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Climate Global Change: Fiction or Reality after 25 Years of Controversy ?

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SUMMARY

The Earth climate evolution is a field of intense research since now many years. Secured by new knowledge on the relations between the solar activity, the size of the Sun and its total and spectral illumination, researchers can revisit the past to study the relations between the solar output and the terrestrial climatic events. One phenomenon is of particular interest: the decrease of the average temperature of the Earth during the XVII century known as the Maunder minimum (1645-1715), a period characterized by a quasi absence of sunspots. Other episodes of the same style took place in the past. Such studies are crucial for understanding the influence of the Sun on the climate of our Planet. But how is defined the Earth climate? In what is it different from meteorology? What the knowledge of the past terrestrial climatic effects can bring to predict the future of our climate? Why there is a "war" of the climate? By describing and discussing well established facts, the author proposes to return to the essential, taking into account serious and impartial scientific data. By indicating how the polemic, and sometimes the errors, can push science ahead.

Keywords: Sun, Solar-Earth links, Earth climate, Climatic change.

RIASSUNTO

Cambiamento Climatico Globale: Finzione o Realtà dopo 25 Anni di Controversia ?

L'evoluzione del clima terrestre è oggetto di intensa ricerca già da molti anni. Grazie alle nuove conoscenze sulle relazioni tra l'attività solare, il diametro del Sole e la sua luminosità totale e spettrale, i ricercatori possono riesaminare il passato per studiarvi le relazioni tra l'attività solare e gli avvenimenti climatici terrestri. Un fenomeno particolarmente interessante è la diminuzione della temperatura media che ha interessato la Terra durante il XVII secolo, nel periodo del Minimo di Maunder (1645-1715) caratterizzato da una assenza quasi totale di macchie solari. Altri episodi di questo tipo hanno avuto luogo in un più lontano passato. Questi studi saranno cruciali per comprendere l'influenza del Sole sul clima del nostro Pianeta. Ma cos'è dunque il clima? Cosa lo distingue dalla meteorologia? Cosa può fornire la conoscenza del passato climatico della Terra

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per predire l'evoluzione del clima futuro? Perché esiste una guerra del clima? A proposito dei fatti ben accertati, l'autore si propone di ritornare all'essenziale, cioè ai dati scientifici seri e imparziali, mettendo in evidenza come la polemica, e qualche volta gli errori, possono far avanzare la scienza.

Parole chiave: Sole, interazioni Sole-Terra, clima della Terra, cambiamento climatico.

1 General purpose

Climate change is today present in our current life. Several years since now, more than twenty years rank among the warmest years in the instrumental record of global surface temperature since 1850. It is well known now that the concentration of gases, such as carbon dioxide or methane far exceed pre-industrial values. Must we be anxious?

If the Earth's warming issue, at least in its positive trend, reaches today a consensus, does this warming can be attributed to the men activities alone? What was the climate before the pre-instrumental period? What are the contributions of natural factors, such as volcanic eruptions, long-term oscillations of the Earth's axis upon the ecliptic, solar variability or even earthquakes? I shall try to answer to some of these questions, by describing and discussing well established facts. I propose to return to the essential, taking into account serious and impartial scientific data. I shall conclude by indicating how the polemic, and sometimes the errors, can push science ahead.

Additionally, I would like to develop two new ideas which are beginning to take shape. Two ideas not developed in the climatologist's community too often preoccupied in founding catastrophic scenarios for the future, but preferably in that of the historians of the climate.

The first idea addresses the issue that the rather large periods of warming or cooling in the past have generated social vulnerabilities. Their critical study render possible to explore if such conditions were produced by natural climatic phenomena or by political, cultural, religious or other risks. If the causal relation between a climatic change over a restricted ranging time and a natural phenomenon can be established, then climatic variability is not of human essence alone. In the second idea intervenes the concept of extreme weather events: are large periods of climatic change preceded by a number of growing and violent weather phenomena, or are they the echo of such a change? Here also the investigation of the historical dimension is essential: do major past disasters are correlated, with a positive or negative temporal lag, with periods of climatic change? And what happens today?

2 The precursor story

In the 1820s, Joseph Fourier was the first scientist who seems to have understood that gases contained in the atmosphere, mainly carbon dioxyde (CO2), might trap the heat received from the Sun. However, his successors such as Arrhenius, Callendar or Chamberlin for instance, were unable to calculate accurately how much a certain amount of radiation would change the temperature of the atmospheric layers. Theoretical work on the question stagnated for decades, and so did measurement of the level of CO2 in the atmosphere (6).

The story of climate change started in the sixties when it clearly appeared that the CO2 rate measured at Hawaii was increasing. The curve presented in Figure 1 (left) shows a significant trend, on which is superimposed an annual cycle. In the eighties, no decline of the measurements appeared, and studies on the carbon cycle, on which other gases such as methane or nitrides proliferated. Without anticipating on the future of this lecture, it can be seen that the rate of CO2 is still increasing today. This is a fact that cannot be ignored and obviously reasons must be searched for.

All through these decades, the preoccupation related to the CO2 rate was followed by the publication of an alarmist diagram (Figure 1, right, up-graded) showing a strong increase of the

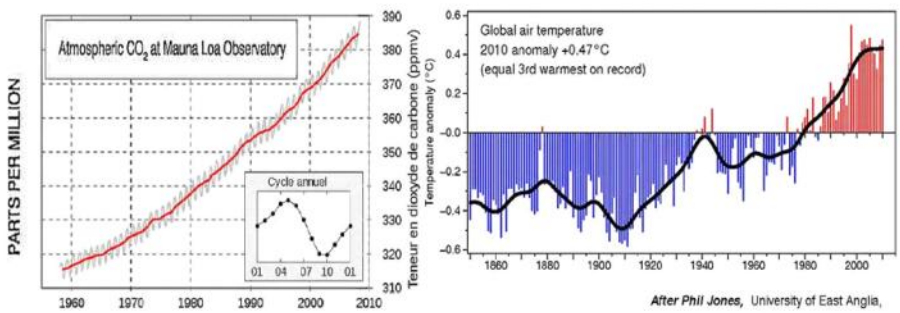


Figure 1: Left: The CO2 increasing rate. Right: The global Earth's temperature increasing rate.

Earth's temperature. Around the year 2000, a report published by the Intergovernmental Panel on Climate Change (IPCC -see paragraph 3) claimed that this increasing trend could only be allotted to human activities, and will reach insufferable temperatures in the future. Catastrophic scenarios were built and numerous papers were written. One of the most known is a report dedicated to the policy makers. Four scenarios were envisaged. One of which claimed that a double CO2 rate will appear in the next twenty years. All this was speculative, and proved little about climate; but for the authors, CO2 was the main driver and so was claimed that time has readily come to reduce the anthropogenic emissions.

The key point stands in the fact that the CO2 rate, trapped into the high atmosphere contributes through the so-called greenhouse effect to warm the atmosphere. This did not prove that the greenhouse effect is responsible for the warming seen in the 20th century. And it did not say how much warming the rise of CO2 might bring in the future. What is now beyond doubt is that the greenhouse effect had to be taken very seriously (9), (14), (16).

Such a correlation, between the CO2 emissions and the climatic warming is now skilfully taken again by the media. The French geologist C. Lorius has recently launched the idea that we would have entered in a new era, the *anthropocene* (from the Greek anthropos) in which the man would have become the principal geological planetary force (and no more the nature itself), by modifying all its environment (water, ground, ice, desert, etc). What is ignored, is all the uncertainties contained in the complex interactions of the entire planetary system.

Figure 1, right, shows that the temperature anomaly can be divided into several phases (at least three). But one can notice that a plateau seems to appear since about seven years, with a strong decrease in 2008. I shall come back later on that. For the time being, a paper published on November, 23rd, 2011 by the World Meteorological Organization indicates that the CO2 concentration has still increased in 2011 (related to 2010) and IPCC indicates that, in such conditions, the most convincing scenario would be a warming of + 6° C in the next 20 years (Figure 2)[2].

3 The Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. It was established by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) with the ambition to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts.

[2]This is not yet fully corroborated by the East Anglia University Climatic Research Unit: 2008 0,325; 2009 0,443; 2010 0,478; 2011 0,340. Ref: combined land and marine temperature anomalies on a 5° by 5° grid-box basis [HadCRUT3].

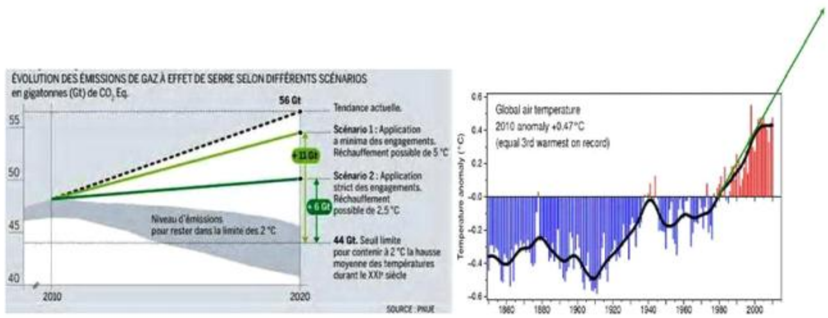


Figure 2: The Earth's temperature is increasing and, according to IPCC, will never stop if men are continuing their polluting emissions (right). Left: The carbon dioxide concentration has been still increasing by 2,3 parts per million (ppm) in 2010 to reach 389 ppm. A scenario at 2°C assumes not to exceed 450 ppm. Thus, a warmer atmosphere of 2°C cannot forecast anymore, and one has to conjecture curves where the average temperature rise will border 2,5°C, 5°C or even 6°C.

The UN General Assembly endorsed the action by WMO and UNEP in jointly establishing the IPCC. The IPCC reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change. It does not conduct any research nor does it monitor climate related data or parameters. The IPCC is an intergovernmental body, open to all member countries of the United Nations. Currently 194 countries are members of the IPCC. Governments participate in the review process and the plenary Sessions, where main decisions about the IPCC work program are taken and reports are accepted, adopted and approved. The IPCC Bureau Members, including the Chair, are also elected (but de facto co-opted) during the plenary Sessions. However, several questions arise. Among them:

- Even if the IPCC reports are never policy-prescriptive, is the work of the organization policy-relevant and most of all policy-neutral ?
- Are the reports based always on relevant publications? How is decided to discard scientific publications?

It must be emphasized that a remarkable work is made. The reports show efforts of synthesis, and are clearly written. But can they be accepted like that by the whole scientific community?

Let us illustrate one point concerning a rather non acceptable conclusion made by IPCC. Diagram 3 has been taken again several times, not only by scientists in international meetings, but also and mostly by the press. The bottom axis is dedicated to the level of understanding, and the plots show the ingredients which contribute to the warming or the cooling of the atmosphere. In this report, written in 2000, it was thus claimed that the solar knowledge was very low. Obviously, it must be noticed that what was underlined, was only related to the way of how the solar energy may influence the Earth's atmosphere, and not to the whole knowledge of our Sun. But is this really true? Nearly nothing about the contribution of the solar output variability was written in the 2000 report. The next report shows substantial improvements in this field, but does not correspond to the correct degree of our current knowledge.

With the 2007 Working Group 1 (WG1) IPCC report (which mention the solar input variability on the upper atmosphere in a few words, abandoned the influence of cosmic rays, too controversial[3] and skip the strong climate sensitivity to variations in the lowermost stratospheric ozone) all scenarios describe at a 20 or 100 years ahead, the evolution of the gases, which are believed to

[3]Ions and radicals in the air formed by cosmic rays can be one of the essential factors of vapor condensation and cloud formation; their modulation can lead to corresponding variations of the Earth climate.

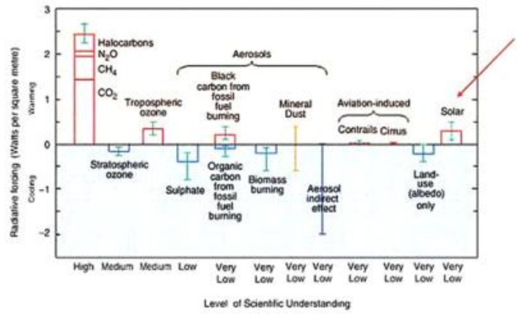


Figure 3: The global mean radiative forcing of the climate system for the year 2000, relative to 1750, according to the IPCC report published in 2000. The solar output on the climate warming is considered as of low knowledge. A more recent diagram has been published in IPCC, 2007, Figure SPM.2, still showing a low degree of understanding of the solar irradiance mechanisms on the atmosphere. Influence of the cosmic rays are considered as insufficient to produce a dynamical response and therefore are not mentioned.

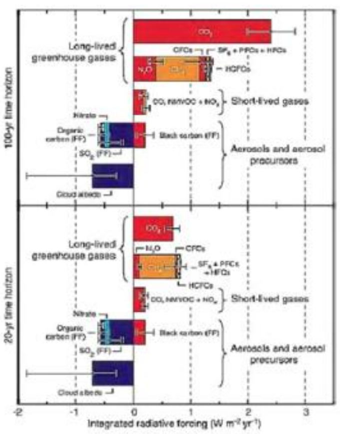


Figure 4: Integrated radiative forcing for the year 2000 global emissions, weighted by 100-yr and 20-yr time horizons. Courtesy Le Treut (2011).

be the main effects on the warming (Figure 4). All other ingredients are considered either as of very low order of magnitude, or of yet unknown mechanisms, and thus can be ignored for the time being. One point must be mentioned to be clear: the low degree of understanding on the stratospheric water vapor from CH4, which likely could also influence the climate.

Indeed the climatic variability is quite complex as shown in Figure 5. It can be easily understood that to build a model taking into account all the factors mentioned is extremely difficult. In modeling our climate, the idea is not only to satisfy our knowledge, but also to build a significant machine aiming at predicting the weather at 3 or 10 days, at 3 or 12 months, etc.

The atmospheric circulation is the key point to understand the evolution of our climate. However two issues arise. (i) Is a system as complex as that of our Earth's atmosphere can be modeled? And (ii) why it is possible to model climatic evolutions on the long term whereas nothing can be envisaged in terms of meteorology beyond 10 days?

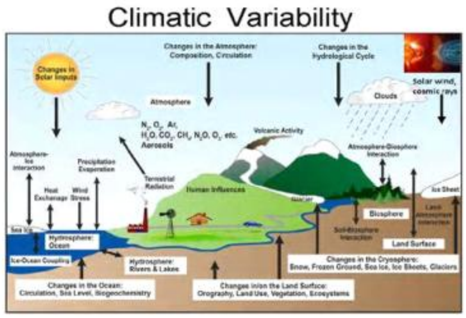


Figure 5: The complexity of the climatic variability. The author added in the up right corner the solar wind and cosmic rays as a possible source of climate forcing; the latter one is poorly mentioned in most of the reports, because still controversial; sensitivity of the ozone density in the tropopause could be also a radiative forcing.

An underlying issue is the difference between climate and meteorology. The debate is often polluted by a misunderstanding of the distinction between climatology and meteorology. Applied meteorology assesses current weather conditions, determines what factors are influencing it and tries to predict what will come next. Climatology, on the other hand, assesses long-term trends to evaluate the state of the climate. Therein lies the problem.

4 Meteorology versus climatology

Meteorology lies upon classical and well known factors such as temperature, pressure, nebulosity, wind speed, etc. They are collected on well determined locations, at a well known altitude and at a given time t. Such parameters are varying with time on scale ranging from seconds to minutes or hours. They can be averaged to get monthly or yearly means. Associated with some basic physical laws, simple models can be built. The main difficulty is to collect data on distance scales of small steps, mainly over the oceans. And the difficulty comes also to record the parameters on several different elevations.

Here, the notion of grid must be understood. If the steps are too large, the accuracy is bad. And so is the prediction. The models failed at 2 or 3 days ahead. If the steps are close together, the accuracy is better, but the solution of the system at a given time in advance necessitates huge computation resources. The grid approach is shown in Figure 7, where it clearly appears that when the spatial step is progressively reduced, details of the continents are emerging which yield more and more credible models.

Fortunately, satellites came to help meteorologists. New parameters continuously measured are recorded such as:
- albedo, which indicates the difference between the incident and the reflected radiation;
- the vegetation index, the surface emissivity, the soil humidity, etc.

These parameters are collected over large areas over the globe (desert, polar caps...), and their variability is in general slower than for the meteorological parameters. The model is now built with two well definite parts appealing the two kinds of parameters above-mentioned. The climate is defined as the *slowly variable component extract from the signal*. The time scale is the century or more.

Climatic effects spread over several years. For example one can note two climatic events: the medieval optimum, where the temperature was mild during at last some ten years, or the little ice age, where the temperature was very cold over some sixty years. By contrast, severe

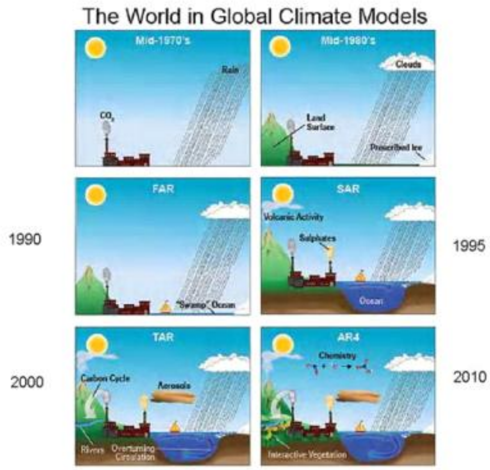


Figure 6: Evolution of the complexity of the models since the mid 70's, as presented in IPCC Climate change WG1, 2007.

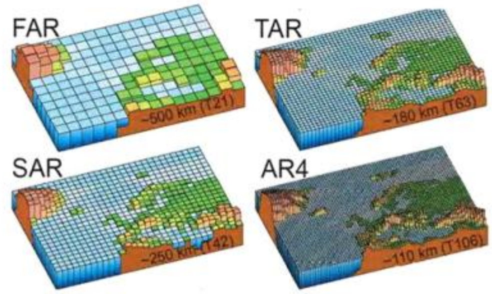


Figure 7: The notion of grid in climate models. As far as the steps are smaller, the confrontation with the reality is better. FAR, TAR, SAR and AR4 refers to the name of the model used in the IPCC reports.

meteorological events spread over only few days. It is a complete abuse of language to say for instance, concerning a huge snow storm of three days over New York area, that a "climatic" event has occurred.

To my mind, it would be of interest to question if *severe extreme weathers can be early indicators that climate was changing in dramatic ways, or not*. For most climate scientists, they reverse this issue by asserting that *global warming will incite more extreme weather events*. Who is right? The cause of the proof is not the proof of the cause. In any case, I think that here lies a key issue that must be investigated in the future.

Figure 6 sums up the evolution of the models since the seventies. On the first cartoon, a few parameters such as the rainfall and the CO2 rate were taken into account. Then, ice surface, clouds coverage and land surface temperature has been accounted for. The last cartoon shows that progressively, more factors are included, leading to more sophisticated models, permitted by the evolution of computational resources and the understanding of the system.

The Earth energy budget. The Earth can be considered as a physical system with an energy budget that includes all gains (and losses) of incoming energy; the planet is about in equilibrium, so the sum of the gains equal approximatively the sum of the losses. On the incoming energy side, there is the solar irradiation captured by the Earth's disc. On the outgoing energy side there is the solar radiation scattered back to space by clouds and the Earth's surface, and the energy lost by thermal emission (Figure 8). Human activities, especially the burning of fossil fuels, release massive amounts of gases into the atmosphere. The challenge is then to measure the consequences and more specifically the effects that can be recorded.

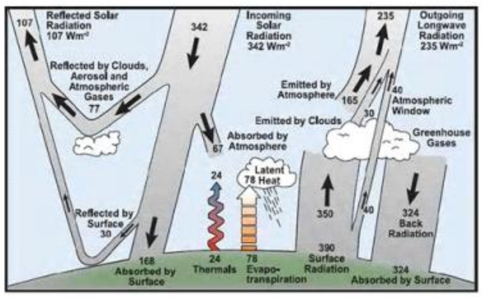


Figure 8: The Earth's annual and global mean energy balance. On the incoming solar radiation, 49% (168 Wm^{-2}) is absorbed by the surface. That heat is returned to the atmosphere as sensible heat, as evapotranspiration (latent heat) and as thermal infrared radiation. Most of this radiation is absorbed by the atmosphere, which in turn, emits radiation both up and down. The radiation lost to space comes from cloud tops and atmospheric regions much colder thant the surface. this causes a greenhouse effect. After (10).

In modeling our climate, two sources of variability are not taken into account yet. The first one is the solar variability output, namely the luminosity, or in a more sophisticated term, the irradiance; the second one are the interaction of the solar wind on the atmosphere of the Earth, without forgetting the water vapor feedback and the control of ozone density through cosmic rays (11).

The question is why? Several issues can be listed.

1. Historically speaking, the first models were built with a constant solar incoming radiation. At that time, solar astronomers were recording the solar constant since several years from ground-based instruments, and it was found ... constant. No reason for meteorologists to put a variable luminosity in the models. Only space dedicated missions were able latter on to put in evidence a temporal variability.

2. As seen, the models are very complicated. Set of physical equations are very huge, complex to solve. A very small variability applied only on one global parameter was thought not to change significantly the results. By contrast, the priority was to include significant parameters, aerosols, orography, ice, etc, to build convincing models for which the output could be directly compared with the recorded data.

3. The competition between scientists is severe. Among world data centers dedicated to the construction of models (General Circulation Models or Global Climate Models -GCM-), it can be quoted one in Boulder, Colorado (US), one in Reading (UK), one in Tokyo (Japan) and another one in Orsay (France). The challenge was to give reliable predictions for one center, in advance to the others. To this regard, the total solar irradiance variability is not of significant order of magnitude to get more accurate predictions. Moreover, General Circula-

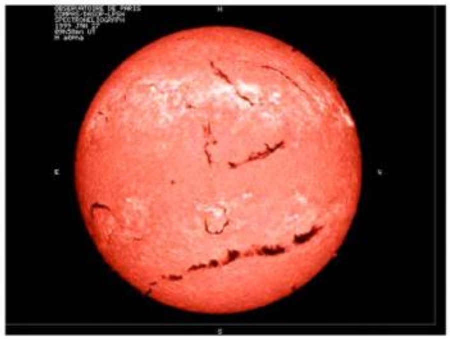


Figure 9: Our Sun.

tion Models (GCM) were (and still are) performed by meteorologists specialists of the low atmosphere and for which the solar output variability was far from their field of interest.

4. And may be the most important point. The models must be filled with increased rates of gases to develop scenarios for the future. There was the real race. To convince policy makers to take decisions in reducing fossils fuels consummation. However, bearing in mind this issue, science progressively veered off politics.

5 Our Sun

Let us go a few minutes on our Sun, for those who are not very familiar with our star. Briefly speaking, and related to our subject, it can be seen in Figure 9 four main features.

1. The background, which is the quiet sun, made of granules. The size of each granules is about 1000 km. Superimposed on this quiet Sun can be seen active regions, i.e.:
2. The faculae, which are seen brighter, due to their higher temperature.
3. The foot of the prominences, flares and eruptive phenomena (seen projected on the disc as long filaments).
4. And the spots, darker, due to their lower temperature.

Spots are of interest because historically, they were the signature of the rotation of the Sun (Figure 10). They were used up to now as an indicator of the solar activity, as they appeared more and more numerous during about 5 to 6 years of the ascendant phase, to decline after during another 5 to 6 more years of the descendant phase.

Sunspot numbers go up and down with an 11-year period, which is half of the 22-year "Hale cycle" (George Ellery Hale discovered solar magnetism, and it turns out that alternate 11-year cycles have mirror-image latitude distributions of magnetic polarity). Richard Carrington, a 19th-century solar astronomer who made many discoveries, started the counts of the 11-year "Carrington cycles" in 1749 (Figure 11). Presently we find ourselves just beginning with the 24th cycle (ascending phase). New sunspots have always before emerged roughly on schedule, except for the interesting period of the Maunder Minimum, a period in the late 17th century when sunspots almost disappeared (see Figure 12). This had many interesting implications, effects on radiocarbon dating via, for example, tree rings. A sunspot deficit is also at the base of the index anomalies of

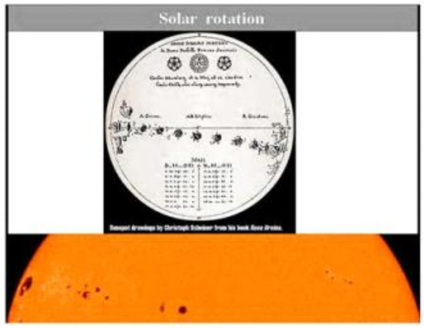


Figure 10: Spots are indicators of the activity and of the rotation.

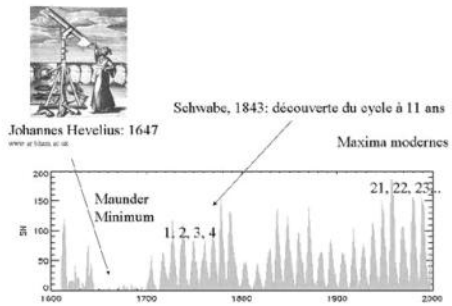


Figure 11: Resume of 400 years of regular sunspot number observations. Cycle 1 starts in 1749.

solar cycle 23 (as a blank era around 2008 was recorded, I am thinking, as some others, that this minimum is a precursor of an other grand minimum which will appear in the next solar cycles).

Fortunately, the sunspot index is closely linked with other indicators, such as the radio flux, and thus it gets a physical meaning. Moreover, the number of spots is well known since now more than 400 years, constituting a very reliable database in solar physics (as shown in Figure 11). For these reasons, this index is widely used. Let us mention that during the Maunder Minimum, the solar activity was not stopped, as it was thought when the phenomena was put in evidence, mainly by John Eddy in 1976 (3), (4). The number of spots was reduced, but the solar machine was at work, a fact confirmed by a continuous discovery of spots drawings in ancient books, as shown by Vaquero (26).

The Sun is the seat of many eruptive phenomena, which are the signature of the magnetic field. Figure 13 (left) shows a beautiful arch, developed along a closed magnetic loop, the feet being anchored at the vicinity of a facula. When the magnetic field is open, it brings with it particles, ions, electrons, etc, coming from the Sun itself. They propagate into the interstellar medium under the name of solar wind, the velocity being approximatively 400 km/s in period of minimum of solar activity and about 800 km/s during period of maximum of activity (Figure 13 right).

Obviously, these particles interact with our upper atmosphere. Their interactions on the ionosphere over the polar areas are known as aurorae. On other regions, such as at the equator, we do not know fairly well the mechanisms, if any, which may influence the upper atmosphere to change significantly the climate after the event. And thus, for the time being, these interactions in the models are discarded.

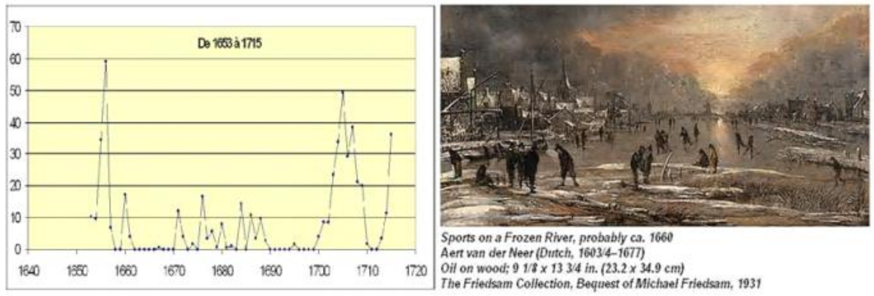


Figure 12: The Maunder Minimum (MM) (left). The so-called "deep MM" is timed around 1670–1680. During the solar MM, temperatures over Europe were very low; for instance river Rhine as other lakes were frozen (as the painting shows on the right), olive-trees froze to death South France, starvations began in some places and the wheat prizes grow up (see also Figure 27). The correlation between the two phenomena was pointed out by J. Eddy as soon as 1976 (3).

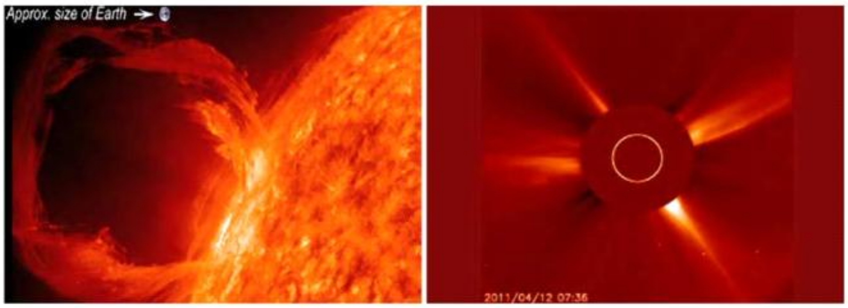


Figure 13: Left: The solar magnetic field shapes beautiful arches. Right: The solar wind particles are ejected along open magnetic field lines.

The solar luminosity is produced by a combination of spots and faculae, physically speaking a weighted function of the facular brightening and sunspot darkening, which produce a modulation in amplitude (Figure 14). The reconstructed irradiance fits the measured irradiance today by a 95% degree of confidence. On such grounds it is possible to reconstruct the irradiance back in the past. We will see that latter on.

Let us plot the irradiance trend versus the temperature of the Earth. Five periods of time taken from the IPCC reports were envisaged to be not questionable (Figure 15). The covariance analysis shows a fair linear trend. The slope of this trend leads to a climatic sensitivity, of 0.46 °C per W and square meter, an estimate good enough to validate the plot. The high point obtained for the period 1976 to 2000 shows that if irradiance variability cannot be anymore the alone parameter to explain the trend in the Earth's temperature, it explains yet part of it, that can be retrieved from the data (Figure 16).

6 The solar irradiance question

Another interesting feature is the low measured irradiance level in 2008 as shown in Figure 17. This measured estimate was at its lowest level for the whole period starting with satellite measurements, which began in the late 1970s. The time since the prior solar minimum is 12 years,

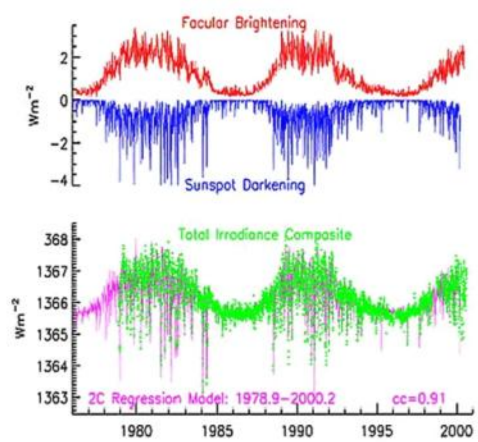


Figure 14: The Total Solar Irradiance (TSI) is a weighted function of sunspot darkening and faculae brightening, and is phased with the activity cycle.

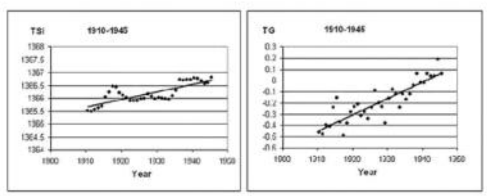


Figure 15: An example of the irradiance (TSI) trend, left, and Earth's temperature trend, right, during the years 1910-1945. After (20).

two years longer than the prior two cycles. This has led some people to speculate that may be, we are entering a "Maunder Minimum" situation, a period of reduced irradiance that could be run over for next decades. Since then, the irradiance recovered higher values and the new cycle 24 is going on. However, let's assume that the solar irradiance had not recovered: in that case, the negative forcing, relative to the mean solar irradiance is equivalent to seven years of CO2 increase at current growth rates. Assuming now that the solar irradiance increases, as expected, there is still some effect on the likelihood of a near-term global temperature record due to the unusually prolonged solar minimum.

The map of global temperature anomalies in 2008 shows a decrease (Figure 18). Due to the thermal inertia of the oceans, the temperature decrease would have to continue for two years more, which is not the case. Most of the world was either near normal than in the base period (1951-1980) or cooler such as in the Pacific ocean. But this was due to a strong La Niña that existed in the first half of the year. Let us recall that La Niña and El Niño are opposite phases of a natural oscillation of tropical temperatures, La Niña being the cool phase.

The fact that 2008 was an exceptional year is also confirmed by the low decline of the mean level of oceans, after a time lag due to the thermal inertia of oceans. Since 1992, thanks to the TOPEX/POSEIDON/JASON altimetry space mission, it is possible to accurately follows the mean sea level (Figure 19). A mean increase of around 3 mm per year is observed, together with a high spatial variability (up to $\pm$ 20 mm per year according to the geographical area). If this increase is an indicator of the Earth warming, it is of high interest in the future, to continue such a monitoring

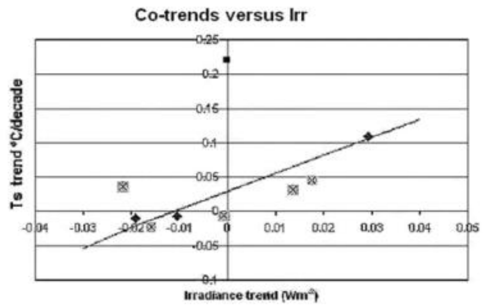


Figure 16: Combined Land and Marine Temperatures trends versus Solar Irradiance trends. Diamonds: three independent periods of time: 1856-1910, 1910-1945 and 1946-1975. The crossed squares represents (i) an other independent set of data (1885-1940; 1941-1975) and (ii) two longer (non-independent) segments (1856-1887; 1856-1975). The linear fit obtained leads to a climatic sensitivity parameter of $\lambda = 0.46$ °C/Wm^{-2}. The square point is the estimate obtained for the 1976-2000 period of time.
The signature of the irradiance can be retrieved, corresponding to the zero ordinate of the regressive line. After (20).

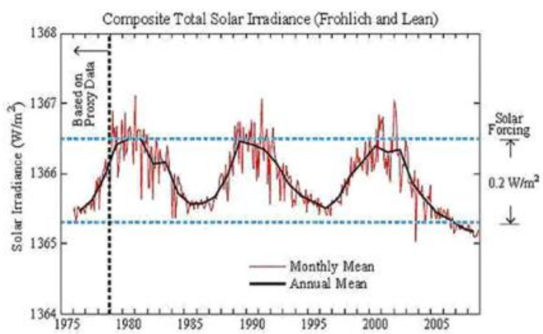


Figure 17: The Total Solar Irradiance was at its minimum in 2008, far below than other prior recorded minima. After (8).

at a high level of accuracy. The decline of about 0.7 mm these last years is the highest in amplitude observed since the beginning of the records.

Everyone agree today that the total solar irradiance variability of about 0.10 to 0.15%, cannot explain most of the Earth's temperature variations. However the solar irradiance variability is very high in the UV, reaching a factor of 2, as seen in Figures 20 and 21.

As solar UV light is primarily responsible for both creation and destruction of ozone in the Earth's stratosphere and mesosphere, its impact on the upper stratosphere is certainly very high. Indeed, a region deserves to be observed: the UTLS (Upper Troposphere-Lower stratosphere) region. At an altitude of about 40 km, species are chemically mixed and/or destroyed. Some global climatic models are trying to take into account such facts. Here lies a great lacuna that have to be filled in the future. Another issue is concerned by the cosmic rays for which the interaction with the ozone concentration is very high.

Discerning the role of the Sun in climate variations on time scales of decades is a challenging task. That climate forcing is well correlated with variations in the Sun's energy output is now

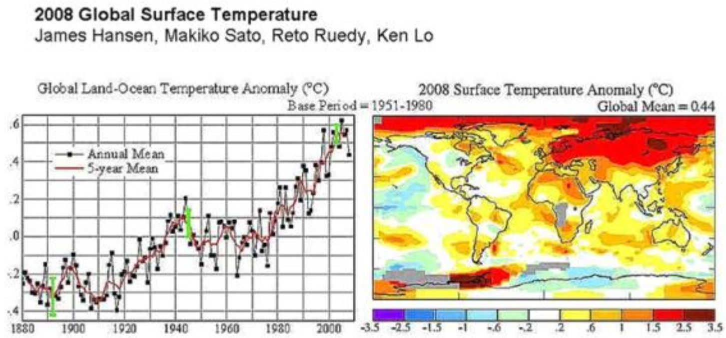


Figure 18: The map of global temperature anomalies in 2008 (right), shows that most of the world was either near normal or warmer than in the base period (1951-1980). Eurasia, the Arctic and the Antarctic Peninsula were exceptionally warm, while much of the Pacific Ocean was cooler than the long-term average. The relatively low temperature in the tropical Pacific was due to a strong La Niña that existed in the first half of the year. La Niña and El Niño are opposite phases of a natural oscillation of tropical temperatures, La Niña being the cool phase. After (8).

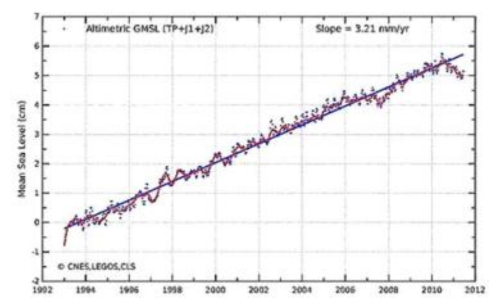


Figure 19: Evolution of the mean sea level since 1992, as measured from the TOPEX/POSEIDON/JASON satellites. This plot is sometimes used biased. The genuine one was retrieved at the end of 2011 on the CNES site:
http : //smsc.cnes.fr/JASON3/Fr/GP_science.htm.

relatively well established for total and UV irradiance using high-precision, space-based solar measurements spanning more than two decades. When the Sun is near the maximum of its activity cycle, it is about 0.1 percent brighter overall, with much greater changes at UV wavelengths.

Let us go back to the solar irradiance variability. The basic assumption is that the variations of the solar irradiance are due to the evolution of the dark and bright magnetic features on the solar surface. As already said, the correlation between the measurements and the model is very high as shown in Figure 22.

On another hand, the evolution of the averaged magnetic flux can be computed from decadal values of cosmogenic isotope concentrations recorded in natural archives employing a series of physics-based models connecting the processes from the modulation of the cosmic ray flux in the heliosphere to their record in natural archives, as we can see in Figure 23.

Mixing these two sets of parameters, it has been thus possible to reconstruct the solar irradiance back to the years -1000 and -8000 (i.e. BC). Results are presented in Figures 24 and 25. It can be seen that the solar irradiance reached in the past significant high values, *of a level quasi similar* as it is today. The analysis is in agreement with earlier reconstructions of the solar activity

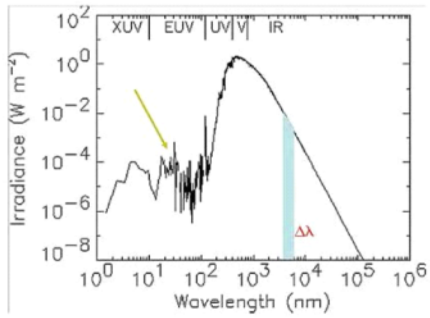


Figure 20: The spectral solar irradiance in all wavelengths, from far EUV to IR. The right part follows the Planck law; the left part is far from being uniform that may explains EUV sensitivity on our upper atmosphere. TSI is the integral over all wavelengths.

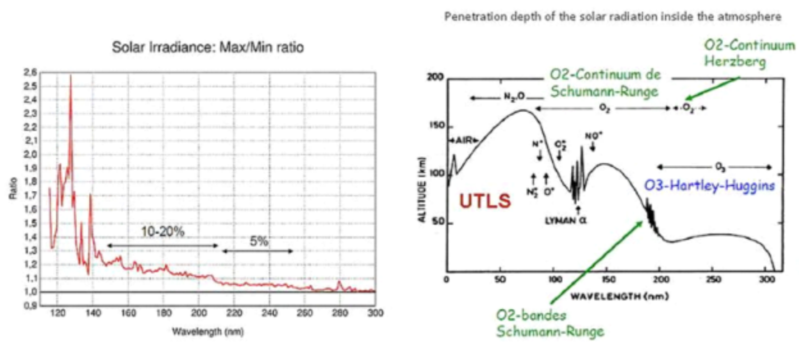


Figure 21: The solar irradiance variability in EUV reaches a factor of 2 (left, after M. Marchand, 2009). Such a high variability cannot be without consequences on the upper atmosphere. It is often claimed that the 0.1% variability (right wing of the graph) is without any effect, which seems true. However, at around 130 nm, where the amplitude of the solar irradiance variability is high, its interaction with the atmospheric molecules is significant (right).

during the Holocene regarding the occurrence of extended periods of low and high solar activity. Episodes of minima displayed changes of the total solar irradiance of about 1.3 W/m^2 and are observed by a lag of about 2800 years.

7 A quick look on the reconstructed past Earth temperature

The reconstruction of the Earth temperature over the past millennium is based on the analysis of archives that can be (briefly) listed as followed:

- Dendrochronology (example of cedar trees in Japan, see Figure 26),
- Palynology,
- Isotopic Variations of marine sediments (foraminifers),
- Ice analyzes (trapping of CO2, Be10),
- Criticized study of old documents, such as parochial registers, dates of harvests, wheat and prizes- (see figure 27), ship's books (see Figure 28), grape harvest, plum trees blossoming in Japan,

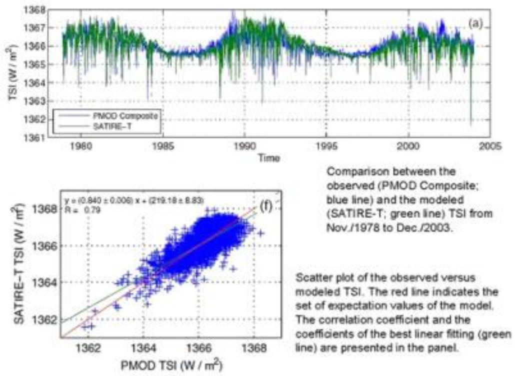


Figure 22: The total solar irradiance reconstruction as done through the magnetic components of the solar surface (sunspots and faculae). After (27).

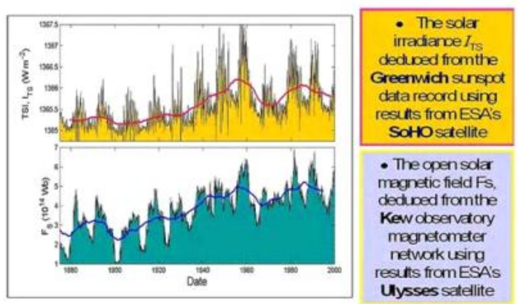


Figure 23: Reconstruction of the solar irradiance and the open magnetic flux from 1880. After (13).

- Glaciers advance and retreats,
- Comets and auroras registers,
- C14 analysis,
- etc.

Figure 29 shows the Be10 isotope contained in the polar ice core. There is a fair agreement between the recorded temperature and the Be concentration, except for some periods of time, mainly around the years 1750 and 1960. Is this fortuitous or can we see here a precursor for a climatic change, as I will mention latter on?

From all these proxies it is possible to reconstruct the Earth temperature since the beginning of our era. Figure 30 shows some examples as deduced by several authors. The only thing on which I will draw here the attention is the fact that during the medieval optimum (1140-1200), the warming could have been almost comparable in magnitude to the warming of the last few decades of the 20th century, which in turn, was unprecedented within the past 500 years.

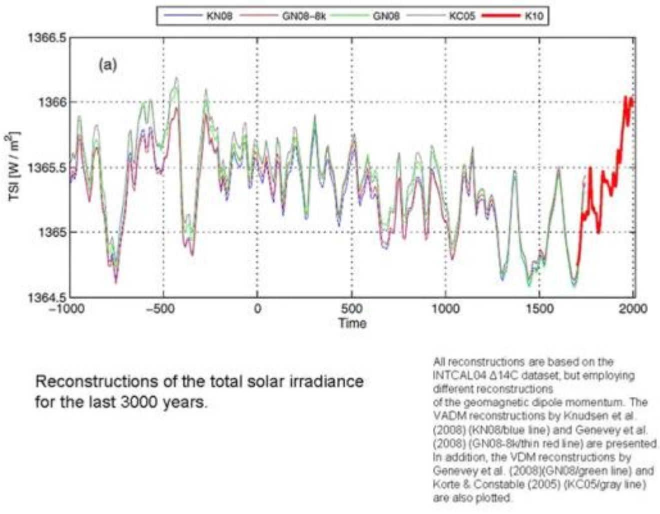


Figure 24: Reconstruction of the total solar irradiance for the last 3000 years. After (27).

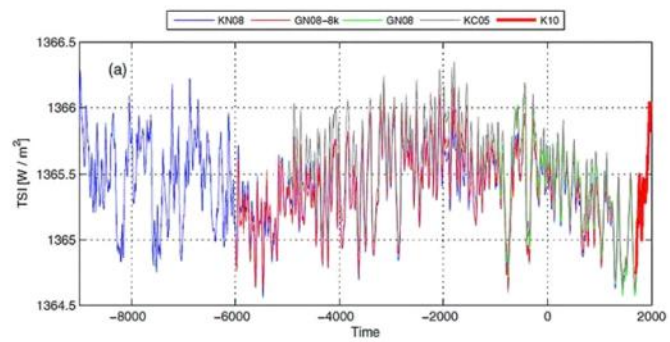


Figure 25: Reconstruction of the solar irradiance for the Holocene. After (27).

8 Some main questions at this turning point

1. The IPCC, always presented as a mere neutral body, is not free from some criticisms, concerning for instance the choice of the scientific publications. Moreover, it too often promotes arguments of authority. As Denis Diderot wrote in the Enlightenment century: *"What was never questioned was not proved. Skepticism is thus the first step towards the truth"*.

   IPCC is currently working on the preparation of the next report scheduled to be delivered by 2014. The Working Group 1 is expecting to give a report on model AR5 by March 2012.

2. Does the Earth warms? Yes. The average temperature on the surface of the Earth, during the XXth century, rose of some + 0.74°C.

3. Is this warming exceptional? Maybe no. It is known by all means, that intense periods of dryness appeared in the Middle East between -2500 and -1900, the duration of which was 100 to 200 years.

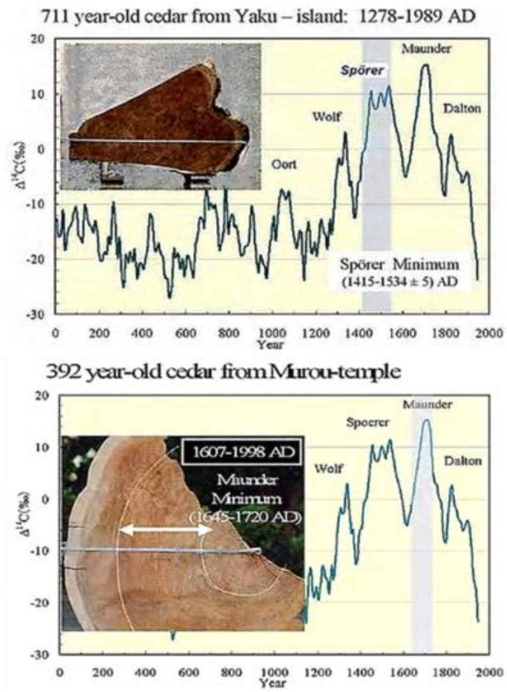
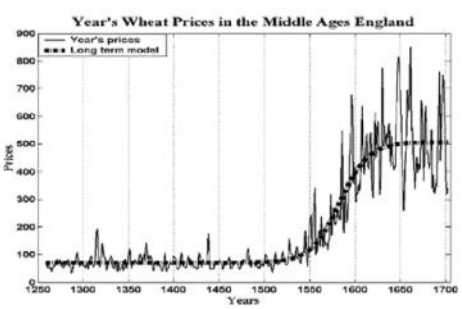


Figure 26: Dendrochronology. Analysis of isotope ^{14}C permits to deduce through the Forbush effect, past periods of very low solar activity (inverse scales as this effect is anticorrelated with solar activity). The analysis of the tree rings has been made here by Hiroko Miyahara et al. from the Solar-Terrestrial Environment Laboratory, Nagoya University, Japan. Episodes of low solar activity are related to climatic conditions on Earth.



Wheat prices in England 1259–1702 with price transition 1530–1610.

Figure 27: Influence of Solar Activity on the state of the Wheat Market in Medieval Ages. When climate became more and more colder, prices were increasing. After (18).

In Greenland: the history is also well known. In 986, Eric the Red found fertile soils when arriving and took advantage of ice-free seas to colonize the far north Greenland. Around the

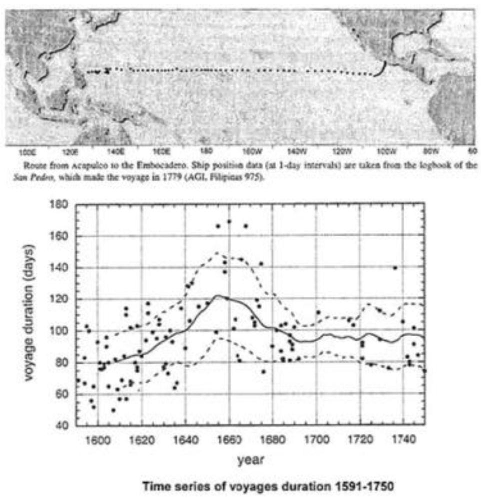


Figure 28: From the ship log-books, time travels can be reconstructed. This figure shows the duration of a travels from Acapulco to Manila between 1591 and 1750. It can be seen that the winds were blowing lower during the deep solar Maunder Minimum.

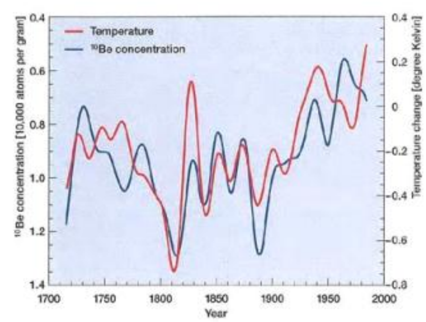


Figure 29: Comparison of the Be10 concentration measured in ice core with a reconstruction of the northern hemispheric temperature. After (1). The agreement is fair except for the years around 1750 and 1960. Are such features precursors of exceptional severe climatic events?

year 1000 AD the climate was sufficiently warm to support a Viking colony[4].

This is known as the "Medieval Warm Period" (MWP) or "Medieval Optimum" (between around 1000 and 1400).

A tree-ring reconstruction of Austral summer temperatures from the South Island of New Zealand, covering the past 1100 years has been made by Palmer et al. (2). The records shows

[4]Emilie Capron in her recent thesis (2011) has identified time episodes where Greenland rapidly warms, then cooling rapidly as well, of about 5° C in a century. A tilt up mechanism seems to exist between the poles during a glacial period: when it is cold in Greenland, Antarctica warms up slowly, around 2° C in 1000 years, whereas a slow cooling begins when an abrupt warming is produced in Greenland. Such a bipolar tilt-up can be shorter, on a century scale. This climatic mechanism is the proof that on short scales (of the order of a century, no more than a millennium), thermal exchanges exist between the two hemispheres certainly linked with the Atlantic oceanic circulation in a context near that of the present climate.

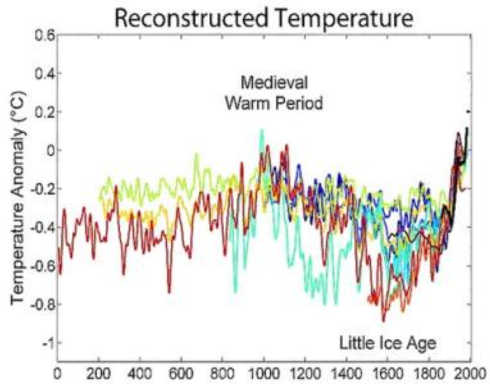


Figure 30: Reconstruction of the Earth's temperature since the first century. This Figure shows comparison of ten different published reconstructions of mean temperature changes during the last 2000 years. More recent reconstructions are plotted towards the front and in redder colors, older reconstructions appear towards the back and in bluer colors. For instance: Red (Anno 1 to 1979): after (15). Light green (Anno 831 to 1992): after (5).

clear evidence for persistent above-average temperatures within the interval commonly assigned to the MWP and it was concluded that the New Zealand temperature reconstruction supports the global occurrence of the MWP.

However, we need to be cautious. It is not because periods of warming occurred in the past, that men can be allowed to do what they want. Political warnings are needful.

4. What are the causes? For most of the climatologists, the current temperature anomaly is only due the men activities. The rise of the CO2 rate (produced by the combustion of coal and oil) and of the CH4 (such as the breeding of the bovines), combined with a lot of other pollutants (such as nitrous oxide or halocarbons) has break the Earth climatic thermostat. We have entered into the "anthropogenic global warming" i.e. "the anthropocene era".

   Yes, the CO2 rate grows and yes, the temperature goes up. But is there a direct relation between the two, that is to say a link from the cause to the effect?

5. Does the Sun plays a role? If the Sun is considered on the one hand to produce no significant output variability to trigger the top of our atmosphere, and on the other hand, if it is claimed that it cannot plays a minor role, then it must act via an amplifying effect in order to explain part of the amplitude of the variations observed during the last century. The argument of the IPCC consists in saying that since no amplifying effect is known, so the effect of anthropic greenhouse must be responsible alone. But this "assumption is only one attribution per defect and not an experimental proof" (Jan Veizer, Ottawa University). The variations of the solar activity, and the induced phenomena could explain up to 40% of the warming, leaving only 60% to the greenhouse effect. In anycase, EUV variations of the TSI in the models must be taken into account. Solar forcing cannot be avoid anymore. Indeed, computations are slowly progressing as can be seen for instance in (7) or (23).

6. Are projections for the future reliable? I would say certainly not yet. As stated by P. Morel, former chairman of the world program on the climate "Drawing scenarios from the consequences of the announced climatic warming is not very realistic. The models do not represent the nature. The weather is governed by turbulent phenomena; beyond a certain duration, they are strictly unforeseeable". And no determinism is contained in the climate

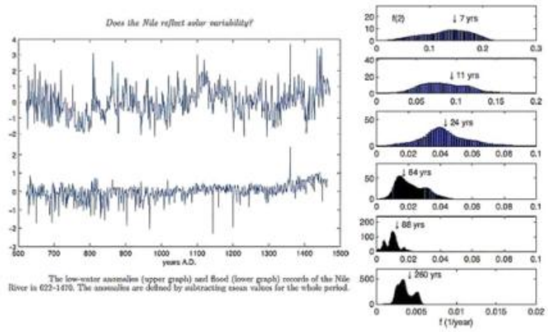


Figure 31: Analysis of the floods of the river Nile shows that oscillations at long periods can be found. After (22).

evolution of our planet. Therefore, related studies of past disasters become a contemporary awakening to the implication of local or regional climatic development.

9 Lastly, some legitimate questions

• *Are men activities responsible alone for climate changes?*

Long term oscillations in the temperature of the Earth can be envisaged. Let us take the example of the river Nile floods. Historical records of the Nile water level provide a unique opportunity to investigate the possibility that solar variability may have influenced (and still influences) the Earth's climate. Particularly important are the annual records of the river level, which are uninterrupted for the years 622-1470 A.D. A time-frequency analysis shows that long periodic oscillations are significant.

Another example is the multidecadal analysis which indicates that the secular warming trend during the 1980s and 1990s was not as large as the linear trends of the observation-based GST (ground-surface temperature) estimated in AR4 (IPCC 2007); and that the unprecedented rate of warming in the late twentieth century was a consequence of the concurrence of the upward swing of the multidecadal variability, quite possibly caused at least in part by an increase in the strength of the thermohaline circulation, and a secular warming trend due to the buildup of greenhouse gases (28).

In a recent paper Rahmstorf and Foster (19) analyzed five prominent time series of global temperature. They show that when the data are adjusted to remove the estimated impact of El Ninõ/southern oscillation, volcanic aerosols and solar variability, the five series show consistent global warming trends ranging from 0.014 to 0.018 °C yr^{-1}, the two hottest years remaining 2009 and 2010. However, the effects of these parameters are expressed in temperature changes in a very unclear way "these ranges (of influence) are for the temperature change induced by these factors, they are not coefficients of their influence" (?). If the authors are right, it remains to remove the long term oscillation to really see the anthropogenic part: the trend found are not yet what they called the "true" warming (Figure 32).

• *Are exceptional severe meteorological events precursors of climate changes?*

This last issue is certainly a key point. Historical climatology and disaster studies have not yet received the attention they deserve as pointed out by Franz Mauelshagen in The Medieval History Journal in 2007.

Historical climatology is defined as a research field situated at the interface of climatology and (environmental) history, dealing mainly with documentary evidence and using the methodology

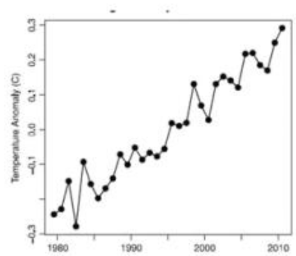


Figure 32: Increase of the Earth temperature after removing El Ninõ, volcanic and solar activity effects. After (19). However, the TSI variations are exactly correlated with the Remote Sensing Systems data which records the low troposphere temperature, thus giving some skepticism: indeed if a warming is due to the TSI, it must be through the upper atmosphere. A clear oscillation is visible.

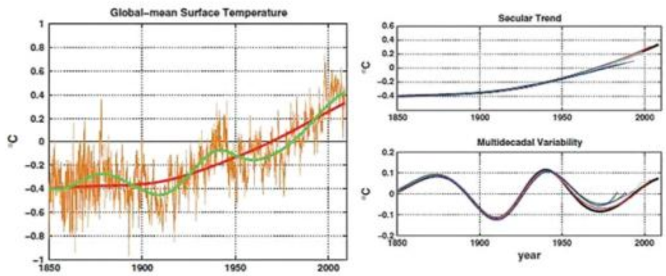


Figure 33: Long term oscillations in the temperature of the Earth can be envisaged, that are still ignored in IPCC reports. Here after Smolak et al. (24). See also (21): a typical long term oscillation of around 330 to 425 years, according to the reconstructed Earth temperature adopted, was found.

of both climatology and history. Its main objectives are *(i) reconstruction of past climates and climate change, focusing on the last millennium: (ii) investigation of the "socio-cultural impacts" of climate and climate change; and (iii) research on past discourses on and concepts of climate, which may be labeled a "cultural history of climate"*.

A new field of research is open. Historical studies of disasters continues to occupy a marginal position, but this is slowly changing today. Climatic scenarios do not have to be built on present models anymore, but have to take into account past disasters, that cannot longer be regarded as single exceptional cases. Deterministic models, as those used in GCM are useful. They are unquestionably allowed and still permit to perform useful projections to help to take right decisions. But it would be of interest to *link historical climatology and disaster studies*, as Christian Pfister wrote in his paper "Weeping in the Snow, the second period of Little Ice Age-type impacts" (17). But *"the greatest obstacle continues to be a general suspicion of natural or climatic determinism. Positing causal links between natural and socio-cultural facts is considered a risky undertaking"* as Erich Landsteiner has already mentioned in his memoir "Wenig Brot und saurer Wein" (12). Substantial efforts has to be made in that way.

10 As a general conclusion

Unfortunately, the issue of global climate change has become too much politicized. Heated debate rages on, both with climato-skeptics and with political partisans. On one extreme, some people are inclined to challenge every bit of data that supports climate change. And they believe, rather illogically, that scientists who believe in human-induced climate change are only ideologists. On the opposite extreme, others maintain an apocalyptic view of climate change and attribute every extreme weather event to global warming due to men activities. In the middle are the scientist doubters, who stay focused on what is known, and who strive to learn more about what is not known. I am one of these.

From the knowledge built on the experience and by the logical reasoning, for the two extreme wings above-mentioned, it is easy to progressively slips to the belief. One does not question any more on the basis of the awareness, on the construction of the reasoning but only on his attested credibility, preferably by somebody that one knows. Confidence replaces the scientific content. One passes from the authority of the expert to that of the par (or the colleague), with an understanding subjectivity at a time where the intellectual component of the majority of the scientific production tends to grow. This brings about a legitimate question. Playing on an ecology of fear, will the ecology of our planet be better preserved? On the other hand, as Blake McBride from U.S. Navy Task Force on Climate Change wrote: "Will scientific objectivity keep people from actively working to mitigate the effects of greenhouse gases and to adapt to changing conditions? If the culprit behind climate change is hydrocarbons placed in the atmosphere, then shouldn't everyone try to wean themselves from it?"

Earth's changing climate and how the nations respond to it needs must be part of discussions based on legitimate science. While some are more convinced of the threat that climate change poses, it is clear that neither a denial of the science nor an exaggeration of the challenges the nations are facing today will be productive to put science forward.

It is necessary to believe in the sincerity of the intellectual.

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