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Natural climate variability, part 2: Interpretation of the post 2000 temperature standstill

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ABSTRACT

The period from 2000 to 2016 shows a modest warming trend that the advocates of the anthropogenic global warming theory have labeled as the "pause" or "hiatus." These labels were chosen to indicate that the observed temperature standstill period results from an unforced internal fluctuation of the climate (e.g. by heat uptake of the deep ocean) that the computer climate models are claimed to occasionally reproduce without contradicting the anthropogenic global warming theory (AGWT) paradigm. In part 1 of this work, it was shown that the statistical analysis rejects such labels with a 95% confidence because the standstill period has lasted more than the 15 year period limit provided by the AGWT advocates themselves. Anyhow, the strong warming peak observed in 2015-2016, the "hottest year on record," gave the impression that the temperature standstill stopped in 2014. Herein, the authors show that such a temperature peak is unrelated to anthropogenic forcing: it simply emerged from the natural fast fluctuations of the climate associated to the El Niño–Southern Oscillation (ENSO) phenomenon. By removing the ENSO signature, the authors show that the temperature trend from 2000 to 2016 clearly diverges from the general circulation model (GCM) simulations. Thus, the GCMs models used to support the AGWT are very likely flawed. By contrast, the semi-empirical climate models proposed in 2011 and 2013 by Scafetta, which are based on a specific set of natural climatic oscillations believed to be astronomically induced plus a significantly reduced anthropogenic contribution, agree far better with the latest observations.

Keywords: Climate Change, Post 2000 Temperature Standstill, Climate Models, Natural Climatic

1. INTRODUCTION

As explained in part 1 of this study [1], in the last decade future climate scenarios have been used to develop and politically enforce energy expensive policies to contrast catastrophic climate warming expectations for the 21st century. This has been done mostly by the United Nations Intergovernmental Panel on Climate Change [2, 3, 4]. Several studies based on general circulation model (GCM) simulations of the Earth's climate concluded that the 20th century climate warming and its future development depend almost completely on anthropogenic activities. Humans have been responsible of emitting in the atmosphere large amount of greenhouse gases (GHG) such as CO_2 throughout the combustion of fossil fuels. This paradigm is known as the *Anthropogenic Global Warming Theory* (AGWT).

However, before trusting GCM projections about future climatic changes, it is necessary to validate these models by testing whether they are able to properly reconstruct past climate changes. In Ref. [1], the authors have argued that since 2001 AGWT was actually supported by the belief that the "hockey stick" proxy temperature reconstructions, which claim that an unprecedented warming occurred since 1900 in the Northern Hemisphere, were reliable [2,5] and could be considered an indirect validation of the available climate models supporting the AGWT [6]. However, since 2005 novel proxy temperature reconstructions questioned the reliability of such hockey stick trends by demonstrating the existence of a large millennial climatic oscillation [7-10]. This natural climatic variability is confirmed by historical inferences [11] and by climate proxy reconstructions spanning the entire Holocene [12, 13]. A millennial climatic oscillation would suggest that a significant percentage of the warming observed since 1850 could simply be a recovery from the Little Ice Age of the 14th - 18th centuries and that throughout the 20th century the climate naturally returned to a warm phase as it happened during the Roman and the Medieval warm periods [9, 11, 14-16].

To test the reliability of the Coupled Model Intercomparison Project Phase 5 (CMIP5) GCMs, in Ref. [1] it was shown that for the period 1860-2016 they predict an excessive warming relative to four independent global surface temperature reconstructions. This was a first significant discrepancy between observations and models.

Then, it was noted that AGWT advocates had claimed that discrepancies between observation and modeled predictions could occur because of an unforced internal variability of the climate system that the same GCMs are able to predict [17].

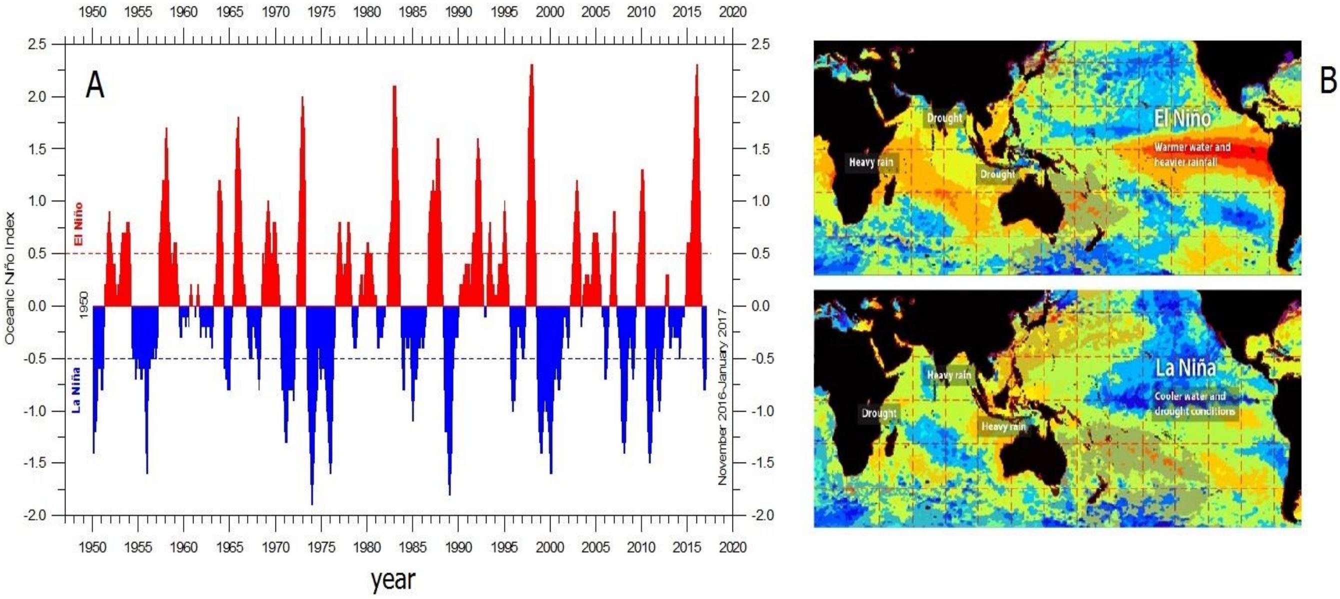

Figure 1. [A] The NINO3.4 index (ONI version) since Dec/1949 - Feb/1950 to Nov/2016 - Jan/2017. [B] Typical El-Niño and La-Niña warm and cool climatic conditions, respectively

These people were very explicit by providing the following scientific criterion to validate the models: "*The simulations rule out (at the 95% level) zero trends for intervals of 15 year or more, suggesting that an observed absence of warming of this duration is needed to create a discrepancy with the expected present-day warming rate*" [18].

By using such a 15-year interval criterion, in Ref. [1] we tested the CMIP5 GCMs against the observations in the periods 1922-1941, 1980-1999 and 200-2016. The first two periods were selected because they are characterized by a strong and compatible warming rate but by very different rate of anthropogenic GHG emissions. On the contrary, the 2000-2017 period is characterized by a very strong increase of anthropogenic GHG emissions while the temperature has been quasi stationary. Our statistical analysis [1] confirmed with a 95% confidence that the GCMs fail to properly reconstruct the temperature trends in 1922-1941 and in 2000-2017. Thus, according to the very criterion proposed by the AGWT advocates themselves, the GCMs used to support the AGWT are demonstrated to be flawed.

Herein, a detailed study of the natural climatic variability observed after 2000 in six available global temperature records versus the performance of the GCMs is carried out. We also critically analyze the year 2015-2016, which has been famed as the hottest year on record. We show that this anomaly is simply due to a strong El-Niño event that has induced a sudden increase of the global surface temperature by 0.6 ºC. This event is unrelated to anthropogenic emissions. In fact, an even stronger El-Niño event occurred in 1878 when the sudden increase of the global surface temperature was 0.8 ºC: see Figure 2 in Ref. [1].

Finally, for the post 2000 period we compare the predictions of the CMIP5 GCMs used by the IPCC [2013], against that of two semi-empirical models proposed a few years ago [15,19]. These models were based on a specific number of natural oscillations suggested by astronomical considerations plus an anthropogenic warming effect strongly reduced by 50% relative to the GCM predictions. We stress that the latter result is consistent with recent scientific literature findings [20] confirming that the real climate sensitivity to CO_2 doubling is about half, that is between 1 ºC and 2 ºC, than what predicted by the GCMs supporting the AGWT, which is about 3 ºC [4].

2. DATA

Herein we use the same climate records (HadCRUT v4.5, NCDC v3.2.1, GISS250, GISS1200, UAH v6.0 and RSS v3.3) and the same CMIP5 GCM simulations used in Ref. [1]. We used all sets of GCM simulations collected in the four emission scenario groups (RCP25, RCP45, RCP60 and RCP85). All records were downloaded from KNMI Climate Explorer (https://climexp.knmi.nl).

An index indicative for the high frequency inter-annual natural climatic variability is the monthly East Central Tropical Pacific SST NINO3.4 time series [21], based on the ERSST.v4 SST anomalies in the region [5ºN-5ºS, 120º-170ºW]. Warm and cold episodes are defined on the base of a threshold of ± 0.5ºC, respectively, relative to a three-month running mean whose values form the Oceanic Niño Index.

Figure 1 shows the Oceanic Niño Index (ONI) since Dec/1949 - Feb/1950 (http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml). The record reveals strong inter-annual oscillations between warm El-Niño events and cool La-Niña events. During El-Niño events the equatorial Eastern Pacific Ocean from Peru to the central ocean gets warmer than usual and is characterized by heavier rainfall: droughts are expected from Australia to

India and heavy rain in sub-equatorial Eastern Africa. On the contrary, during La-Niña events the same Eastern Pacific Ocean region gets cooler than usual while the Western equatorial ocean warms. Droughts are likely to happen in Western equatorial America and Eastern equatorial Africa, while warmer weather and heavier rains are expected from India to Australia. Complex climatic patterns occur around the world because of seasonal El-Niño and La-Niña events.

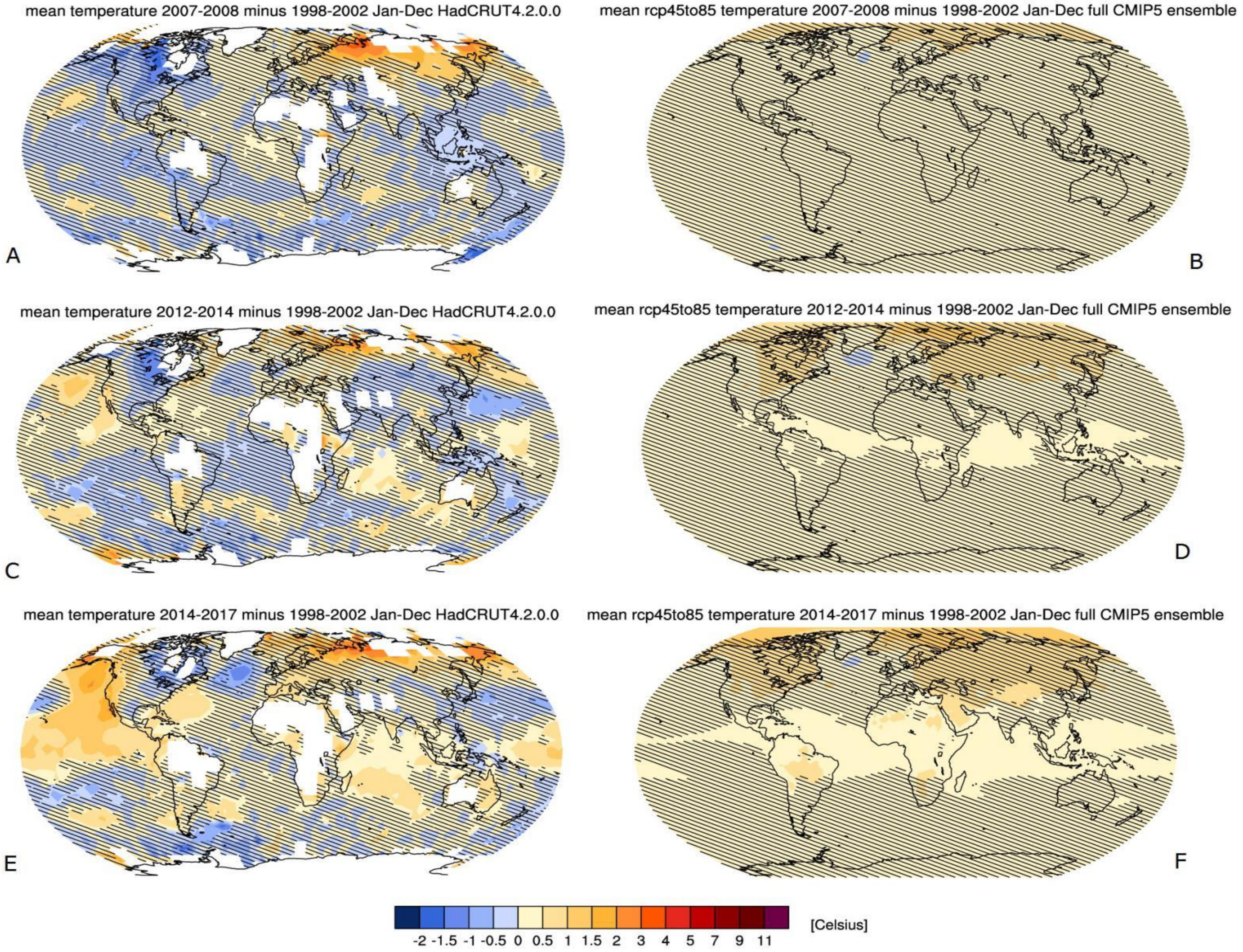

Figure 2. Comparison between the regional mean temperature variations between two periods 2007-2008 and 1998-2002, 2012-2014 and 1998-2002 and 2014-2017 and 1998-2002 in the HadCRUT temperature record and modeled in the historical + RCP45/RCP60/RCP85 scenario CMIP5 GCMs

3. ANALYSIS

Figure 2 compares the regional mean temperature variations between two periods 2007-2008 and 1998-2002, 2012-2014 and 1998-2002, and 2014-2017 and 1998-2002 observed in the HadCRUT temperature record and modeled in the historical + RCP45/RCP60/RCP85 CMIP5 GCM simulations. The figure reveals that while the GCMs predicted a progressive warming diffused uniformly around the entire world as indicated by the progressive yellow color, the temperature observations showed significantly more complex patterns. Many regions of the world actually cooled between the three periods, as indicated by the blue area. Also the 2014-2017 period shows cooler area respect to the 1998-2002 period despite the strong 2015-2016 El-Niño event that has warmed in particular the Pacific.

Figure 3 complements Figure 2. Here we compare the regional mean linear trend observed in the GISS-1200 temperature record and that modeled in the historical + RCP45/RCP60/RCP85 CMIP5 GCMs for the period 2000-2008, 2000-2014 and 2000-2017. Again, we observe that the temperature data reveal a rich dynamic with numerous wide regions showing a cooling (blue color) and other showing a warming (red color). On the contrary, the GCM simulations show a progressive and accelerating warming that is nearly uniform around the world. The 2000-2017 period shows wider warming areas because the strong 2015-2016 El-Niño event that has warmed in particular the Pacific, but still wide cooling areas are evident in the diagram.

Figures 2 and 3 demonstrate that the Earth's climate is driven by a complex spatial dynamic that the GCMs are not able to reproduce. In the following, we briefly estimate the ENSO influence on the post 2000 warming trend.

ENSO-like inter-annual climatic oscillations are observed in the temperature records (cf. Figure 2 in Ref. [1]). In particular, note the two strong global temperature peaks occurred in 1997-1998 and in 2015-2016, in coincidence with two strong El Niño events, known also as super El Niño, that reached an ONI value of about 2.25. In those occasions, the NINO3.4 area sea temperature anomaly reached 2.5-3.0°C above the average. This suggests that to properly evaluate the warming trend of a period such as from 2000 to 2016 that has experienced a super El-Niño between 2015 and 2016 is necessary to filter out the ENSO contribution because the ENSO peak would bias the trend toward higher values.

To do this, we first evaluate the correlation coefficient and the existence of a time lag between the ENSO signal and the temperature records from 2000 to 2016. Table 1 collects the various correlation coefficients referring to the several global surface temperature records and to various time lags from 0 to 6 months. The table shows that the ENSO signal is very strongly correlated to the temperature records ($r>0.5$ for 192 points, $p<0.01\%$). However, the best correlation coefficients ($r=0.6$ for the surface temperature records and $r=0.7$ for the satellite measures) occur on average when a three-month time-lag is applied to the ENSO record. This means that the ENSO anomaly is felt globally about three months later: a property that can be used for seasonal forecasts.

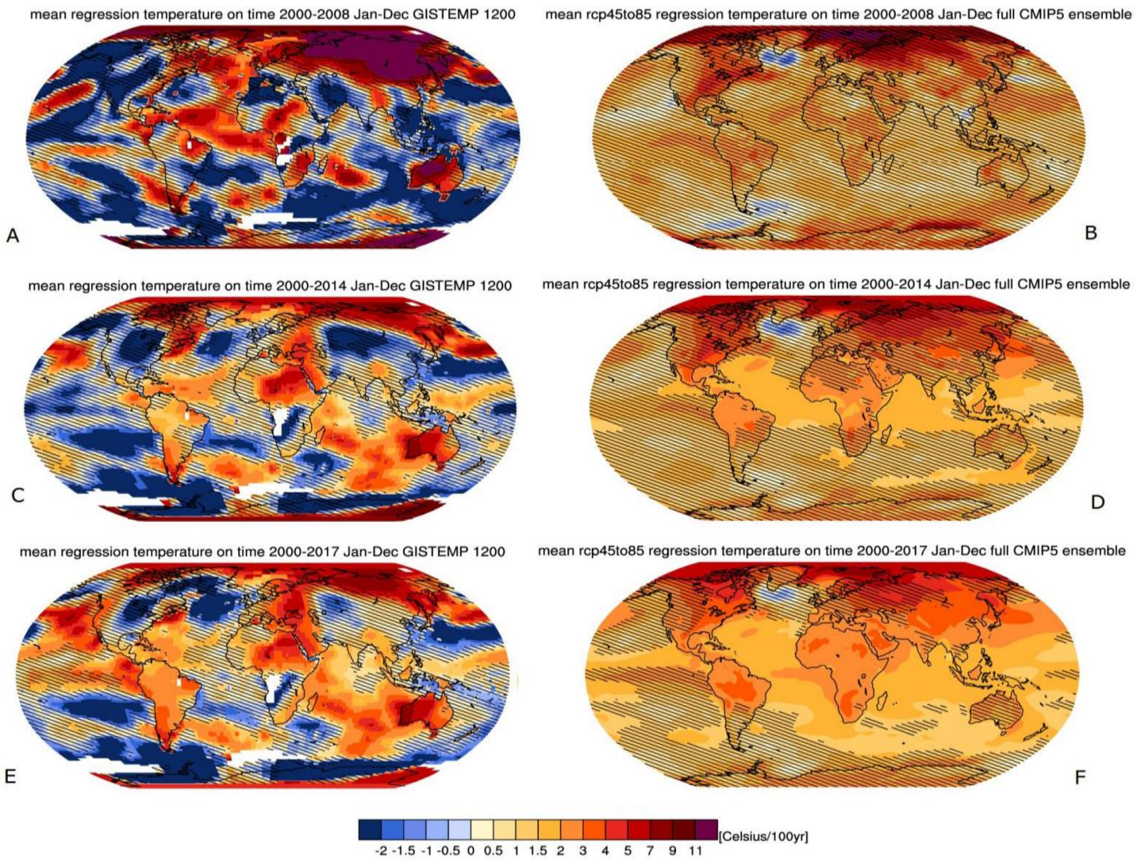

Figure 3. Comparison between the regional mean linear trend observed in the GISS-1200 temperature record and that modeled in the historical + RCP45/RCP60/RCP85 CMIP5 GCMs for the period 2000-2008, 2000-2014 and 2000-2017

Table 1. Correlation coefficient between the temperature records and the NINO3.4 index

	NCDC	HadCRU4	GISS.250	GISS.1200	RSS	MSU
ENSO3.4 (0)	0.55	0.56	0.59	0.52	0.52	0.48
ENSO3.4 (1)	0.58	0.60	0.63	0.57	0.63	0.60
ENSO3.4 (2)	0.59	0.61	0.63	0.59	0.69	0.68
ENSO3.4 (3)	0.58	0.61	0.62	0.59	0.70	0.71
ENSO3.4 (4)	0.57	0.60	0.60	0.58	0.70	0.71
ENSO3.4 (5)	0.53	0.56	0.56	0.55	0.67	0.69
ENSO3.4 (6)	0.50	0.52	0.52	0.50	0.63	0.65

Note 2. Correlation coefficient “r” between the the global surface temperature records and the monthly NINO3.4 index with a time lag in month that is expressed in parenthesis from 0 to 6 months. The considered time interval is between Jan/2000 to Dec/2016.

To evaluate the trend from 2000 to 2016 we use the three-month time-lag and apply a simple nonlinear multi-regression of the temperature record of the type:

$$T(t) = c + b\,t + \text{polynomial}\,(\text{ENSO, degree } n) + \text{random}, \quad (1)$$

where:

$$\text{Polynomial}\,(\text{ENSO, degree } n) = a_1\,\text{ENSO} + a_2\,\text{ENSO}^2 + \ldots + a_n\,\text{ENSO}^n \quad (2)$$

We varied the polynomial exponent n to take into account a possible non-linearity of the relation between the ENSO and the global temperature record. Table 2 collects the linear regression coefficient “b” of Eq. 1 from 2000 to 2016 under the various conditions. We noticed that for all temperature records there is a significant reduction of the linear rate value from the case in which the ENSO signal is not considered (n=0) to that in which it is considered (n>0). However, for n=3 and n=4 the linear coefficient "b" are nearly equal, suggesting that the regression is converging and that a cubic polynomial of the ENSO signal is sufficient to well reproduce its signature in the observed temperature records. The regression linear coefficients "b" calculated using n=3 are those that are depicted in table 1 and figure 5D of Ref. [1].

Figure 4 shows the six temperature records against their estimated NINO3.4 signature (red). The latter has been calculated considering a 3-month time-lag and a polynomial regression of order n=3. In particular, we notice the nearly exact correspondence between the large temperature peak occurred in 2015-2016 and the NINO3.4 peak.

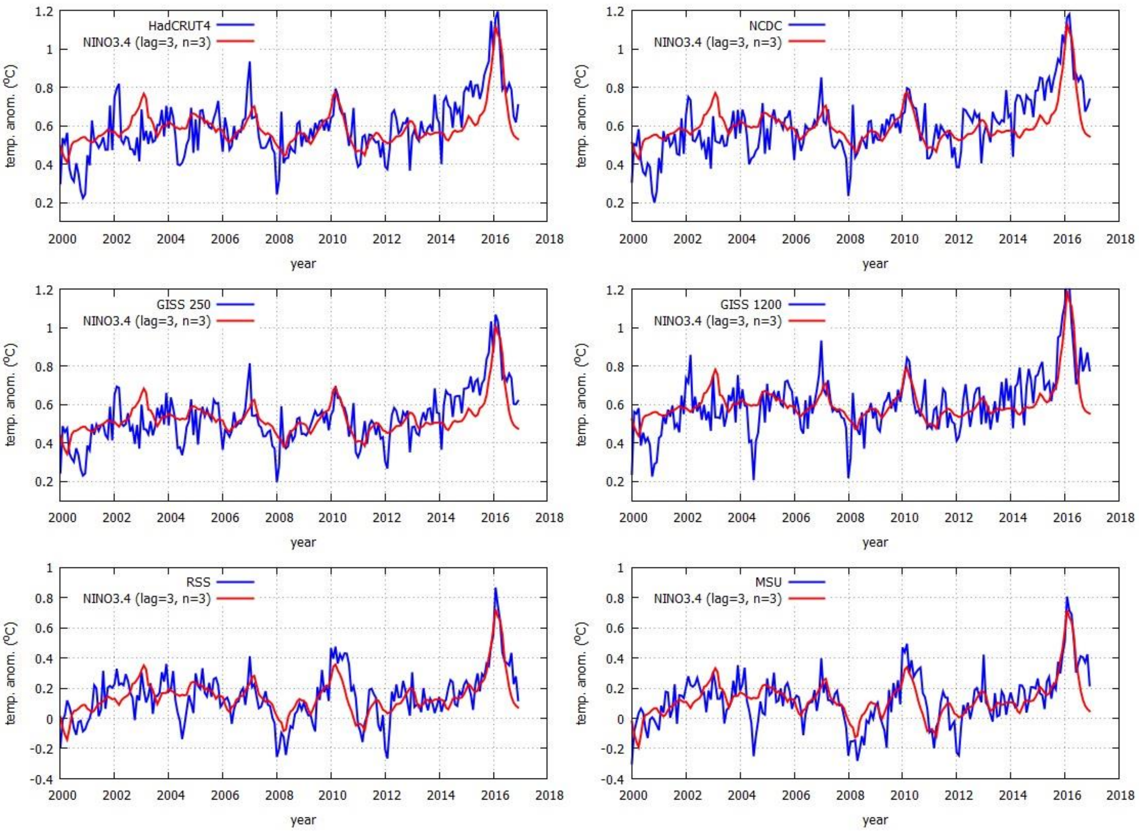

Figure 4. Original temperature records (blue) and their estimated NINO3.4 signature (red)

Table 2. Jan/2000-Dec/2016 linear trend b from Eq. 1 as function of the ENSO polynomial exponent

	n=0	n=1	n=2	n=3	n=4
	ºC/decade	ºC/decade	ºC/decade	ºC/decade	ºC/decade
MSU	0.108 ± 0.024	0.058 ± 0.017	0.054 ± 0.017	0.045 ± 0.018	0.048 ± 0.017
RSS	0.095 ± 0.023	0.047 ± 0.017	0.042 ± 0.017	0.033 ± 0.017	0.036 ± 0.017
GISS.250	0.144 ± 0.017	0.113 ± 0.014	0.108 ± 0.014	0.103 ± 0.014	0.106 ± 0.014
GISS.1200	0.156 ± 0.020	0.122 ± 0.016	0.113 ± 0.016	0.107 ± 0.016	0.111 ± 0.016
HadCRU4	0.162 ± 0.019	0.127 ± 0.016	0.121 ± 0.015	0.112 ± 0.016	0.120 ± 0.016
NCDC	0.193 ± 0.018	0.162 ± 0.015	0.155 ± 0.014	0.153 ± 0.015	0.153 ± 0.015

Note 3. Linear trend b is from Eq. 1 and it is reported as a function of the ENSO polynomial exponent.

Figure 5 shows on the left panels the six original temperature records (blue) from 2000 to 2017 against the CMIP5 mean simulations from 138 GCMs. On the right panels, Figure 5 shows the same temperature records after that the estimated NINO3.4 signature is detrended. Although the 2015-2016 temperature peak gives the illusion of a late agreement between the observation and the modeled records, the divergence between the two record sets becomes quite evident once the ENSO signal is removed from the observation. The statistics of these trends are listed in Table 2 and in Figure 5B of Ref. [1].

Thus, the occurrence of a strong El-Niño event between 2015 and 2016 has caused a worldwide sudden warming, which could misleadingly suggest that the observations have been consistent with the analyzed GCM predictions. However, once the ENSO signal is filtered off from the temperature observations, their trend disparity toward the climate simulations becomes clear (Figures 4 and 5).

4. SEMI-EMPIRICAL MODEL PREDICTION

Since 2010 Scafetta [14, 15, 16, 19, 22] has proposed that the dynamics of the climate records suggests that the system is oscillating with specific harmonics that can be found in the gravitational and electromagnetic oscillation of the sun and of the solar system. At the decadal to the millennial scales these oscillations have periods of: 9.1 year, which is a likely solar-lunar tidal cycle; 10-11 year, which is the 11-year solar cycle that has been on average about 10.5 year during the 20th century; quasi 20-year and 60-year oscillations, which are related to the major solar system oscillations due to the movement of Jupiter and Saturn; quasi 115-year and 980-year, which are related to specific major beats between planetary and solar oscillations. Other oscillations are likely relevant [23, 24, 25], but where not included yet in these models.

The proposed semi-empirical model also takes into account a contribution from anthropogenic forcing and volcano activity. Detailed data analysis [15, 19] has concluded that the climatic effects of the radiative forcing is about half of that simulated by the CMIP5 GCMs. The climate sensitivity to CO_2 doubling of the CMIP5 GCMs is about 3.0ºC with a range spanning between 1.5ºC and 4.5ºC (IPCC, 2013).

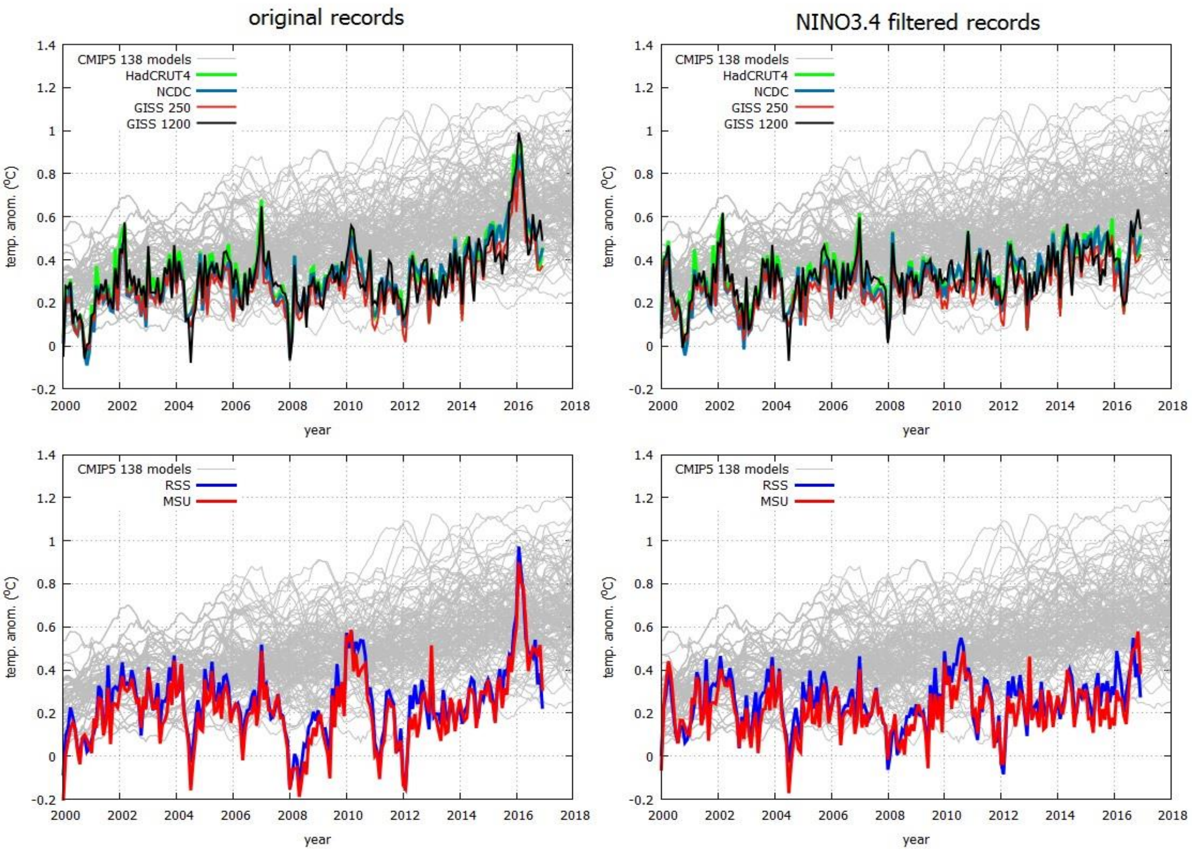

Figure 5: (left) Original temperature records (blue) against the CMIP5 mean simulations from 138 GCMs. (right) The original temperature records are filtered off of their estimated NINO3.4 signature depicted in Figure 4, respectively

However, the real climate sensitivity appears to be half of it, that is between 0.75ºC and 2.25ºC. This low range for the climate sensitivity to radiative forcing is consistent with a large number of recent studies [20] as Figure 7 shows.

Figure 6 shows the good performance of the semi-empirical models proposed in 2011 and 2013 [15, 19]. The semi-empirical models based on astronomical oscillations plus an anthropogenic contribution is indicated by the yellow/red area while the CMIP5 GCMs predictions are represented by the green area. Figure 6A and 6B use the HadCRUT temperature records available in 2011, 2013 and up to Dec/2016. Figure 6C and 6D use the UAH and RSS records available up to Feb/2017. The diagrams clearly show that the semi-empirical models have performed much better than the CMIP5 GCMs in forecast the observed temperature record from 2000 to 2017.

5. CONCLUSIONS

Before the Enlightenment and the scientific revolution of the XVIII century the experience of extreme painful events like famine or epidemics, especially when large communities were involved, was often believed to be punishment given by God to people for their sins. Thus, in most cases, the question was: “who is the guilty one”? Consequently, some individuals were believed to have been committed to perform evil actions; and this belief caused different actions in the various ages: witch hunt during the famine of the 16th century, hunting spreaders during plague epidemic events, etc. [26]. A similar behavior can be checked from historical documents of the ancient peoples: the calamities were generally ascribed to the whims or anger of Gods.

Nowadays the culture has evolved and the level of knowledge is much higher than in the past; but some residues of the old mentality and attitude are still present, maybe hidden. For example, since the environmental pollution is mainly caused by human activities, mankind could be assumed to be directly responsible for any sort of climatic change that we may observe. In other words, “look for the guilty one” once again. But people are not enough educated to discriminate between the anthropogenic and the natural causes of climate changes [26]. They do not properly consider that natural phenomena have driven the evolution of the climate along the whole history of our planet. How could be possible that the natural processes, which have dominated the climate for millions of years, did become negligible in a few decades just because the influence of our activities increased? This mentality may also spread to scientists and politicians.

In this regard, it is worth reminding that, in coincidence with the cooling period occurred from 1940 to 1970, many scientists and politicians believed that a next glacial age was approaching and proposed some very naive measures that now look to be simplistic and even ridiculous. The authors think that knowledge is continuously progressing: in the face of very complex phenomena we should be cautious, because many mechanisms and links are still unknown. Some of them are being hardly and slowly discovered, but many things are still to be deepened. Anyhow, the attitude of the "politically correct" scientists can prevent their rational and hard engagement in the search of new findings, especially if their statements, following the majority current of thought, enable them to get research funds or other benefits.

To check the validity of a model, it is very important to compare its forecast with the results of instrumental records applied to carefully chosen periods. But sometimes these efforts are neglected, because the researchers have too much confidence on their models, with the risk of excessively relying on them, particularly when the results agree with their expectations. The models now available, like the GCMs, are not yet completely reliable and need much more work. Many aspects must be studied and deepened. It is what the authors tried to explain and suggest in the present paper, where alternative approaches have been introduced without the claim of being perfectly able to forecast the future. The science of climate is young: we should be aware that many things will be discovered and, probably, some "certainties" will be reconsidered and perhaps denied in the future.

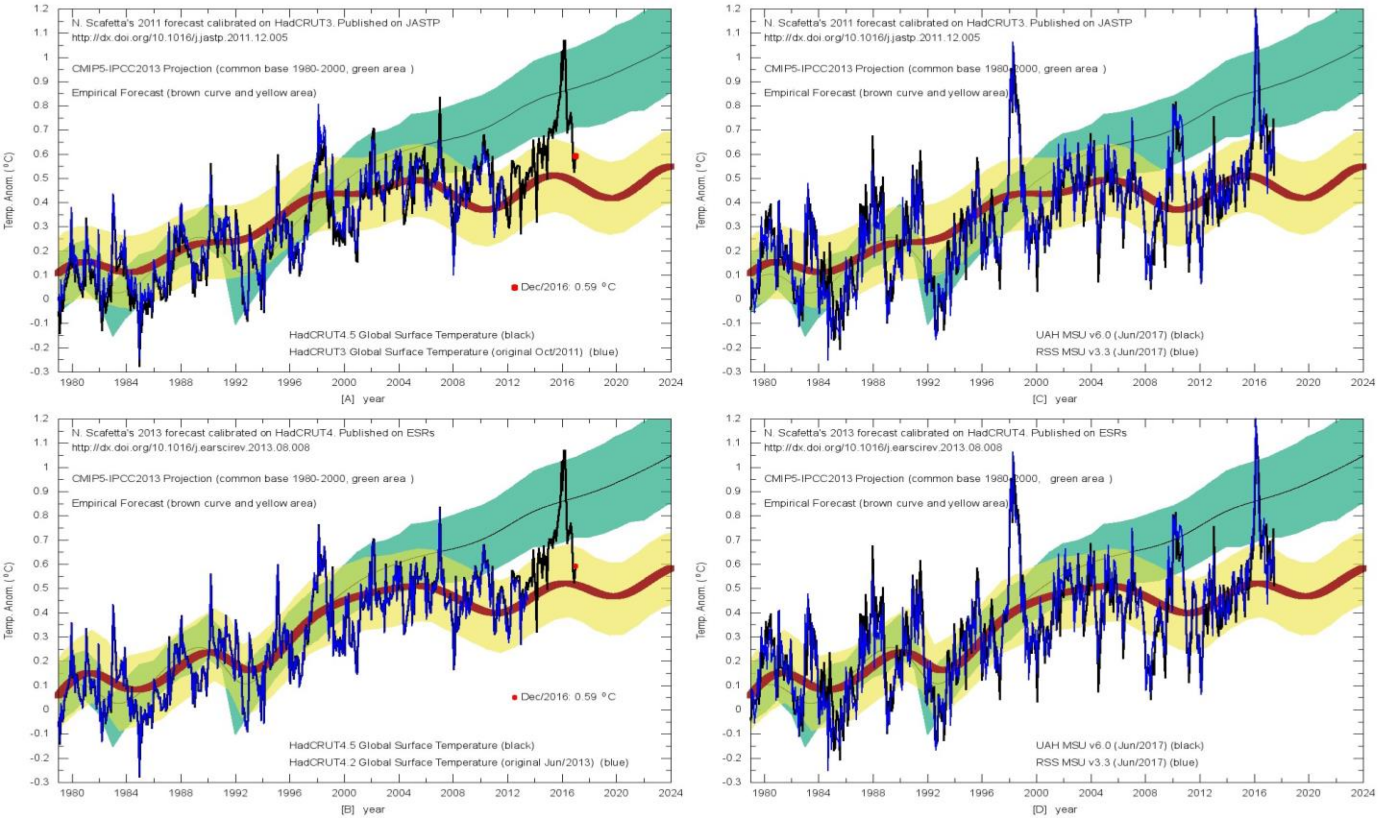

Figure 6. Performance of the semi-empirical models (yellow area) based on astronomical oscillations proposed in 2011 ([A] e [C] diagrams) and 2013 ([B] e [D] diagrams) [15,19] versus that of the CMIP5 models (green area). [A] and [B] use the HadCRUT temperature records available in 2011, 2013 and up to Dec/2016. [C] and [D] use the UAH and RSS records available up to Jun/2017. Data well agree with the Scafetta's forecast

Herein, the authors have studied the post 2000 standstill global temperature records. It has been shown that once the ENSO signature is removed from the data, the serious divergence between the observations and the CMIP5 GCM projections becomes evident. Note that Medhaug et al. [28] claim that the models agree with the post 2000 temperature trend. However, these authors did not remove the ENSO signal and used annual mean temperature records up to 2015 that camouflage the real nature of the 2015-2016 ENSO peak.

Moreover, a semi-empirical model first proposed in 2011 based on a specific set of natural oscillations suggested by astronomical considerations plus a 50% reduced climatic effect of the radiative forcing, which includes the anthropogenic forcing, performs quite better in forecasting subsequent climate changes. Thus, the GCMs used to promote the AGWT have been also outperformed [15].

This result is indeed consistent with recent findings. In fact, although the equilibrium climate sensitivity (ECS) to CO_2 doubling of the GCMs vary widely around a 3.0°C mean [3,4], recent studies have pointed out that those values are too high. Since 2000 there has been a systematic tendency to find lower climate sensitivity values (Figure 7). The most recent studies suggest a transient climate response (TCR) of about 1.0 °C, an ECS less than 2.0 °C [20] and an effective climate sensitivity (EfCS) in the neighborhood of 1.0 °C [29]. Thus, all evidences suggest that the IPCC GCMs at least increase twofold or even triple the real anthropogenic warming. The GHG theory might even require a deep re-examination [30].

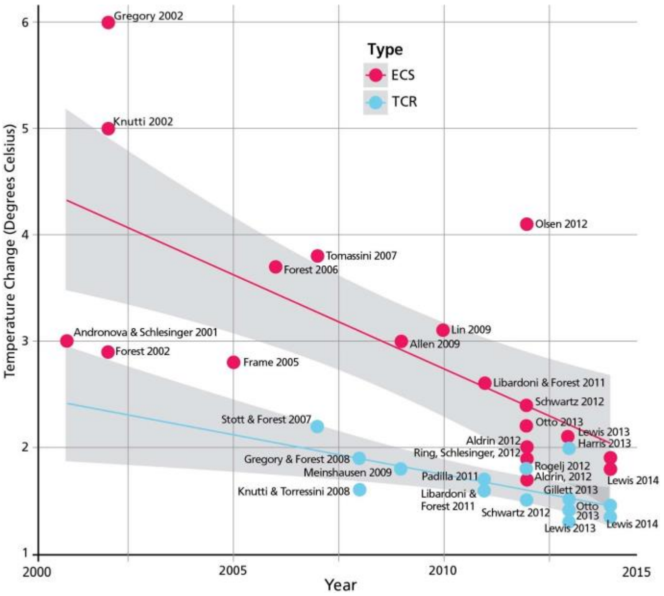

Figure 7. Compilation of published transient climate response (TCR) and equilibrium climate sensitivity (ECS) values to atmospheric CO2 doubling. (Adapted from Figure 1 in Refs. [20,27] where all references listed in the figure are reported: from link)

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