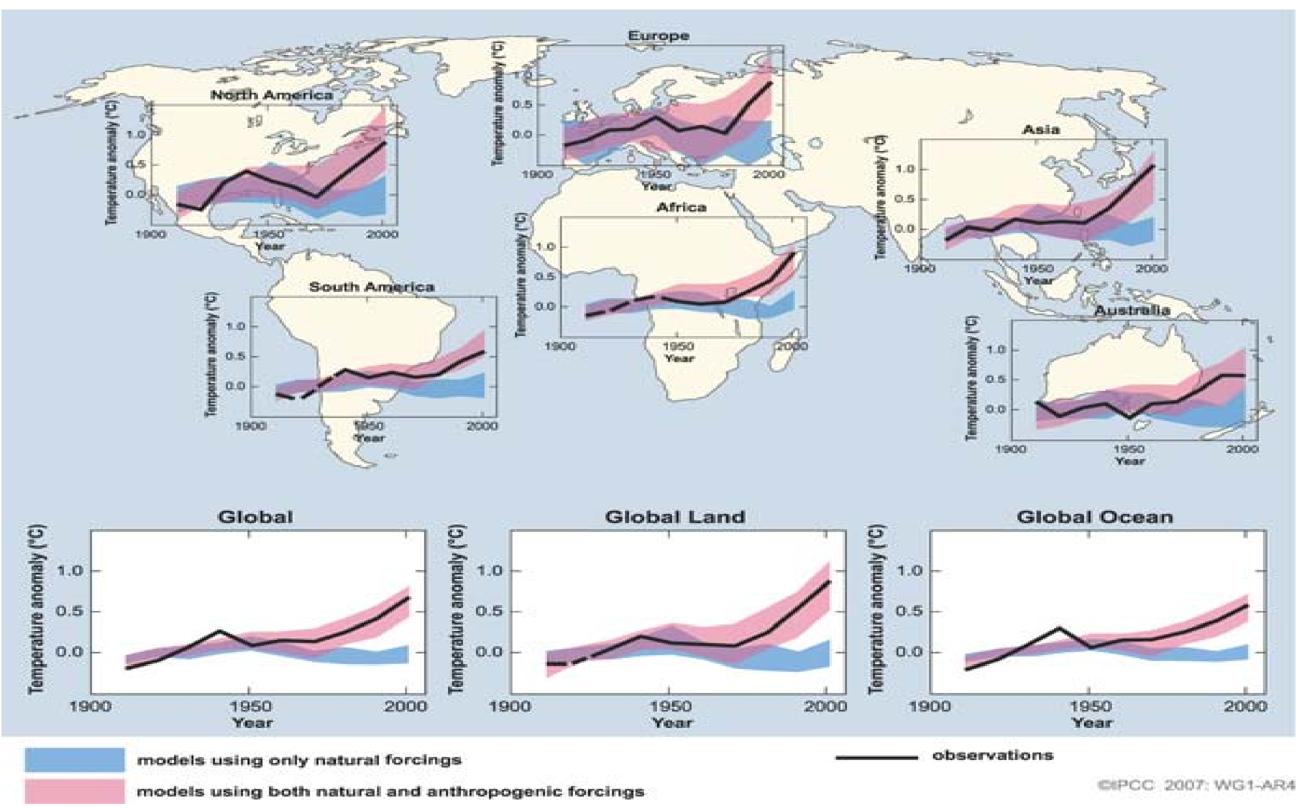

Figure 4: Comparison of global and continental-scale changes in the Earth's surface temperature from 1906 to 2005, with results of simulations by mathematical models relative to average values for the period of 1901 to 1950. The black lines indicate the observed changes and are dotted when the available data covers less than 50% of the concerned surface. The blue bands correspond to simulations that take into account only natural phenomena. The red bands correspond to simulations that take into account both natural phenomena and phenomena resulting from human activities. The three bottom panels, from left to right, correspond to the global average, landmass average, and ocean averages respectively.

However, the discrepancy between the observations and the modeling results is glaring when models deliberately ignore changes in the concentration of greenhouse gases. In other words, natural phenomena do not explain the recent observations.

In particular, variations of total solar radiation, observed by satellite, are insufficient to explain the perceived warming in the absence of an amplification phenomenon that has yet to be specified. Objections to the thesis of a preponderant role for the sun are threefold. Firstly, the greenhouse effect related to the change in atmospheric composition is enough to quantitatively explain the climatic observations; if the sun had a greater impact, it would cause more warming than it actually does. Secondly, the 11-year sun cycle is more important than the variations that occur over a few decades and should therefore translate into a periodicity marked by 11 years in climate variations. Finally, the rise observed in temperature decreases with altitude and actually begins to decrease at the level of the stratosphere. This variation in altitude cannot be explained by a variation in solar radiation. Yet, it is predicted by the models that simulate the modification of the transfer of radiation caused by an increase in gases absorbing infrared radiation.

Can We Estimate the Climate Changes That Will Take Place during the Course of the 21st Century?

Only mathematical models simulating real phenomena allow an estimation of the potential effect of anthropic emissions on global climate in the decades to come. They therefore need to be based on assumptions about the evolution of these emissions. Greenhouse gas emissions depend on human factors that are by nature unpredictable, such as demography, rate of economic development, the nature of exchanges, behavior, etc. We are therefore led to develop scenarios that are likely to occur within the realm of the possible.

What Will the Evolution of the Climate Be in the Absence of Pro-active Measures?

The first family of scenarios that was used is based on the absence of pro-active measures taken to reduce the magnitude of climate change. Present trends show a rapid increase in emissions—especially in terms of CO2—given that 80% of the commercialized energy comes from fossil fuel. We are therefore led to believe that CO2 concentrations will reach 1,000 ppm in 2100, which represents more than 3.5 times the pre-industrial concentrations.

The expected concentrations of CO2 during the 21st century are two to four times those of the pre-industrial era.

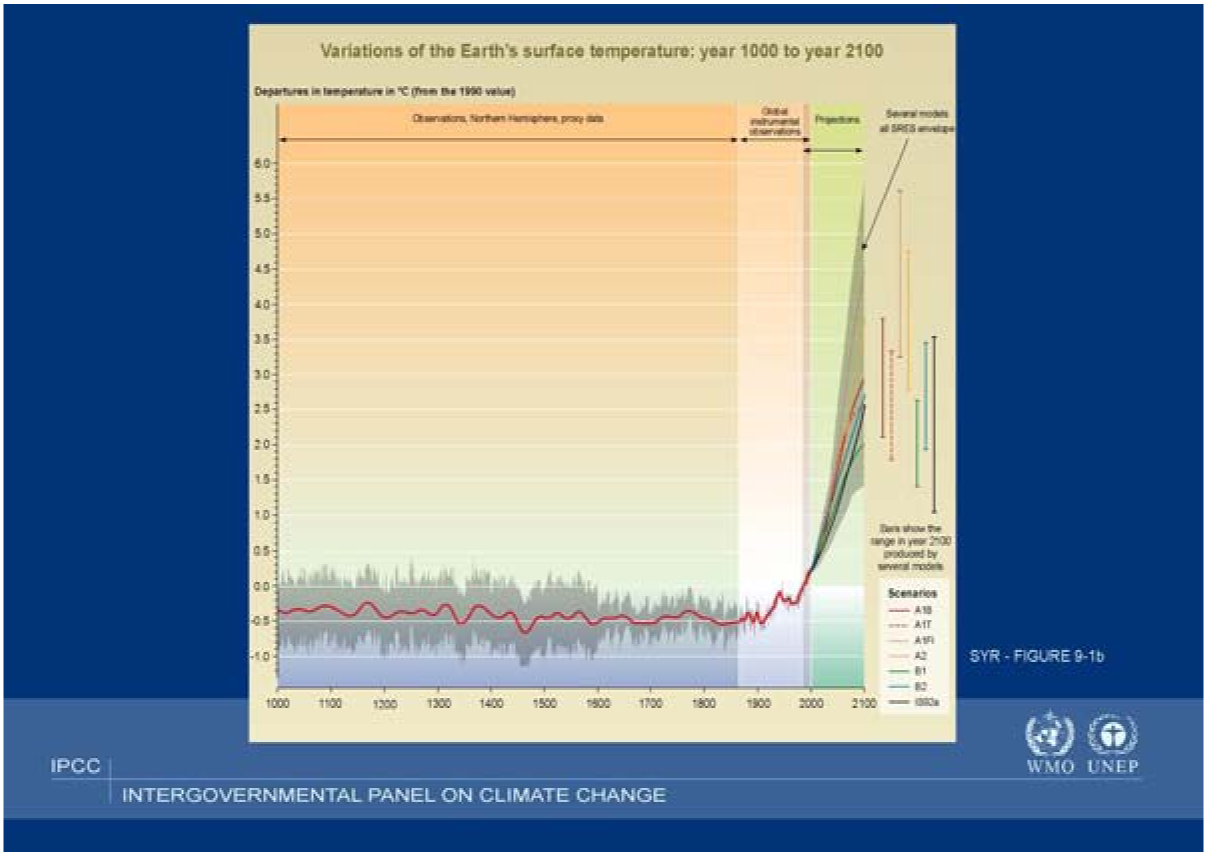

Figure 5: Scenarios for the evolution of the concentration of CO2 gas in the atmosphere in the absence of any kind of pro-active measures to reduce the emissions.

The inherent uncertainty associated with models adds to the difficulty of choosing the correct scenario for the evolution of emissions. The result is an increase in global temperatures in 2100 ranging from 1 to 6°C. These numerical values may appear to be small when compared to variations observed on a daily basis. To measure the extent of these changes, we need to remember that these are global averages and that the Earth's temperature—even in the last glacial period when 3 km of ice covered northern Europe—differed from present day average temperatures by only 6°C.

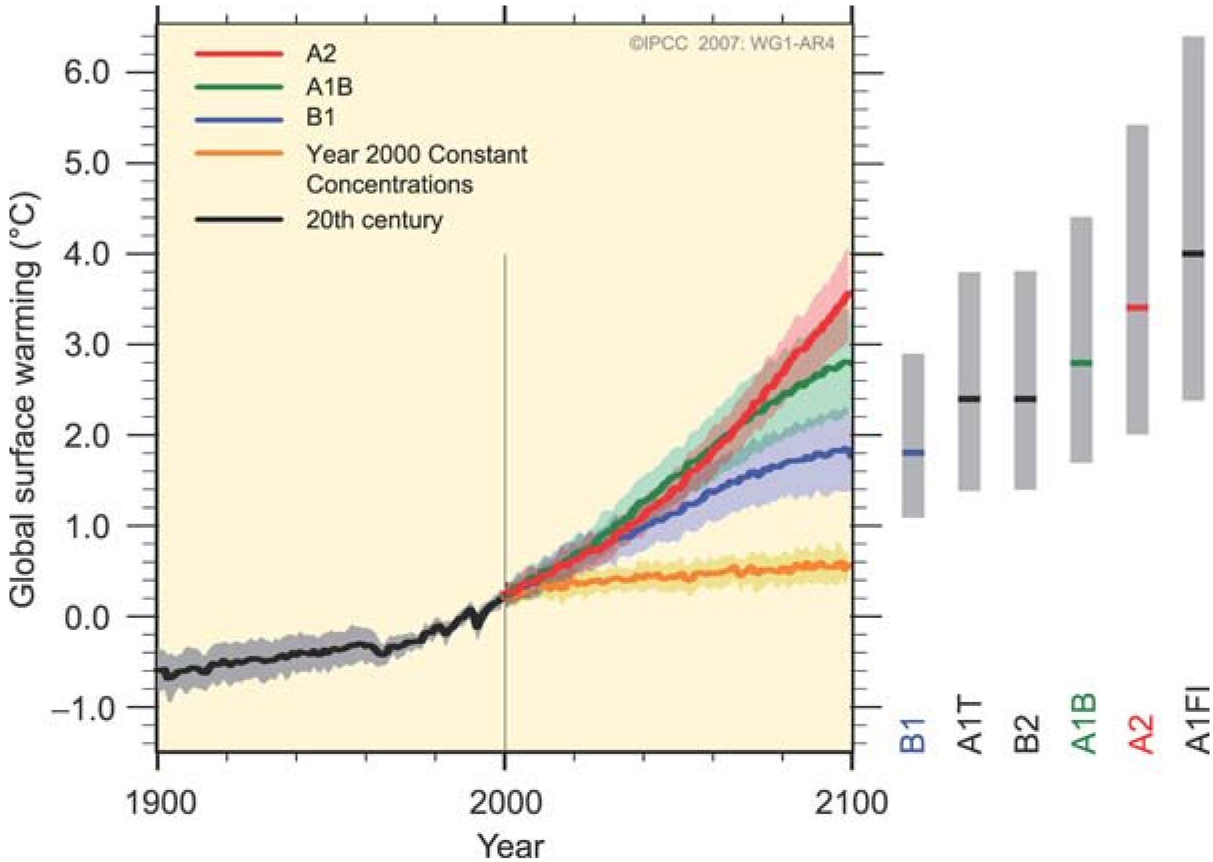

Figure 6: Increase in average surface temperatures from 1980 to 1999. The colored curves—continuations of the 20th century simulations—show the variations for scenarios A2, A1B, and B1 as well as an unrealistic scenario where concentrations are held constant at their year 2000 values. This improbable situation is interesting in that it shows the warming to which we are condemned by past emissions. The colored zones give an indication of the dispersion of simulations. In the bars on the right, the horizontal line indicates the most probable value for the emission scenario considered and the range of the bars indicates the range of likely values.

Average temperature is obviously not enough to characterize climate. That is why important geographical variations are simulated. The increase in continental temperature is double the average and triple the average of northern regions.

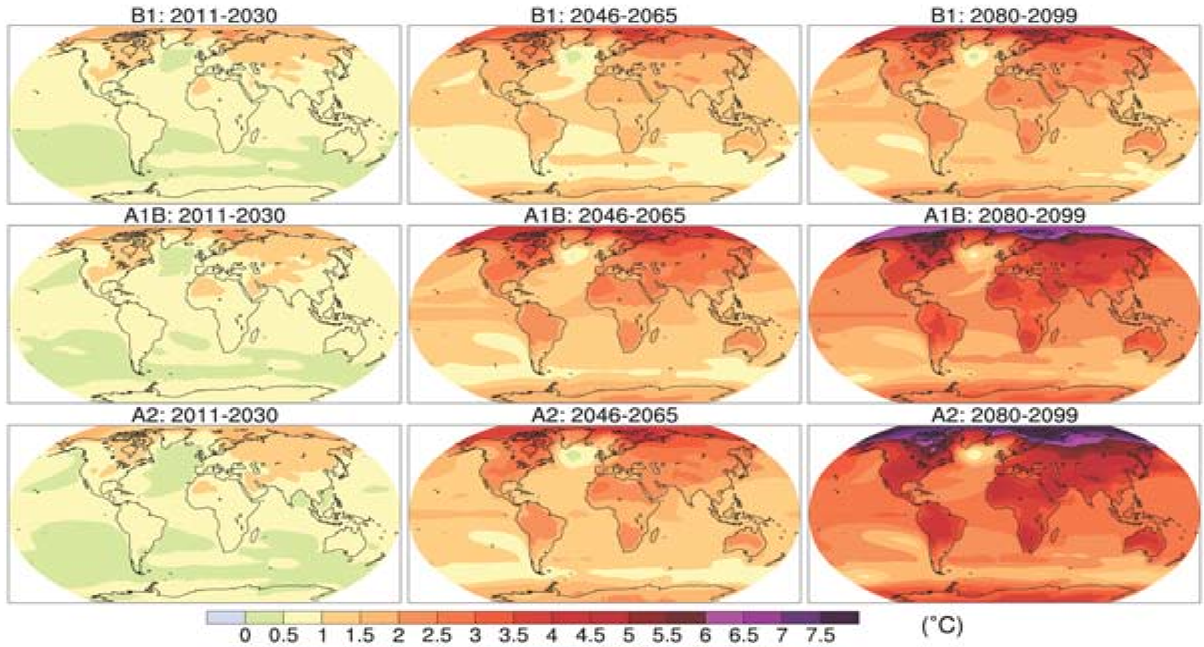

Figure 7: Global distribution of temperature increases for three scenarios (in rows) and three time periods (in columns)

Moreover, precipitation is affected. All models simulate an increase in precipitation in northern Europe and a decrease in areas surrounding the Mediterranean, especially in summer for both regions.

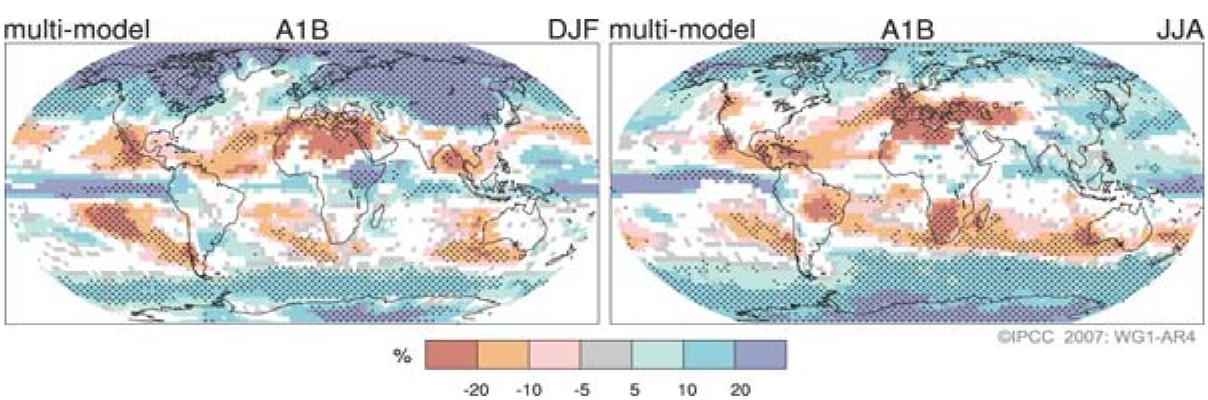

Figure 8: Changes in the percent of precipitation for the period 2090–2099 as compared to 1980–1999. These values are model averages for the A1B average scenario of emissions for the months of December to February (left) and June to August (right). White areas are where less than two-thirds of the models indicate a change of the same sign while the dotted areas correspond to areas where more than 90% of the models indicate a change of the same sign.

Can We Consider Limiting Emissions to Reduce the Extent of Climate Change?

Reducing emissions to put a ceiling on greenhouse gases in the atmosphere and restricting the extent of climate change is an objective that is explicitly mentioned in Article 2 of the United Nations Framework Convention on Climate Change, signed at the Earth Summit in Rio de Janeiro, Brazil in 1992. The Convention—prepared by 28 heads of state and taken cognizance of at the Copenhagen summit in December 2009—specified this objective more clearly by giving a value of 2°C as the maximum permissible rise in average global temperature. The declaration does not, however, involve any concrete commitment on limiting emissions that would make this result achievable.

The latest report of the Intergovernmental Panel on Climate Change (IPCC) has provided the range of average global temperatures that the planet could reach for a maximum CO2 equivalent concentration ranging from 450 to 1,000 ppm. This idea of CO2 equivalent concentration involves expressing the average warming potential of all greenhouse gases during the years to come in terms of the change in concentration of CO2 (the main greenhouse gas) alone that would result in the same warming. It is necessary to specify the number of years considered, since all gases do not have the same life. Conventionally, in the absence of any other indication, a time frame of 100 years has been fixed.

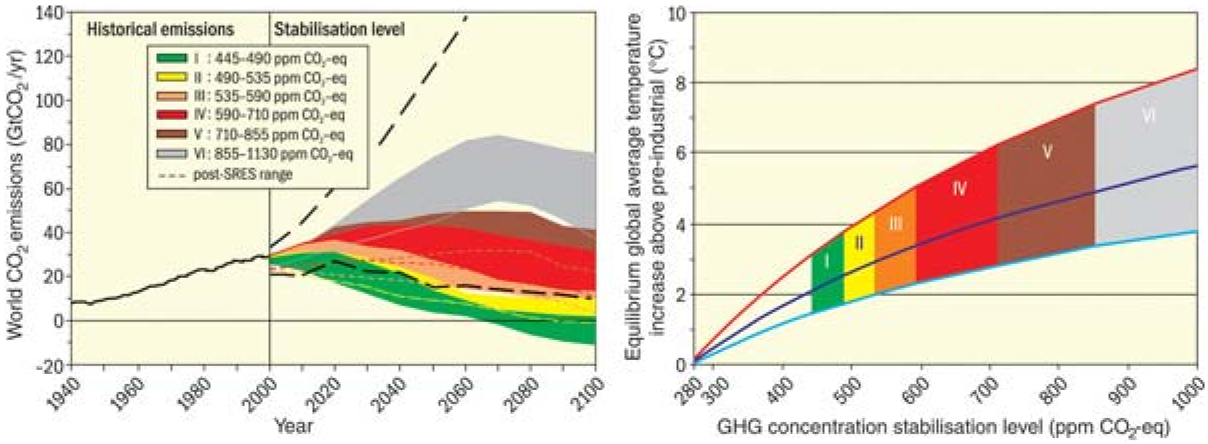

Figure 9: Global CO2 emissions between 1940 and 2000 and emission ranges corresponding to various categories of stabilization scenarios, from 2000-2100 (left). Probable deviation between the equilibrium of global average temperature and pre-industrial temperature (right) depending on the stabilization level of the concentration. The height of the band corresponds to the uncertainty of the models arising from sensitivity of temperature to changes in concentration.

For a concentration of 450 ppm equivalent (close to the current values with a CO2 concentration alone of more than 380 ppm), the rise in temperature would be 1.5°C to 3°C and for 1000 ppm 4°C to 8°C. To limit this concentration to around 500 ppm equivalent, it would be necessary to halve the total global emissions from now to 2050. Since French emissions per inhabitant are double the world average, these emissions would have to be divided by a factor of four—if we admit that each inhabitant of the planet has the right to emit the same quantity of CO2 equivalent.

Reducing emissions in such vast proportions is a formidable challenge especially since 80% of commercialized global energy comes from fossil fuels. The various approaches to scale back emissions involve, first of all, a reduction in the quantity of energy required for a given service. This means, for example, better thermal insulation of buildings or an improvement in the efficiency of motors and processes. A second possibility involves the production of energy with little or no greenhouse gas emissions. One way of attaining this objective is through carbon dioxide capture and storage. This involves recovering the gases emitted by the combustion of coal, oil, or natural gas—when the size of the facility allows it—and preventing their release into the atmosphere by storing them in suitable underground structures. Another way is to rely upon the production of energy that does not release greenhouse gases such as hydroelectricity, nuclear energy (fission and fusion), and renewable energies.

Will the Global Depletion of Fossil Fuels Be Enough to Prevent a Climatic Upheaval?

It is a fact that underground resources are finite. Estimates relating to oil and natural gas lead to the conclusion that these two fossil fuels should start becoming very scarce in a few decades. Coal, on the other hand, is more abundant and will probably not be exhausted before the next two or three centuries. Since coal produces more CO2 per unit of energy than oil or natural gas, the exploitation of all coal deposits would lead to a variation in atmospheric composition. This would bring about a climate change that is greater than that which separates glacial periods (during the last of which northern Europe was covered with a 3 km-thick ice layer and the sea level was 120 m less than it is today). While it is true that global warming caused by anthropogenic emissions would make us move even further away than the glacial era, this comparison with natural climatic cycles allows us to imagine the extent to which the climate would change. We can specially fear a rise in sea level of several meters, leading to dramatic consequences.

Nonetheless, in a few centuries, when all fossil fuels will be exhausted and will no longer be able to supply us with cheap sources of energy, we will have to learn to do without them in a situation of stress. Learning gradually to live without them from now on will allow us to prevent an energy crisis in a few decades. It will also save us from the disadvantages of a brutal change in the very climate that made our development possible.

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