Refuting IPCC's claims on climate change, by showing how science basis has been used in an inappropriate way

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Abstract

Intergovernmental Panel on Climate Change (IPCC) in its fifth assessment report (AR5) claims that:

(1) *Equilibrium climate sensitivity is likely in the range 1.5°C to 4.5°C, extremely unlikely less than 1°C, and very unlikely greater than 6°C. (No best estimate for equilibrium climate sensitivity can now be given because of a lack of agreement on values across assessed lines of evidence and studies). {TFE.6}*

(2) *It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century. {10.3–10.6, 10.9} Human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system. {2–14}*

(3) *Global surface temperature change for the end of the 21st century is likely to exceed 1.5°C relative to 1850 to 1900 for all representative concentration pathways (RCPs) scenarios except RCP2.6. {11.3,...}*

IPCC's "working group I" (WGI) is made up of 259 experts, (between: 209 leading authors and 50 review editors), that collect more than 600 contributions from external experts. WGI seem to have based these claims: in mathematics (statistics, perturbation theory, control theory, Monte Carlo simulations, ...) and in thermodynamics (conservation of energy, infrared radiative transfer, Planck radiation, Stefan-Boltzmann, Clausius-Clapeyron, ...).

I intend to refute these claims reached by IPCC's WGI in their AR5, by showing how mathematics and thermodynamics have been used in an inappropriate way.

It might seem quixotic that a person, on its own, dares to challenge what hundreds of those WGI experts agree; but anyone reading this paper will understand that:

(a) deduction of climate sensitivity value is basically science fiction,

(b) ascribing the observed increase in global surface temperatures as being man-made is incorrect,

(c) IPCC's projections are likely inaccurate due to inadequacies in current global climate modeling (in those models that AR5 calls CMIP5) and to inappropriate statistical treatment.

Key words: IPCC, climate, change, sensitivity, statistics.

1.- Definitions contained in the glossary of IPCC's WGI AR4 (with updates from WGI AR5):

- Climate: *is the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind*.

- Global (mean) surface temperature: *is an estimate of the global surface air temperature. However, for changes over time, only anomalies, as departures from a climatology, are used, most commonly based on the area-weighted global average of the sea surface temperature anomaly (t.a.) and land surface air t.a.*.

- Radiative forcing: *is the change in the net, downward minus upward, irradiance (expressed in* $W \cdot m^{-2}$*) at the tropopause (or top of atmosphere) due to a change in an external driver of climate change, such as, for example, a change in the concentration of carbon dioxide or the output of the Sun. Sometimes internal drivers are still treated as forcings even though they result from the alteration in climate, for example aerosol or greenhouse gas (GHG) changes in paleoclimates. The traditional radiative forcing is computed with all tropospheric properties held fixed at their unperturbed values, and after allowing for stratospheric temperatures, if perturbed, to readjust to radiative-dynamical equilibrium.* (*For the purposes of this report, radiative forcing is further defined as the change relative to the year 1750 and, unless otherwise noted, refers to a global and annual average value).*

- Climate feedback: *an interaction mechanism between processes in the climate system is called a climate feedback when the result of an initial process triggers changes in a second process that in turn influences the initial one. A positive feedback intensifies the original process, and a negative feedback reduces it. (In AR5, the climate quantity that is perturbed is the global mean surface temperature, which in turn causes changes in the global radiation budget. In either case, the initial perturbation can either be externally forced or arise as part of internal variability).*

- Climate model (spectrum or hierarchy): *a numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes, and accounting for all or some of its known properties. The climate system can be represented by models of varying complexity, that is, for any one component or combination of components a spectrum or hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions, the extent to which physical, chemical or biological processes are explicitly represented, or the level at which empirical parametrizations are involved. Coupled Atmosphere-Ocean General Circulation Models (AOGCMs) provide a representation of the climate system that is near the most comprehensive end of the spectrum currently available. There is an evolution towards more complex models with interactive chemistry and biology. Climate models are applied as a research tool to study and simulate the climate, and for operational purposes, including monthly, seasonal and interannual climate predictions.*

- Climate feedback parameter: *a way to quantify the radiative response of the climate system to a global surface temperature change induced by a radiative forcing (units:* $W \cdot m^{-2} \cdot °C^{-1}$*). It varies* ($\Lambda \approx \lambda^{-1}$) *as the inverse of the effective climate sensitivity. Formally, the Climate Feedback Parameter (*Λ*) is defined as:* $\Lambda = (\Delta Q - \Delta F)/\Delta T$*, where Q is the global mean radiative forcing, T is the global mean air surface temperature, F is the heat flux into the ocean and* Δ *represents a change with respect to an unperturbed climate.*

- Climate sensitivity, λ: *In IPCC reports, equilibrium climate sensitivity refers to the equilibrium change in the annual mean global surface temperature following a doubling of the atmospheric equivalent carbon dioxide concentration. Due to computational constraints, the equilibrium climate sensitivity in a climate model is usually estimated by running an atmospheric general circulation model coupled to a mixed-layer ocean model, because equilibrium climate sensitivity is largely determined by atmospheric processes. Efficient models can be run to equilibrium with a dynamic ocean. The climate sensitivity parameter (units:* $°C \cdot (W \cdot m^{-2})^{-1}$*) refers to the equilibrium change in the annual mean global surface temperature following a unit change in radiative forcing.*

The effective climate sensitivity is a related measure that circumvents the requirement of equilibrium. It is evaluated from model output for evolving non-equilibrium conditions. It is a measure of the strengths of the climate feedbacks at a particular time and may vary with forcing history and climate state.

The transient climate response is the change in the global surface temperature, averaged over a 20-year period, centred at the time of atmospheric carbon dioxide doubling, that is, at year 70 in a 1% yr^{-1} *compound carbon dioxide increase experiment with a global coupled climate model. It is a measure of the strength and rapidity of the surface temperature response to greenhouse gas forcing.*

2.- Comments about these definitions.

C1.- From the definitions of 'climate' and 'global surface temperature' (GST) we must know that: while meteorologist can measure the temperature of a place in a given time; climate temperatures cannot be measured: only estimated. Thus, all climatic parameters (e.g. radiation, GST, ...) are based in statistical estimations. That is why WMO set those 30 years for averaging variables: because, by statistical convention, a minimum of 30 samples is required to apply the central limit theorem and to accurately obtain the statistical inference. So then, inferences from less samples might be inaccurate.

C2.- National oceanic and atmospheric administration / National climatic data center (NOAA/ NCDC), in its annual report of the State of the Climate, estimate GST by averaging: land and ocean's temperature. In 2012's report temperature anomalies, [Sa13], were as in fig.1:

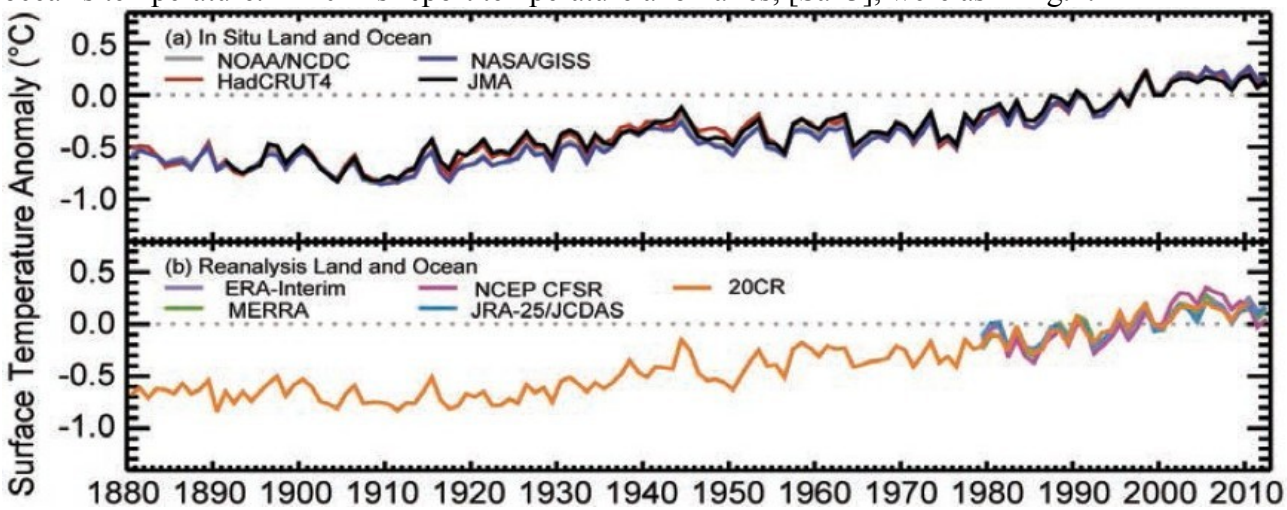

Fig.1.- Global average surface temperature annual anomalies (ºC, 1981-2010 base period).

in this figure it is remarkable that the averaged anomaly in the base period 1981-2010, (in grey dotted line), has been set to 0ºC. Just by looking at the graph anyone can understand that, despite it is true, it is not statistically correct to say that between 1944 and 2012 there has been a GST increment of 0.2ºC, or that between 1950 and 2010 the GST increment was of around 0.75ºC. It is statistically correct to say that in the base period 1951-1980 respect to 1981-2010, GST increased in around 0.25ºC; or that from the period 1891-1920 to 1921-1950, GST increased nearly in 0.15ºC.

C3.- There are many radiative forcing (RF) sources: solar irradiance, cloud albedo effect, ozone, greenhouse gases, … but, as we have just seen (in C1), climate RF sources cannot be measured: only estimated. The estimation of each of these climatic parameters should consist in averaging, on a period (e.g: 1981-2010), the radiative forcing corresponding to the related source.

The following figure (fig. 2) contains the RF sources that IPCC considered as most relevant. Some other radiative forcings can be seen in the original figure TS.5 or fig. 2.20a [IP07] of 2007's AR4.

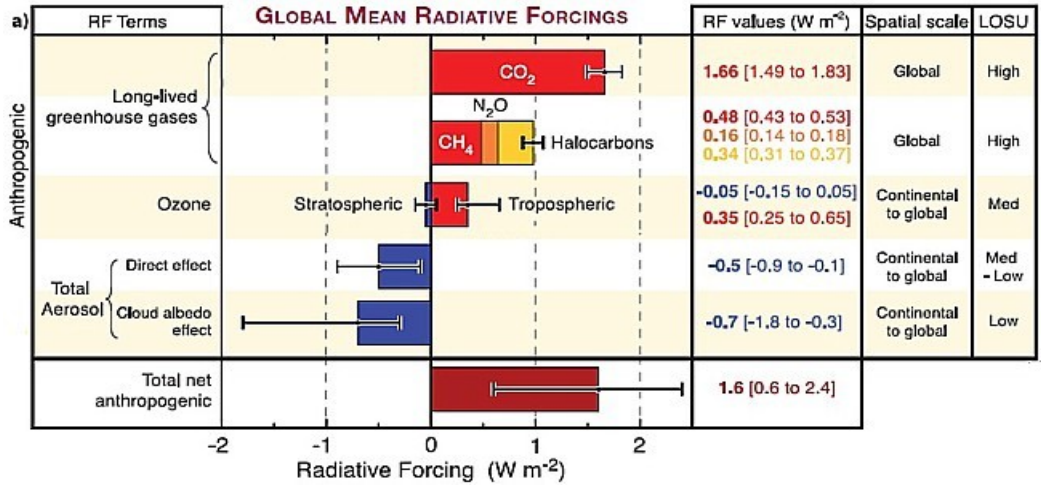

Fig. 2.- Global mean radiative forcings (values, spatial scale and level of understanding)

C4.- Radiative forcing of greenhouse gases in a given year is not directly measured; instead, it is modeled. For example, carbon dioxide (or CO_2) model could be: $\Delta F_{CO_2} = a \cdot \ln(C/C_0)$ where the reference concentration, from the year 1765, is: $C_0 = 279.00$ ppmv and where radiative forcing of CO_2 (ΔF_{CO_2}) has a simple logarithmic dependence with CO_2 tropospheric concentration C. The value of the '*a*' coefficient is deduced from spectroscopic analysis of CO_2 absorption bands in HITRAN database. In reference [My98] this coefficient is deduced and set to: $a = 5.35$, so if doubling CO_2 concentration at the tropopause, radiative forcing would be: $\Delta F_{2xCO_2} = 5.35 \cdot \ln 2 = 3.701\ W \cdot m^{-2}$ [1]

C5.- In AR4 (fig. 2), [and in fig. 8.14 of AR5], the level of scientific understanding (LOSU) was set to high [very high] only for greenhouse gases. Statistical uncertainties can be added: either as average errors, $\Delta z = \Delta x + \Delta y + ...$; or as standard deviations of symmetric dependent distributions, $\Delta z^2 = \Delta x^2 + \Delta y^2 + 2 \cdot Cov(x,y) ...$; or, as IPCC's AR4 explains in "fig. TS.5.b" (fig. 3), by using a Monte Carlo technique that deals with asymmetric uncertainty ranges (Monte Carlo methods apply random parameters that usually follow certain probability distribution functions).

C6.- 'Climate feedback' definition comes from control theory under the fundamental assumption that climate system behaves linearly and independently. About climate forcing mechanisms, in [Cu99] Ch. 13, it is said: "In principle, the contribution of each mechanism to the total feedback could be individually determined and ranked. In a nonlinear system, however, the feedbacks are not independent and addition of the individual terms will not give the true feedback of the nonlinear climate system. Applications of this type of linear feedback analysis have been made to the climate system, justified by considering only small perturbations to the radiative flux and surface temperature".

C7.- On the hierarchy of 'climate models': (α) coupled atmosphere-ocean general circulation models (AOGCM) combine atmospheric with oceanic models where the appropriate fluid mechanic equation is discretised in certain spatial dimensions and integrated over time; so then, general circulation models (GCM) intend to represent physical processes in atmosphere, ocean, cryosphere and land surface; (β) three dimensional atmosphere circulation models (ACM) are based in one dimensional radiative convective models (RCM): where it is modeled how radiation properties of tropospheric greenhouse gases might affect Earth's surface temperature; (γ) RCM are inspired on the fundamental assumption that there is a linear relation between global surface temperature and the radiative forcing (called ΔF_{2xCO_2} in equation [1]) that, in Charney's report [Ch79], was called ΔQ (the resulting change in net heating of the troposphere, oceans and land, for a doubling atmospheric CO_2 concentration). So then, that global mean surface temperature variation ΔT is: $\Delta T = \Delta Q / \Lambda$ [2]

3.- Refuting IPCC's claims on climate change

3.1.- (a) deduction of climate sensitivity (λ) value is basically science fiction.

RC1- 'Climate feedback parameter' (Λ) has been defined as *a way to quantify the radiative response of the climate system to a global surface temperature change induced by a radiative forcing*. This definition assumes that RF ΔF_{2xCO_2}, in eq. [1], must have a linear and independent effect on global surface temperature (GST) variation ΔT: $\Delta T = \Delta F_{2xCO_2} / \Lambda$. But the value of Λ, ($\Lambda \approx \lambda^{-1}$), has not been logically deduced in the climatic literature. Let us review:

RC2.- In documents seem to appear these scientific justifications of the climate sensitivity value:

* Climate sensitivity with no feedbacks ($\lambda = \lambda_0$) could be derived from **Stephan-Boltzmann equation**: $Q = \sigma \cdot T^4$. By means of: $dQ/dT = 4 \cdot \sigma \cdot T^3 = \Lambda_0$ with $T \approx 255$ K (T would be GST without greenhouse effect) and $\sigma = 5.67 \cdot 10^{-8}\ W \cdot m^{-2} \cdot K^{-4}$, it fixes $\Lambda_0 = 3.76\ W \cdot m^{-2} \cdot K^{-1}$. And, from [1]: $\Delta F_{2xCO_2} = 5.35 \cdot \ln 2 = \Delta Q = \Lambda_0 \cdot \Delta T \rightarrow \Delta T \approx 1$K. So doubling CO_2 concentration, increases GST in 1K (if accounting the variations on latitude and season: $\Lambda_0 \approx 3.3\ W \cdot m^{-2} \cdot K^{-1}$ and $\Delta T \approx 1.1237$ K).
  In [Ce76] derivation, emissivity 'ε' is used, with $\varepsilon \approx 0.6$ and $T \approx 288$ K (T being now the actual GST with the greenhouse effect), to provide the tuned value required: $\Lambda_0 = 4 \cdot \varepsilon \cdot \sigma \cdot T^3 \approx 3.3\ W \cdot m^{-2} \cdot K^{-1}$.
  All these derivations from Stephan-Boltzmann equation do not make sense: not just because of their inner errors, but because translating $\sim 5.35 \cdot \ln 2 \approx 3.7\ W \cdot m^{-2}$ of more radiating energy into a ~1K temperature increase could be correct only for an ideal black body, but it is incorrect for any gas body at the tropopause: as too many thermodynamic assumptions would be needed.

* Climate sensitivity value with no feedbacks could be also derived from a one dimensional **radiative-convective model**, (RCM), which computes temperature as a function of altitude. In [Ha81] mean surface temperature, T_s, is set in terms of the effective Earth's radiating temperature, T_e, as: $T_s \approx T_e + \Gamma \cdot H_e$; where H_e is the flux-weighted mean altitude of the emission to space, and Γ is the mean temperature gradient (lapse rate) between surface and H_e.
Any atmospheric book, e.g. [Cu99], shows that average lapse rate in troposphere is $\Gamma \approx 6.5$ºC/km.
RCM seems to deduce climate sensitivity value in a proper way: as infrared absorbers increase in concentration, H_e increases (e.g. by ~150m, if CO_2 concentration is doubled), and T_s increases proportionally (i.e. $\Delta T_s \sim 150\text{m} \cdot 6.5\text{K/km} \approx 1$ K). That $\Delta H_e \approx 150$m seems to be justified by some kind of atmospheric opacity but, in fact, is another tuning of parameters that do not make sense.
In [Ma67] for average cloudiness and fixed absolute humidity $\Delta T_s \approx 1.33$ K, and for fixed relative humidity $\Delta T_s \approx 2.36$ K. In [Ha81] (as they use various feedbacks) $\Delta T_{s,1} \approx 1.2$ K, $\Delta T_{s,2} \approx 1.9$ K, $\Delta T_{s,3} \approx 1.37$ K, $\Delta T_{s,4} \approx 2.7$ K, $\Delta T_{s,5} \approx 2.6$ K, $\Delta T_{s,6} \approx 3.5$ K. But all these climate sensitivity feedback values (and the one with no feedback), as RCMs allow tuning, do not follow a logical deduction.
* AR5, see (1), sets equilibrium climate sensitivity (ECS) values (with feedback): *likely in the range 1.5°C to 4.5°C*. IPCC admits that there is *a lack of agreement on values across assessed lines of evidence and studies*. We have checked that there is no line of evidence involving ECS, while the studies are on: instrumental data, last glacial maximum (LGM) warming, volcanic eruptions, ...
Studies based in instrumental data and volcanic eruptions are, in general, inaccurate due to the short amount of time evaluated. For example, Earth radiation budget experiment (ERBE), leads to opposite estimations: in [Fo06] ECS is in the [1.0,4.1] K range, while in [Li09] ECS = 0.5 K.
Studies based in LGM warming (or paleoclimate) are, in general, inaccurate due to uncertainties in the measurement of CO_2 concentrations and of GST: driving also to opposite estimations.
The problem with all these studies is that, in general, a tuning of parameters provide any climate sensitivity value requested, so: there is not a clear logical deductive estimation of ECS values.

3.2.- (b) ascribing the observed increase in global surface temperatures as being man-made is incorrect

RC3.- In AR5, the anthropogenic RF value for 2011 relative to 1750 is: 2.29 [1.13 - 3.33] $W \cdot m^{-2}$. While RF from emissions of well-mixed greenhouse gases (CO_2, CH_4, N_2O, and Halocarbons) for 2011 relative to 1750 is: 3.00 [2.22 - 3.78] W m^{-2}. These similar values seem to evidence that greenhouse emissions are: the main contributors to anthropogenic RF and the fundamental cause of climate change. But this is incorrect. On one hand, attributing the RF value 2.29 [1.13 - 3.33] $W \cdot m^{-2}$ as being man-made is a scientific non sense: an abuse of Monte Carlo techniques, as they cannot be applied to uncertainties with such a lack of understanding. A correct procedure for adding asymmetric uncertainties, from comment C5, would be as shown in the following figure 3 ([IP07] fig.2.20b of AR4): where long lived greenhouse gases and ozone RFs have a red dashed probability distribution function (PDF) while total aerosol RF has a blue dashed PDF and where combination of these provide an accurate total anthropogenic RF PDF in red.

The problem arises in fixing that dashed blue line: if there is a much lower understanding of total aerosol RF, why can not that dashed blue line have a different weight and/or shape?. In fact, [Bo01] could have included many more scenarios from their fig. 1. And IPCC's AR5, in fig.8.16, could set any aerosol RF PDF: so they have used one that seem to support their claim.

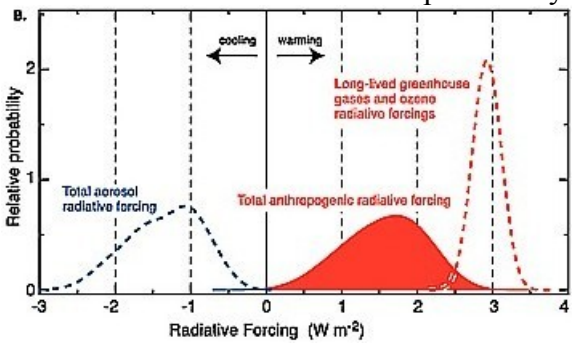

Fig. 3.- PDFs of different RFs

On the other hand, as we have just seen in RC2, climate sensitivity values are not justified by any logical scientific deduction. Thus, climate sensitivity values cannot correlate RF sources to GST.

Anyhow, as seen in C2, it has been observed an increase in global surface temperatures (GST) during certain periods of the 20th century. But there is no scientific criteria, based on statistical climate parameter estimations, that allow us to ascribe these GST increments as caused by humans.

3.3.- (c) IPCC's projections are likely inaccurate due to inadequacies in current global climate modeling (in those models that WGI in AR5 calls CMIP5) and to inappropriate statistical treatment.

RC4.- IPCC in AR5, see (3), claims that: *Global surface temperature change for the end of the 21st century is likely to exceed 1.5°C relative to 1850 to 1900 for all Representative Concentration Pathways (RCPs) scenarios except RCP2.6*. This claim is supported by a group of models, called by the IPCC, the *CMIP5 concentration-driven experiments* (here, the word 'experiments' is an abuse of language).

CMIP5 models follow a method that makes use of a global linearized energy budget approach:

$N = F - \Lambda \cdot \Delta T$, where N is the top of atmosphere (TOA) change in energy imbalance, F is a climate forcing component, Λ are climate feedbacks' components with units $W \cdot m^{-2} \cdot K^{-1}$ and ΔT is the averaged GST change [Fo13].

There are set 4 scenarios where RCPs follow different CO_2 equivalent concentration growths (8.5 is nearly exponential, 6.0 is linear: growing from 2050 and attenuates by 2080, 4.5 is linear and attenuating from 2060 and 2.6 increases a bit but linearly decreases from the year 2040).

The result of this method is shown in figure 4. As anyone could expect: each GST variation output, follows the related RCPs input. But it is inadecuate to extract conclusions from such a type of models; although IPCC uses them for 'justifying' this claim (AR5: Box1.1, Fig. 12.5).

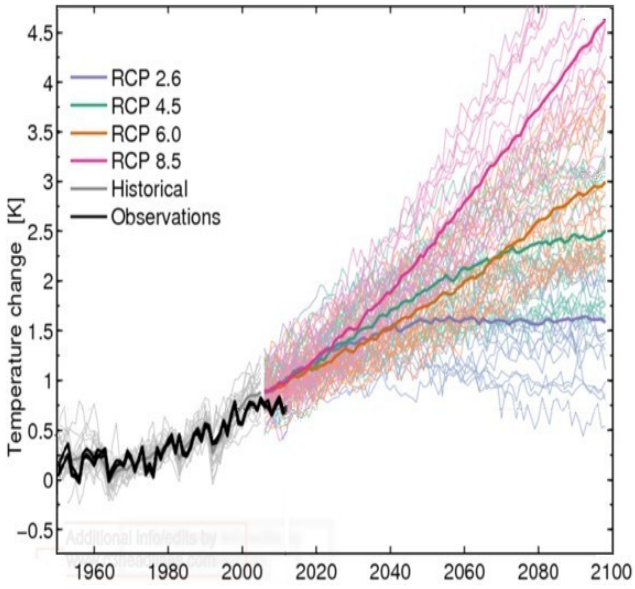

Fig. 4.- Global Surface Temperature change (relative to the period 1850-1900) observed up to the year 2012 and projected up to the year ~2100.

AR5 WGI report says: *Projections of changes in the climate system are made using a hierarchy of climate models ranging from simple climate models, to (...) Earth System Models. These models simulate changes based on a set of scenarios of anthropogenic forcings.*

We now understand: anthropogenic forcings cause a global climate change because global climate models, created to compute how anthropogenic forcings cause a global climate change (by means of a fictitious climate sensitivity value), say that anthropogenic forcings cause a global climate change. The above paragraph is known as "circular reasoning": a useful tool in politics, but not in science.

IPCC's WGI in AR4 explained why hierarchy, see C7 comment, had to be used in 'climate models': *With the development of computer capacities, simpler models have not disappeared; on the contrary, a stronger emphasis has been given to the concept of a 'hierarchy of models' as the only way to provide a linkage between theoretical understanding and the complexity of realistic models*. This is an euphemistic way to say that models validate models; but this not how scientific method works. No matter if any general circulation model (HadCM#, GFDL CM#, CCSM#, ...) agree with the Λ_0 computed value of around 3.3 $W \cdot m^{-2} \cdot K^{-1}$ or if every IPCC report agrees in setting climate sensitivity into a range between [2 and 4.5]K, what it really matters is that models should only be validated by observation.

RC5.- And talking about observation and climate, let us understand their appropriate time-scale. By my C1 comment, the minimum number of years/samples to obtain accurate statistical inferences could be set to 30 (as a convention). So then, every 30 years climatic parameters can be averaged and their change observed. Mankind seems to have measured the many climatic parameters only from the year 1950. Thus, we can only evaluate two data: belonging to the base periods, 1951-1980 and 1981-2010. But the minimum time-scale to evaluate how climate actually changes is not two; again by C1, it should be thirty. Then, around the year 2850 (30·30 = 900), mankind would have enough data to establish accurate correlations between climatic parameters as well as appropriate attributions. Until then, it seems that all climatic speculations dealing with models of decadal time-scales might be useless: including those against IPCC's claims ([Fy13]) or those in favor ([So06]). So taking only last 15 years, for the observed pause in GST increase (see fig. 4 & C1), is inaccurate.

4.- Concluding remarks.

Intergovernmental Panel on Climate Change, is a scientific body initially established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) with a millionaire yearly budget and a global influence on many nations' economies.

After this essay anyone can understand that IPCC's claims are not as scientifically well based as they should, in accordance to their global influence. So IPCC needs to justify why if doubling CO_2 concentration (doubling $C_0 \approx 279.0$ ppmv) or other GHG, GST will increase in a range of [1.5,4.5]K. This hypothesis appeared historically as the result of an inappropriate use of thermodynamics (computations involving Stephan-Boltzmann and radiative-convective models) and in present time anyone could agree that it is probably an error due to some kind of oversimplification.

The other major abuse from IPCC is on the field of mathematics. In the supposed validation of the climate sensitivity values: perturbation theory only allows to set a linear relation between ΔT and ΔQ (in eq. [2]) if and only if perturbations are small. So in order to get alarmist conclusions an abuse of control theory provide the useful tuning tools. Also, Monte Carlo simulations have been manipulated letting IPCC to point at who is the main responsible of climate change.

But the worst abuse of all is on statistics. There are many scientist (may be all of them!) that do not use the appropriate time-scales: only after hundreds of years of climatic analysis, mankind will be statistically able to accurately predict future trends and to address appropriate attributions.

5.- Acknowledgments.

From the persons I contacted, while writing this essay, I would like to thank: those who helped me.
IPCC seems to be a scientific authorized organization with a monolithic consensus message. But, after I challenged some of its experts, I noticed that they do not assume the responsibility of IPCC's WGI AR5 claims (one WGI AR5 expert told me: *the final text of a chapter is not the result of a balance of votes or the responsibility of a person but reflects an agreement to evaluate the evidence on a topic*).

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