

## Original Research Article

# Semi Empirical Model of Global Warming Including Cosmic Forces, Greenhouse Gases, and Volcanic Eruptions

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### ABSTRACT

In this paper, the author describes a semi empirical climate model (SECM) including the major forces which have impacts on the global warming namely Greenhouse Gases (GHG), the Total Solar Irradiance (TSI), the Astronomical Harmonic Resonances (AHR), and the Volcanic Eruptions (VE). The effects of GHGs have been calculated based on the spectral analysis methods. The GHG effects cannot alone explain the temperature changes starting from the Little Ice Age (LIA). The known TSI variations have a major role in explaining the warming before 1880. There are two warming periods since 1930 and the cycling AHR effects can explain these periods of 60 year intervals. The warming mechanisms of TSI and AHR include the cloudiness changes and these quantitative effects are based on empirical temperature changes. The AHR effects depend on the TSI, because their impact mechanisms are proposed to happen through cloudiness changes and TSI amplification mechanism happen in the same way. Two major volcanic eruptions, which can be detected in the global temperature data, are included. The author has reconstructed the global temperature data from 1630 to 2015 utilizing the published temperature estimates for the period 1600 – 1880, and for the period 1880 – 2015 he has used the two measurement based data sets of the 1970s together with two present data sets. The SECM explains the temperature changes from 1630 to 2015 with the standard error of 0.09 °C, and the coefficient of determination  $r^2$  being 0.90. The temperature increase according to SCEM from 1880 to 2015 is 0.76 °C distributed between the Sun 0.35 °C, the GHGs 0.28 °C (CO<sub>2</sub> 0.22 °C), and the AHR 0.13 °C. The AHR effects can explain the temperature pause of the 2000s. The scenarios of four different TSI trends from 2015 to 2100 show that the temperature decreases even if the TSI would remain at the present level.

*Keywords: Climate change, Climate model, Cosmic forces, Global warming, Greenhouse gases*

## INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) has published five assessment reports (AR) about the climate change. According to IPCC the climate change is almost totally due to the concentration increases of GH gases since the industrialization 1750. The Radiative Forcing (RF) value of the year 2011 corresponds the temperature increase of 1.17 °C, which is 37.6 % greater than the observed temperature increase 0.85 °C [1]. Because of the temperature pause since 2000, the error of this model is now about 49 %. This great error of the IPCC's model means that the approach of IPCC can be questioned. One obvious reason is that IPCC mission is limited to assess only human-induced climate change. In this paper, other climate changing forces Greenhouse Gases (GHG), the Total Solar Irradiance (TSI), the Astronomical Harmonic Resonances (AHR), and the Volcanic Eruptions (VE), are analyzed and their impacts on the global temperature are quantified on the theoretical and empirical ways. The objective of this paper is to construct a global temperature data set from 1610 to 2015 and to combine the above listed climate change forces on the theoretical and empirical grounds to explain the temperature changes during this period.

Table 1 includes all the symbols, abbreviations, acronyms, and definitions used repeatedly in this paper.

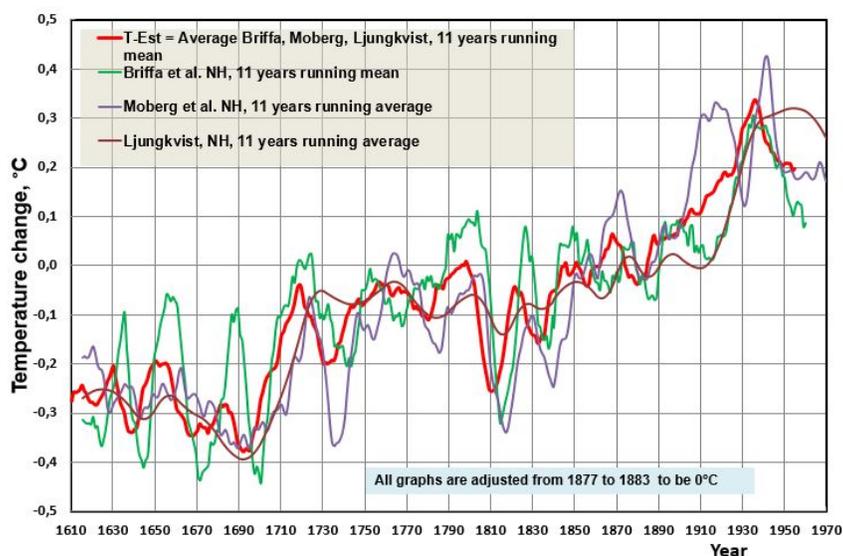
**Table 1. List of symbols, abbreviations, and acronyms**

Acronym	Definition
AGW	Anthropogenic global warming
AHR	Astronomic harmonic resonances
AR	Assessment report of IPCC
Barycenter	Gravity center of the solar system
CF	Cloud forcing
CS	Climate sensitivity
CSP	Climate sensitivity parameter ( $=\lambda$ )
ECS	Equilibrium climate sensitivity
GCR	Galactic cosmic rays
GH	Greenhouse
GHG	GH gas
GISS	Goddard Institute for Space Studies
HadCRUT4	Temperature data set of Hadley Centre
IPCC	The Intergovernmental Panel on Climate Change
ISCCP	International Satellite Cloud Climatology Project
LIA	Little ice age
NH	Northern hemisphere
RF	Radiative forcing change
SECM	Semi empirical climate model
SH	Southern hemisphere
TCS	Transient climate sensitivity
T-est	Proxy temperature estimate
T-rec	Measured temperature
T-comp	T-est + T-rec
UAH	University of Alabama in Huntsville
VE	Volcanic eruptions

## 2. CONSTRUCTION OF THE GLOBAL TEMPERATURE FROM 1610 TO 2015

### 2.1 Estimated global temperature from 1610 to 1890

There is no generally accepted temperature data for the period from 1610 to 1890 because there have been no global temperature recording methods available. Therefore, all the global temperatures for this period are estimated using different proxy methods. The author has selected three commonly used proxy data sets namely Briffa et al. [2] applying tree ring density data, Moberg et al. [3] applying tree ring data and lake and ocean sediment data, and Ljungqvist [4] applying nine different proxy methods. The data sets are normalized to give zero Celsius degrees for the period from 1877 to 1883, because the year 1880 is generally used as a starting point for the recorded temperatures. The three data sets and the average data set is depicted in Fig. 1.

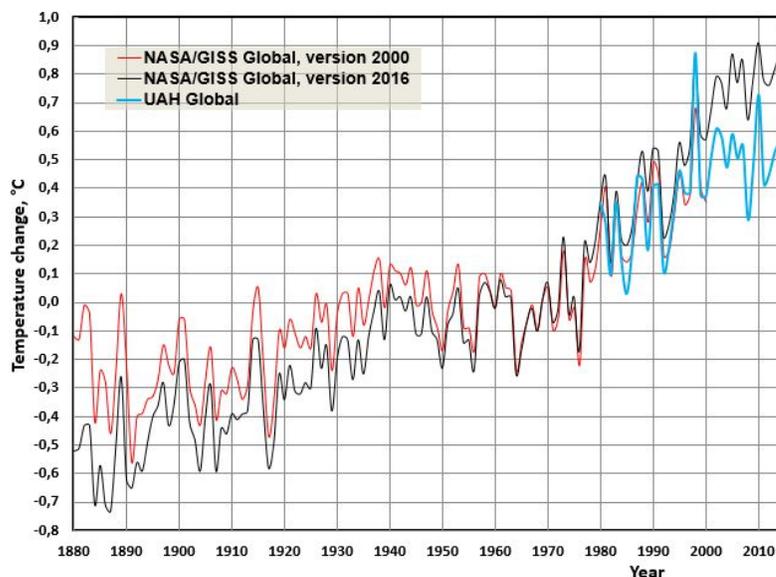


**Figure 1. Estimated global temperature T-Est constructed as the average of three temperature proxies.**

The three data sets applied cover the northern hemisphere (NH) only. The NH and SH satellite data sets of the University of Arizona in Huntsville (UAH) [5] shows that the difference of the average values from 1980 to 2015 is only 0.013 °C. This small difference means that it is justified to use NH temperatures as the global temperature change as well.

### 2.2 Recorded global temperature from 1880 to 2015

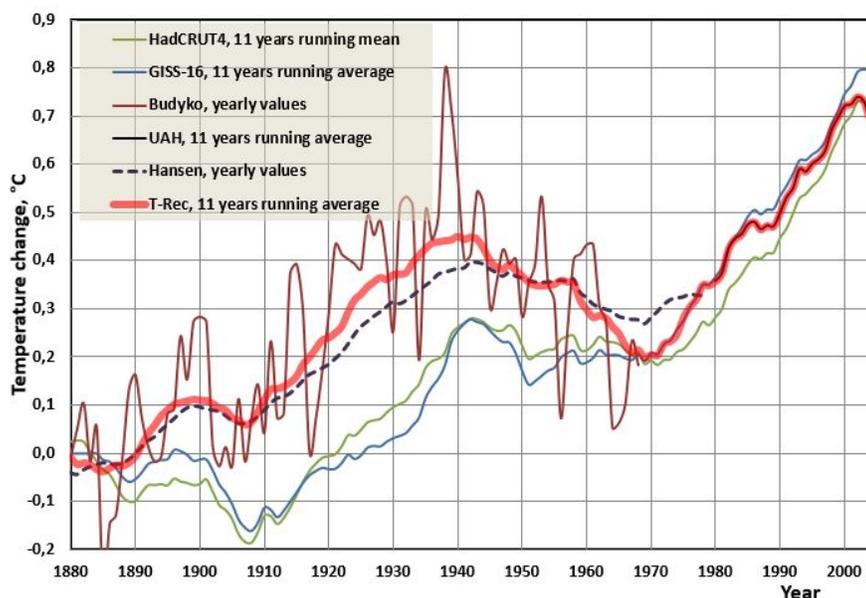
HadCrut4 [6] temperature data set starts from 1850 but the coverage of the data is not very good. A special problem has been detected in different data set versions of GISS [7]. The versions of the year 2000 and 2015 of this data and the satellite temperature data set of UAH are depicted in Fig. 2.



**Figure 2. The temperature data versions 2000 and 2016 of NASA/GISS [7] and UAH [5].**

The temperature increase from 1880 to 2000 has been 0.47 °C according to GISS version 2000, and the same increase has been 1.09 °C according to version 2016. As one can see in Fig. 2, the version 2016 (GISS-16) temperature in 1880 has been much lower but the temperature in 2000 is higher than the one of the version 2000. Also, the average temperature of GISS-16 [7] during the period from 2000 to 2015 is 0.26 °C higher than that of UAH [5]. These new versions have been adjusted in the name of data homogenization. Another suspicious element in the GISS data sets is the warming during 1930s. The extreme weather events like heat waves and draughts in USA [8, 9] related to high temperatures show that in 1930s these events have been stronger and more frequent than during the 2000s. Therefore, the author has been looking for older data before 1979, which was the starting year of UAH temperature data set.

In 1974, the Governing Board of the National Research Council of USA established a Committee for the Global Atmospheric Research Program. This committee consisted of tens of the front-line climate scientists in USA and their major concern was to understand in which way the changes in climate could affect human activities and even life itself. A stimulus for this special activity was not the increasing global temperature but the rapid temperature decrease since 1940. There was a common threat of a new ice age. The committee published in behalf of National Academy of Sciences the report [10] by name “Understanding Climate Change – A Program for Action” in 1975. The committee had used the temperature data published by Budyko [11], which shows the temperature peak of 1930s and cooling to 1969. This digitized temperature graph from 1880 to 1969 is depicted in Fig. 3. The temperature peak of 30s is little bit lower in the graph published by Hansen [12]. There is another global data graph published by Angell and Korshover [13] from 1957 to 1975 following the trend of Budyko [11] but because it so short a period, it has not been used. In constructing the recorded global temperature data set T-rec, the author has used the average of Budyko [11] and Hansen [12] data from 1880 to 1969. The temperature change from 1969 to 1979 is covered by the GISS-16 data and thereafter by UAH [5]. The UAH data has been normalized to GISS-16 [7] by equaling the average values from 1979 to 1981. All these data set values are depicted in Fig. 3.



**Figure 3. The different recorded temperature data set and the constructed data set T-rec.**

The constructed data set T-rec is normalized by averaging the decade 1880 to be same as that of T-est. The constructed T-rec shows the peak value of 1930s to be about 0.25 °C lower than the 2000s. The same difference in the GISS-00 (version 2000) is about 0.3 °C and in the GISS-16 version the difference is about 0.6 °C. As references, there are GISS-16 [7] and HadCrut4 [6] temperature graphs also depicted in Fig. 3. The difference between these data sets and T-rec is even 0.35 °C during the period from 1880 to 1950. In the late 1970s the differences between different data sets are almost neglectable, when the present warming was in the early phase. A general conclusion is that the history (1880-1960) of the global temperature of the new versions of GISS is getting colder and the newer temperatures of 2000s are getting warmer. These changes, which happen always in the newer versions of GISS, arouse doubts of justification of these changes. Soon et al. [14] have analyzed that the rural land-based meteorological stations data results into a temperature trend, which deviate from the official temperature trends especially during 30s, it is very close to T-rec calculated in this study. Their conclusion is that the urban heat island syndrome of meteorological stations has caused a bias into the measurement data. Therefore, the author considers that the T-rec constructed from the older global temperature data sets is more reliable than the GISS [5] and HadCRUT4 [7] temperature data. The combination of the T-est and T-rec is labelled as T-comp, which is valid from 1630-2015.

### 3. DEVELOPMENT OF SEMI EMPIRICAL CLIMATE MODEL (SECM)

#### 3.1 Temperature impacts of greenhouse gases (GHG)

According to IPCC<sup>1</sup> the climate change is almost totally due to the concentration increases of GH gases since the industrialization 1750 and the global warming can be calculated using Eq. (1) [15]:

$$dT = CSP * RF \quad (1)$$

where  $dT$  is the temperature change (K) since 1750, CSP (also marked by  $\lambda$ ) is a climate sensitivity parameter ( $K/Wm^{-2}$ ) and RF is radiative forcing ( $Wm^{-2}$ ) caused by GH gases and other drivers. The total RF in AR5 [15] was  $2.34 Wm^{-2}$  in 2011 and the RF value of solar irradiance was  $0.05 Wm^{-2}$ , which means 2.1 % positive contribution. The CSP is nearly invariant parameter having a typical value about  $0.5 K/(Wm^{-2})$ .

The transient climate sensitivity (TRC) according to Eq. (1) and the RF value of  $3.7 Wm^{-2}$  for  $CO_2$  is  $1.85 ^\circ C$  [16] and it is close to the average TRC  $1.75 ^\circ C$  (from  $1.0 ^\circ C$  to  $2.5 ^\circ C$ ) reported in the AR5 [1]. The equilibrium climate sensitivity (ECS) reported in AR5 [1] is in the range  $1.5 ^\circ C$  to  $4.5 ^\circ C$ , which means the average ECS to be  $3.0 ^\circ C$ . Several researchers have reported much lower ECS values than  $3.0 ^\circ C$  (the best estimates / the minimum values): Aldrin [17]  $2.0 ^\circ C / 1.1 ^\circ C$ ; Bengtson & Schwartz [18]  $2.0 ^\circ C / 1.15 ^\circ C$ ; Otto et al. [19]  $2.0 ^\circ C / 1.2$ , and Lewis [20]  $1.6 ^\circ C / 1.2 ^\circ C$ . In the above referred studies the RF [16] value of  $3.7 Wm^{-2}$  for  $CO_2$  has been used. It means that the CSP values of these studies are essentially lower than  $0.5 K/Wm^{-2}$  and it means that there is no positive water feedback. Harde [21] has used spectral analysis methods and the two-layer climate model in calculating the ECS values and his result is  $0.6 ^\circ C$ . Ollila [22] has also reported the ECS value of  $0.6 ^\circ C$  by utilizing spectral analysis and no water feedback in CSP and in RF formula:

$$dT = 0.27 K/(Wm^{-2}) * 3.12 * \ln (CO_2/280) \quad (2)$$

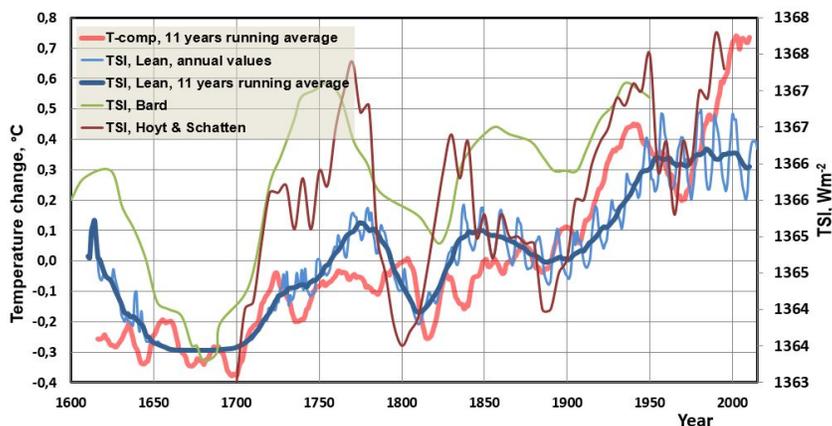
where  $CO_2$  is the actual  $CO_2$  concentration (ppm). The warming effect of  $CO_2$  according to Eq. (2) until to 2015 is  $0.28 ^\circ C$ . Ollila [23] has shown that the total precipitable water (TPW) changes are neglectable from 1979 to 2015 challenging the assumption of the constant relative humidity assumption of IPCC. Ollila [24] has combined the warming effects of  $CH_4$  and  $N_2O$  into one linear equation based on the spectral analysis calculations:

$$dT = -0.5558 + 0.0003176 * Year \quad (3)$$

The temperature increase by  $CH_4$  and  $N_2O$  from 1750 to 2015 is  $0.083 ^\circ C$  according to Eq. (3).

### 3.2 Temperature impacts of total solar irradiance (TSI) changes

The second element in the SECM is TSI (Total Solar Irradiance) changes caused by activity variations of the Sun. The TSI changes have been estimated by applying different proxy methods. Lean [25] has used sunspot darkening and facular brightening data. Hoyt and Schatten [26] have used three different indices namely sunspot structure, solar cycle, and equatorial solar rotation rate data. Bard [27] has used isotopes  $^{14}C$  and  $^{10}Be$  production rates in evaluating the solar magnetic variability. These TSI trends based on these three methods are depicted in Fig. 4. There are similarities and differences between these three trends.



**Figure 4. TSI from 1610 to 2014 Lean [25], Froelich [28], Bard [27] and Hoyt & Schotten [26] and the global temperature T-Comp.**

The author has selected the data set of Lean [25] and Froelich [28]. According to this data, TSI has increased  $2.75 \text{ Wm}^{-2}$  since the 1650's as depicted in Fig. 4. The direct warming impact can be calculated by Eq. (4) derived from the Earth's energy balance

$$T = (TSI \cdot (1 - \alpha) / 4s)^{0.25} \tag{4}$$

where  $\alpha$  is the Earth's total albedo, and  $s$  is Stefan-Boltzmann constant. The dependency of the Earth's albedo on the cloudiness can be calculated by the Eq. (5), which is fitted as the second order polynomial based on three pairs of cloudiness and albedo values [29]:

$$\alpha = 0.15497 + 0,0028623 * \text{cloudiness-\%} - 0.000009 * (\text{cloudiness-\%})^2 \tag{5}$$

McIntyre & McKittrick [30], Alley [31], Ljungvist [4], and Esper et al. [32] have come into conclusion that there have been at least two warm periods about 1000 and 2000 years ago. The direct irradiance changes have not been big enough to explain these changes, because the direct temperature impact by TSI change from 1650 to 2015 is  $0.12 \text{ }^\circ\text{C}$ . In the pioneer research Svensmark [33] has introduced evidence about the phenomena in which solar cycle variations modulate galactic cosmic ray (GCR) fluxes in the earth's atmosphere, which phenomenon could cause clouds to form. They argued that cosmic ray particles collide with particles in atmosphere, inducing electrical charges on them and nucleating clouds. Svensmark et al. [34] have found further evidences about this mechanism by studying the coronal mass ejections from the Sun. They found that low clouds contain less liquid water following cosmic ray decreases caused by the Sun. This mechanism amplifies the impacts of the original changes in the Sun's activity on the Earth's climate but the researchers have not been able to calculate the quantitative effects of TSI changes.

The author has calculated the empirical warming effects of TSI changes on the three periods: 1665 – 1703, 1844 – 1873, and 1987-1991. The periods are selected so that the positive and negative temperature effects of AHRs during these periods compensate each other, see section 4. The first period acts as a reference period, when the warming impacts of the Sun are zero. The observed temperature changes caused by the TSI changes during the two other periods are calculated by subtracting the  $dT$  caused by the GH gases from the observed  $dT$ -comp. The cloudiness-% of the selected periods are calculated applying Eq. (4)

and Eq. (5). The cloudiness-% of 1987-1991 is practically same as the one from the ISCCP data set [35].

**Table 2. TSI, albedo, cloudiness, and temperature changes during three periods.**

Period	TSI, Wm <sup>-2</sup>	dT, °C	Albedo	Cloudiness-%
1665-1703	1363.45	0.0	0.308807	68.5
1844-1873	1365	0.24	0.306988	67.4
1987-1991	1366.2	0.50	0.304343	66.0

The relationship between the temperature change and the cloudiness-% change can be fitted by the 2. order polynomial, which is slightly nonlinear:

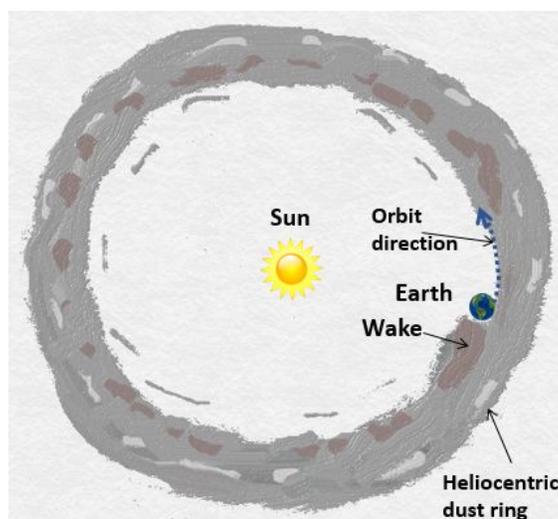
$$dT = -457777.75 + 671.93304 * TSI - 0,2465316 * TSI^2 \quad (6)$$

where dT (°C) is the temperature change by the TSI. During the analyzed period from 1630-2015 the corresponding albedo and temperature changes are calculated by Eq. (4) and Eq. (5). The temperature change of 0.50 °C caused by TSI change of 2.67 Wm<sup>-2</sup> can be divided between the direct impact of TSI change 0.12 °C and the cloudiness-% decrease of 2.67 % causing the temperature increase of 0.38 °C. Cloud forcing according to Eq. (4) and Eq. (5) is 1.7 °C/cloudiness-% and this relationship is included in Eq. (6). In this analysis, the cloudiness-% decrease from 68.5 to 66 explains the amplification of TSI increase. Because we do not have real cloudiness measurements before 1980, we do not know exactly what have been the real cloudiness variations before that year. Kauppinen et al. [36] and Ollila [29] have reported that the cloudiness forcing is -0.1 °C/cloudiness-% using two different approaches. According to this cloud forcing, the cloudiness-% change needed to explain the temperature change would be from 69.45 to 66.0. Anyway, the empirical result is that the relatively small cloudiness changes can explain, why the temperature effect of the TSI changes are amplified by a factor = 0.5 °C / 0.12 °C = 4.2.

### 3.3 Temperature impacts of astronomical harmonic resonances (AHR)

The third element of the SECM is a phenomenon called Astronomical Harmonic Resonances (AHR). This approach has proposed Scafetta [37]. He found that large climate oscillations with peak-to-trough amplitude of about 0.1 °C and 0.25 °C, and periods of about 20 and 60 years, respectively, are synchronized to the orbital periods of Jupiter (29.4 years) and Saturn (11.87) years.

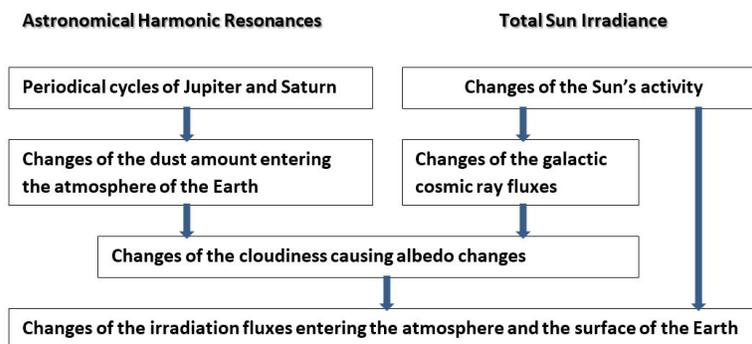
Ermakov et al. [38] have proposed that the influence mechanism of the AHR happens through the variations of space dust entering the Earth's atmosphere. The estimates of daily dust amount vary from 400 to 10 000 tons. The optical measurement of the Infrared Astronomical Satellite (IRAS) revealed in 1983 that the Earth is embedded in a circumsolar toroid ring of dust [39], Fig. 5. This dust ring co-rotates around the Sun with Earth and it locates from 0.8 AU to 1.3 AU from the Sun [40].



**Figure 5. A schematic picture of the circumsolar dust cloud reproduced by the author according to the presentation of the numerical simulations [40].**

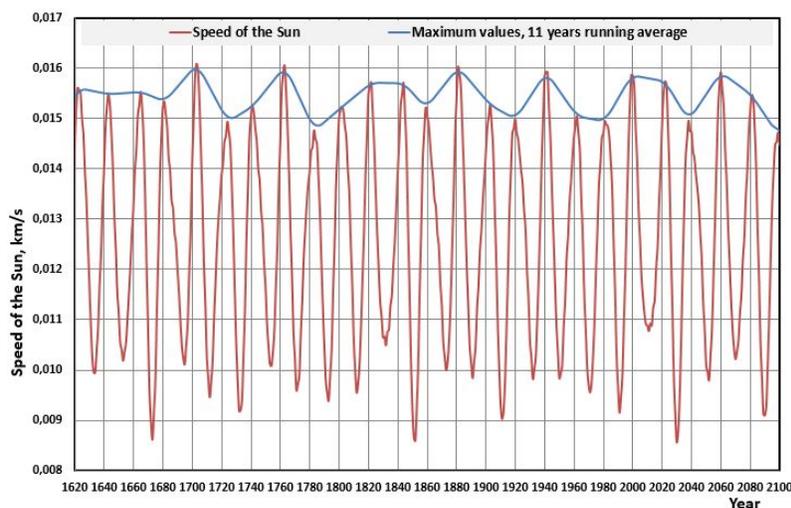
In the wake of the Earth is the permanent trail of dust particles having about 10 % greater density than the background zodiacal cloud. The darker spots in Fig. 5 represent higher concentrations of dust. Gold [39] has pointed out that the small particle in the Solar System spiral toward the Sun but they may become trapped in resonances with the planets. This should result the circumsolar dust cloud, which is not uniform. Dermott et al. [41] have shown by numerical simulations that the trailing density of the cloud is higher than the leading density and this is confirmed by the IRAS quantitative measurements. Simulations show that the dust particles are trapped in a 5:6 resonance with the Earth with the results that their paths are not symmetric about the Sun-Earth line. According to Dermott et al. [41] this asymmetric nature of the heliocentric dust cloud leads to greater dust amount encountering the Earth during September-October when the Earth is closest to the trailing cloud.

Variations in dust amounts happen during a longer time scale depending on the periodicities of the planets, which can move the dust cloud position in the Earth's orbit. Scafetta [37] has proposed that the climate can also be directly influenced by the magnetic field oscillations caused by the perturbations of the planets. AHR resonance, collective synchronization and feedback mechanisms could amplify the effects of a weak external periodic forcing. In the same way that galactic cosmic rays (GCR) cause ionization in the atmosphere, dust particles can do the same phenomenon. In this respect, the cosmic ray model and the cosmic dust model have a common meeting point but the original reasons are different: The Sun activity changes and planetary periodical motions as illustrated in Fig. 6.



**Figure 6. The influence mechanisms of TSI changes and Astronomic Harmonic Resonances (AHR).**

Ollila [24] has analyzed that using the graphical data of Ermakov et al. [38] and the GH gas warming effects, the correlation between the combined model (AHR, TSI and GH gases) and the real temperature data is very good with the coefficient of correlation  $r^2$  being 0.957 from 1880 to 2015. The calculated correlation in this case is not based on the quantified warming effects of AHR and TSI. The major objective of this paper is to assess the quantified effects AHR and TSI changes on the global temperature starting from the LIA. The periodicities caused by Jupiter and Saturn can be found in the calculated speed variations of the Sun around the Solar System Barycenter (SSB). The author has used the Horizon’s application of NASA [42] in depicting the graphs in Fig. 7.



**Figure 7. The speed variations of the Sun around the Solar System Barycenter.**

In Fig. 7 is also depicted the variations of the maximum speed values (blue line) of the 20 years’ cycles. This graphical line is 11 years running average. It should be noticed that the speed variations are not fully symmetric around the average speed and thus the temperature effects are also asymmetric. The 60-year’s cycle can be easily detected. These temperature effects of the AHR changes are based on the speed changes of the Sun. The magnitude of the AHR effect is calculated on the empirical basis. The change from 1941 peak temperature  $+0.185\text{ }^{\circ}\text{C}$  to the minimum temperature  $-0.15\text{ }^{\circ}\text{C}$  in 1962 is used to estimate the AHR impact:

$$dT = -6.43125 + 418.75 * SS \quad (7)$$

where  $dT$  ( $^{\circ}\text{C}$ ) is the temperature change and  $SS$  is the Sun speed ( $\text{kms}^{-1}$ ).

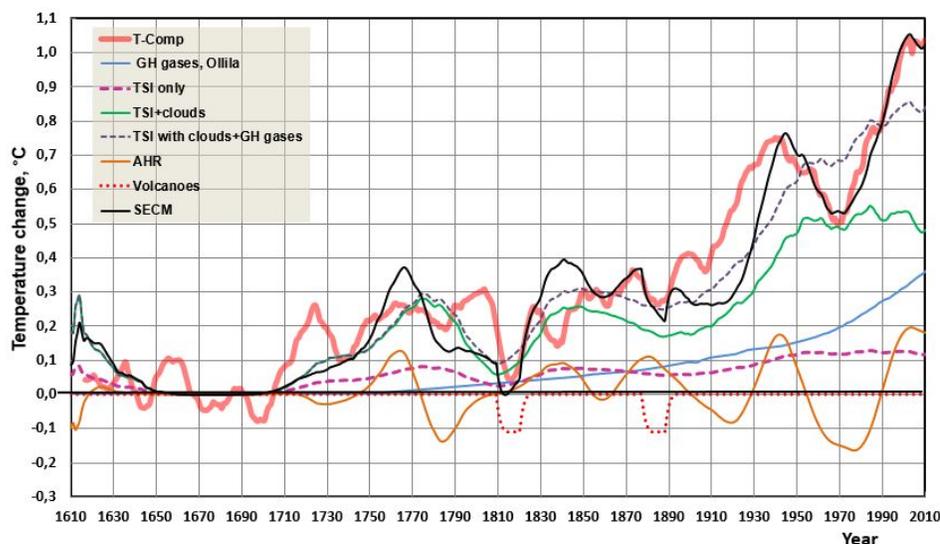
Because the TSI variations and the AHR variations finally happen through the cloudiness changes, these effects cannot be summarized directly. The average cloudiness-% according to ISCCP [35] is about 66 % and the average cloud layer is from 1.6 km to 4.0 km [43]. When the low activity of the Sun has increased cloudiness to its maximum value, the cloudiness growth by nucleation process increase cannot increase the cloudiness anymore. It means that 1) the humidity in the atmosphere is not adequate to increase the cloudiness area over the drier areas of the globe even though the nucleation process has increased or 2) the AHR actually changes the thickness and the mass of the existing clouds but these changes do not change the area of the clouds. When the Sun's activity is in maximum, the cloudiness changes by AHR can have a full effect, because in these conditions the nucleation process controls the amount of cloudiness. In calculating this relationship, the author has used a factor, which has a sinusoidal dependency on the TSI value: TSI of  $1363.43 \text{ Wm}^{-2}$  during the LIA gives factor value zero and the TSI value of  $1366.2 \text{ Wm}^{-2}$  during the present maximum gives the value = 1. The sinusoidal dependency smoothens the changes close to the maximum and the minimum TSI fluxes.

### 3.4 Temperature impacts of major volcanic eruptions (VE)

The strong volcanic eruptions, which have the Volcanic Explosivity Index (VEI) 5 or 6, have capacity to create eruption columns reaching the stratosphere [44]. The best documented eruption of this kind was the Mt. Pinatubo eruption in 1991. The aerosol cloud covered the latitudes from 60S to 60N after three months and in six months the cloud was uniform over the hemispheres [45]. These kinds of eruptions typically reduce the global temperature by  $0.5 \text{ }^{\circ}\text{C}$  from 2 to 5 years. During the period from 1600 to 2015 there has been four volcanic eruptions with VEI index 5-7 namely Tambora 1815, Krakatoa 1883, Novarupta 1912, and Pinatubo 1991. In the global temperature record constructed in this research, the eruptions of Tambora and Krakatoa can be identified but the Novarupta ja Pinatubo effects disappear in the 11 years running mean presentation. The temperature effects of both eruptions have been estimated in the same way. The temperature decrease starting from the eruption year and the consecutive years have been  $-0.5 \text{ }^{\circ}\text{C}$ ,  $-0.35 \text{ }^{\circ}\text{C}$ ,  $-0.1 \text{ }^{\circ}\text{C}$ , and  $-0.05 \text{ }^{\circ}\text{C}$ .

### 3.5 The summary of the SECM temperature effects

The estimated and observed temperature T-comp and the temperature by the SECM are depicted in Fig. 8. All temperatures are smoothed by 11 years running average. The average values of the SECM and T-comp are normalized to be the same for the period from 1630 to 2015. This figure shows that the global temperature does not follow the monotonically increasing temperature effect of GH gases. The major driver of the climate change is the Sun. The AHR explain the strong temperature peaks of 30's and the now in 2000's. Without the AHR effects the total explanation power of SECM would be much weaker since 1900. Because the temperature effects depend on the Sun activity, the magnitude of AHR effects disappears totally in 1600s. The coefficient of correlation  $r^2 = 0.90$  for the period from 1630 to 2015 and the standard error of estimate is  $0.09 \text{ }^{\circ}\text{C}$ .



**Figure 8. The estimated and observed temperature T-comp and the temperature by SECM. All temperatures are smoothed by 11 years running average.**

The average contributions of the different climate forcing elements during the centuries and in year 2015 have been summarized in Table 3.

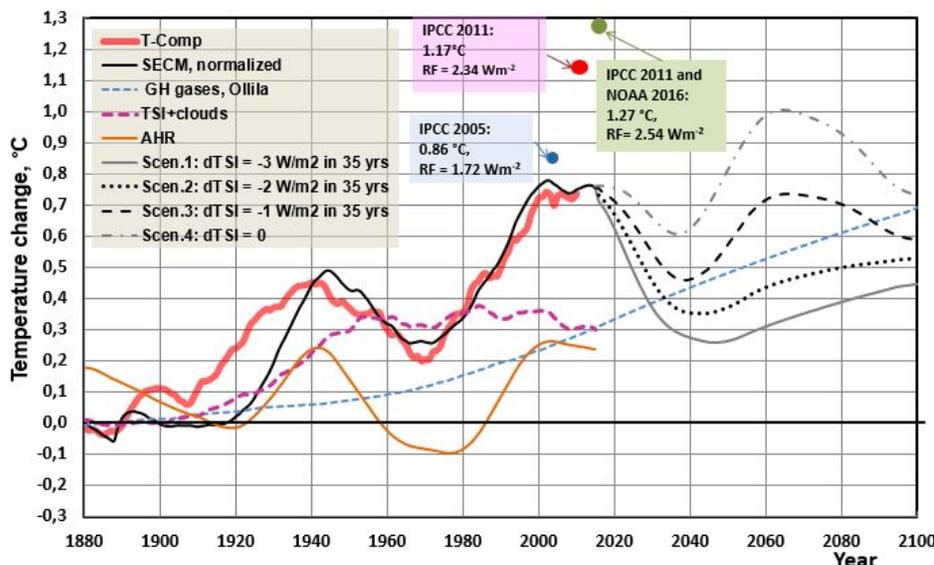
**Table 3. The summary of warming effects during the centuries, %.**

Century	Sun	GHGs	AHR	Volcanoes
1700-1800	99.5	4.6	-4.0	0.0
1800-1900	70.6	21.5	17.4	-9.4
1900-2000	72.5	30.4	-2.9	0.0
2015	46.2	37.3	16.6	0.0

The Sun’s contribution is the greatest but the warming effect of GHGs is steadily increasing having the impact of 37.3 % in 2015. The average contribution of AHRs is zero in the long run but during the shorter periods they may be positive or negative.

### 3.6 The future temperature scenarios by the SECM

The possible scenarios depending on the future changes in the Sun’s activity can be easily calculated using the SECM. The author has selected four different scenarios with different decreasing TSI trends in 35 years: Scenario 1, TSI decrease  $-3\text{Wm}^{-2}$ ; scenario 2, TSI decrease  $-2\text{Wm}^{-2}$ ; scenario 3, TSI decrease  $-1\text{Wm}^{-2}$ ; scenario 4, TSI decrease  $0\text{Wm}^{-2}$ . After the decrease phase, the TSI flux stays at the same level to 2100. These scenarios are depicted in Fig. 9.



**Figure 9. Four scenarios from 2015 to 2100 using four different TSI change trends.**

The behavior of the Sun has been difficult to predict for researchers. The two dynamo model of the Sun developed by Shepherd et al. [46] explains very well the Sun’s activity during the last three solar cycles. This model predicts that the Sun’s activity approaches the conditions, where the Sun spots disappear almost totally during the next two solar cycles like during the Maunder minimum. The AHR effect explains, why the present temperature pause has continued so long, because the positive peak duration is exceptionally long, Fig. 7. Because the AHR effect also turn to a decreasing phase after 2020, the temperature would start to gradually decrease regardless of the Sun’s activity change trend. In Fig. 9 the temperatures according to the IPCC model are depicted for the years 2005, 2011 and 2016. The error in comparison to the observed temperature is very clear and if the temperature does not increase in the coming years, the error is becoming intolerable.

#### 4. CONCLUSIONS AND DISCUSSION

The constructed average global temperature T-comp is a combination of historical proxy data sets from 1610 to 1890 and the observed temperature data from 1880 to 2015. The correctness and accuracy is difficult to estimate, because even the measurement based data sets deviate from each other even 0.3 °C in yearly values.

The semi empirical climate model SECM has the coefficient of correlation  $r^2 = 0.90$  and the standard error is 0.09 °C. The SECM follows very well the ups and downs of the T-comp. The TSI variation is the major driving force of the temperature increase having the contribution of 71-73 % during 1800 and 1900 centuries. Lean et al. [47] have carried out the correlation analysis between the NH surface temperature and the reconstructed solar irradiation and they found that a solar induced warming was 0.51 °C from the LIA to 1990’s and the correlation was 0.86. This result is in line with the results of this study but the overall accuracy of SECM of this study is better, because of GHG and AHR effects included.

The warming impact of GH gases has increased from 0 % in 1750 to 37 % in 2015. The Astronomic Harmonic Resonances (AHR) can explain the temperature peaks of 1930s and the present warming period since 2000. The Anthropogenic Global Warming (AGW) theory

cannot explain any periods with decreasing temperatures. It is also obvious that the climate model of IPCC [1], which is based on the sums of the radiative forcings (RF), gives about 50 % too high value in 2015. In this study, the author has used the formula of Ollila [22] in calculating the warming impact of CO<sub>2</sub>. This formula does not assume the constant relative humidity but the constant absolute humidity both in the radiative forcing and in the climate sensitivity parameter calculations.

The four scenarios calculated to 2100 show that the temperature would start to decrease after 2020 even though the TSI level would stay at the present level.

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