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Is the Sun tending the Earth to Warm?

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ABSTRACT

Scientists have spent decades figuring out what is causing global warming. They are believed that the increases in the greenhouse gases and aerosols concentration are the main cause of this warming. However, there are many theories discussed the natural sources, such as the solar parameters and volcanic eruptions and their effect in the climate change where the influence of this parameters on global warming are still ongoing. In this paper we will try to study how the solar parameters have a great effect in the global change, which will mean it's playing an important rule in our climate, and their effect beside the man-made gases may produce a dangerous factor that threatening the human life.

Keywords: Solar activity; regional climate change; cyclic variations; surface air temperature; climatic change

1. Introduction

Global warming is a term used to describe an increase over time of the average temperature of the Earth's atmosphere and oceans. It plays an important role in the ongoing public debate concerning global warming and the risk of many parameters that led the climate change. The observations of the global warming of the Earth since the beginning of the 20th century have been employed to infer that increased concentration of greenhouse gases are the cause. Naturally, this leads to the question of whether or not the Sun is playing an active role in this temperature rise.

Human activities, in particular those involving the combustion of fossil fuels for industrial or domestic usage and biomass burning, produce greenhouse gases and aerosols which affect the composition of the atmosphere. The emissions of chlorofluorocarbons (CFCs) and other chlorine and bromine compounds have not only an impact on the radiative forcing, but have also led to the depletion of the stratospheric ozone layer. Land-use change due to urbanization, human forestry and agricultural practices affect the physical and biological properties of the Earth's surface. Such effects change the radiative forcing and have a potential impact on regional and global climates.

For about a thousand of years before the industrial revolution, the amount of greenhouse gases in the atmosphere remained relatively constant. Since then, the concentration of various greenhouse gases has increased. The amount of carbon dioxide, for example, has increased by more than 30 % since pre-industrial times and is still increasing at an unprecedented rate of on average of 0.4 % per year, mainly due to the combustion of fossil fuels and deforestation.

Climate model projections, summarized in the latest IPCC, reported and indicated that the global surface temperature is likely to rise a further 1.1 to 6.4 °C during the 21st century (IPCC, 2007; 2009). The uncertainty in this estimate arises from the use of models with differing sensitivity to greenhouse gas concentrations and the use of differing estimates of future greenhouse gas emissions. Most studies focus on the period leading up to the year 2100. However, warming is expected to continue beyond 2100 even if emissions stop, because of the large heat capacity of the oceans and the long lifetime of carbon dioxide in the atmosphere (Archer, 2005; Solomon *et al*, 2009; El-Borie *et al*, 2010)

However, statistical analyses of the climate records since 1860 reveal significant interannual and interdecadal variabilities (Allen and Smith, 1994; Wigley, 1997; Crowley, 2000; Benestad, 2002; Mann *et al.*, 2005; Klick, *et al.,* 2008), suggesting that the cause of the global warming is more complex than the influence of increasing greenhouse gases alone, but there are other parameters that have a high effect to change the global surface temperature. These parameters are the solar activity and geomagnetic indices, where the Earth climate system would have been controlled by the Sun before the pre industrial era (Hoyt and Schatten, 1997; North and Stevens, 1998; Pulkkinen *et al*., 2001; Souza Echer *et al*., 2009), but later anthropogenic effect began to dominate.

The scientists studied many parameters to show the Sun climate interaction, these parameters are the sunspot numbers Rz (David *et al*, 2002; Valev, 2006; El-Borie and Darwish, 2006; Duhau and de Jager, 2008; Souza Echer *et al*, 2009), sunspot area (David *et al*, 2002), solar cycle length (Lassen and Friis-Christensen, 1991), geomagnetic *aa* indices (Cliver and Boriakoff, 1998; Clivered *et al.,* 2002; El-Borie *et al.*, 2009; 2010), solar irradiance changes (Chapman, 1987; Lee III *et al.,* 1995; Pap, 2002; Floyd, 2002; Douglas, 2004; Mendoza, 2004).

Climate commitment studies the prediction that even the levels of greenhouse gases and solar activity were to remain constant; the global climate is committed to 0.5 ^{0}C of warming over the next hundred years due to the lag of warming caused by the oceans. Hence, solar activity and green house gases play an important role in changing the climate.

Georgieva *et al,* (2007) studied the relation between long-term changes in the solar activity and prevailing type of atmospheric circulation for the last four centuries, they found that when the southern solar hemisphere is more active, increasing solar activity increases meridional circulation for atmosphere.

There are many other parameters expel from Sun have a high effect to change the global surface temperature such as the ultraviolet radiation that affect the stratospheric ozone in the upper atmosphere, and its modulation effects on cosmic rays which in turn may affect the cloud cover and thus lead to temperature changes (Svenmark, 1998). At time of enhanced activity on the Sun, the solar wind is pumped up with intense magnetic fields that extend far out into interplanetary space, blocking more cosmic rays that would otherwise arrive at Earth. The resulting decrease in cosmic rays means that fewer energetic charged particles penetrate to the lower atmosphere where there may help produce clouds, particularly at higher latitude where the shielding by Earth's magnetic field is less. The reduction of clouds, that reflect sunlight, would explain why the global surface temperature gets hotter when the Sun is more active (Lang, 2002).

2. Data and analysis

It is now obvious, according to past data on large variations in planetary surface temperature over timescales of many thousands (even millions) of years, that the Earth's global climate change is determined not only by internal factors but also by factors originating in space. These include the moving of the solar system around the center of our galaxy, thus crossing galactic arms, clouds of molecular dust, nearby supernovae and supernova remnants. Another important space factor is the cyclic variations of solar activity and the solar wind (mostly on the scales of decades and hundreds of years), (**L. I. Dorman, 2012).**

In our work, we get our data for the solar parameter like (the geomagnetic activity, aa, the sunspot number, Rz, the dynamic pressure of solar wind, nv^2 , the total solar irradiance, TSI, and the solar flares) and data for the GST that referee to the climate from the available web site such as (National Geophysical data center, Omni web data Exploler, World data center, and many other) this data may be available as an daily or monthly or annual data we selecting the type of data that we need in our work.

To investigate the degree of the relationship between the surface air temperature of, and the solar activity. Linear regression has been used, where the linear regression has been used to determine the degree of similarity between two signals with zero lag. If the signals are identical, then the correlation coefficient is 1; if they are totally different, the correlation coefficient is 0, and if they except that the phase is shifted by exactly 180, then the correlation coefficient is -1.

Then the running cross-correlation was applied to find the similarity between two signals with lag time (T). Also to investigate the periodicity of the solar indices and surface temperature, we have used the Fourier analysis technique. A series of power spectral density (PSD) have been performed. The results of PSDs were smoothed using the Hanning window function. This is necessary since most of the disturbed features will completely disappear, while the significant peaks are clearly defined. Nevertheless, the particular window chosen dose not shifts the positions of the spectral peaks. All harmonic signals have been obtained by using of 90, 95, 99 % confidence level.

3. Results and Discussion

It is obvious that the Sun is tremendously important for the life on the Earth while, the interaction of the solar output variations with the atmosphere is still not well understood. It is well known that the energy produced by fusion reactions in the solar cores, is transferred to the outer upper layers of the Sun by radiation and convection processes to finally escape into space by radiation. As the energy variations are far from the constancy, and due to the interaction between such radiation and the Earth magnetic field, we may expect changes on terrestrial level-auroras, proton events, geomagnetic storms which may in turn, have some disruptive effects on the Earth such as on communications, on board satellite equipment, navigation systems, electric powers, etc (Klick *et al.,* 2008).

To investigate the relation between the solar variation and the climate we do it through four steps to have a complete vision for the solar activity and the earth climate.

A. Solar Variability and Their Possible Role on the Global Warming through the last century (1880-2008)

As a first order we start to study the relation between the solar activity and the global surface temperature due to the long period from 1880-2008, the longest historical records of the solar variability are the sunspot number. It is the number of the dark spot that appear in photosphere and it is reflected the magnetic activity of the sun. In the middle of the 19th centuries it was discovered by druggist H.Schwabe that the number of spots on the sun varied in a cyclic manner with a characteristic time of about 11 years. After the sunspot numbers, aa index, the time series characterizing the geomagnetic activity provides the longest data set of solar proxies which goes back to 1868 (Mayaud,1972). The role of geomagnetic activity in the climate change becomes a topic theme of many recent studies. So for this reason we choose the sun spot number Rz and the geomagnetic index aa as an indicator for the solar activity beside that they are the only parameter that have a data cover this period, our analysis go on the annual and monthly reading for them.

Figure 1 shows the 3-year running averages of the yearly GST. It displays a substantial year–to-year variability of the global temperature GST, as well as, coherent long-term change over the period 1880 to 2008. The time interval is based on the coverage of both pre-industrial and fast-industrial growth era witnessed in this period. The values of GST are seen to show a broad variation with clear minimum near the beginning of the 20th century. A deep minimum in GST is evident and few cold decades are clearly seen. The sunspot activity also reached a minimum around the same period as the GST (M.A. El-Borie, et al, 2006). Around the year 1890 the GST had a tendency to increase almost steadily for more than hundred-year ago, showing the Earth's environment has been becoming warmer with time since the pre-industrial era. The annual mean temperature showed a first warming of about +0.45°C from 1890 to 1940 (+0.09°C/decade). An important feature is that the temperature rose sharply by about 0.4ºC between 1910 and 1940. The concentration of the man-made gases (greenhouse gases) increased and occurred after 1940 and therefore, cannot be the cause of the 0.4ºC warming that occurred earlier years. Then there was a cooling period of about -0.22°C from 1940 to around 1970 (~ -0.07°C/decade), followed by a second phase of warming of about +0.7°C from 1975 to 2008 (~ +0.23°C/decade).

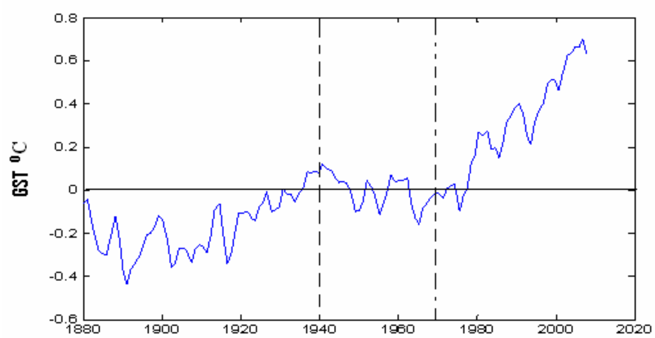

Fig 1. The 3-year running averages of the annual-mean global surface temperature throughout the period 1880-2008

The correlation between the GST and the solar activity studied by using the running cross correlation technique, which showed that the solar parameters have a strong and moderate correlation for aa and Rz with the GST reach to 0.64 and 0.33, respectively. Beside that it shows the correction become higher with 2-3yr lag time and it's clear as shown in figure 2.

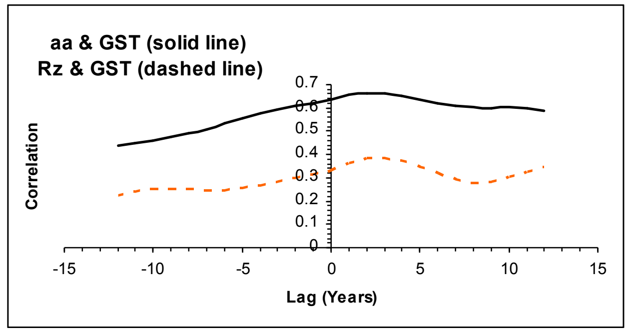

Fig . 2 Running cross-correlation (based on the annual averages) between the GST with aa (solid line) and Rz (dashed line)

Then we ended our study through this period by comparing the periodicity for the geomagnetic index and the sunspot number with the global surface temperature by finding the power spectrum density for each one of them. From the comparison between them we can see that the global surface temperature are strongly sensitive to the 21.3-yr, 10.7-11.6 yr and 5.3 yr variations that observed in the considered geomagnetic and sunspot spectra. From that we can conclude that the solar activity may play an important role in the climate change, Also this obtained result demonstrate that the interplanetary magnetic field (IMF) effect is more powered on GST than the solar activity cycle (M.A. El-Borie, et al, 2010).

B. The connection between the solar activity and the climate change throughout the recent forty years.

After we discussed the variation of the solar activity through the long period, and their effect in the climate. We need to take a close look to see the connection between them but this time due to the last forty years.

Four components (monthly and yearly averages) that may be closely associated with the climate have been studied, which are the geomagnetic activity, aa, the sunspot number, Rz and the dynamic pressure, nv2, and total solar irradiance, TSI.

In Fig. 3 the time series of monthly averages global temperature (GST), geomagnetic activity index (aa), sunspot number (Rz), the dynamic pressure (nv^2), and the total solar irradiance (TSI), are shown and their very well-known behavior is easily seen. The Rz has a cyclic variation with the minimum of a cycle reaching the same level than the minimum of the preceding cycles, while aa shows an increasing trend in both minima and maxima values of the cycles.

Generally, the aa maxima had an irregular pattern and two aa maxima were observed (double peaked modulations), one near the maximum solar activity period and the other in the descending phase (G.N. Shah, S. Mufti, 2005). It is believed that the first peak is caused by coronal mass ejections, whereas the second peak is caused by geomagnetic disturbances due to the coronal-hole fast streams, which are more frequent in this part of each solar cycle (I.G. Richardson, et al, 2000). In some cycles (1985-1996) the geomagnetic aa have three peaks structure, the

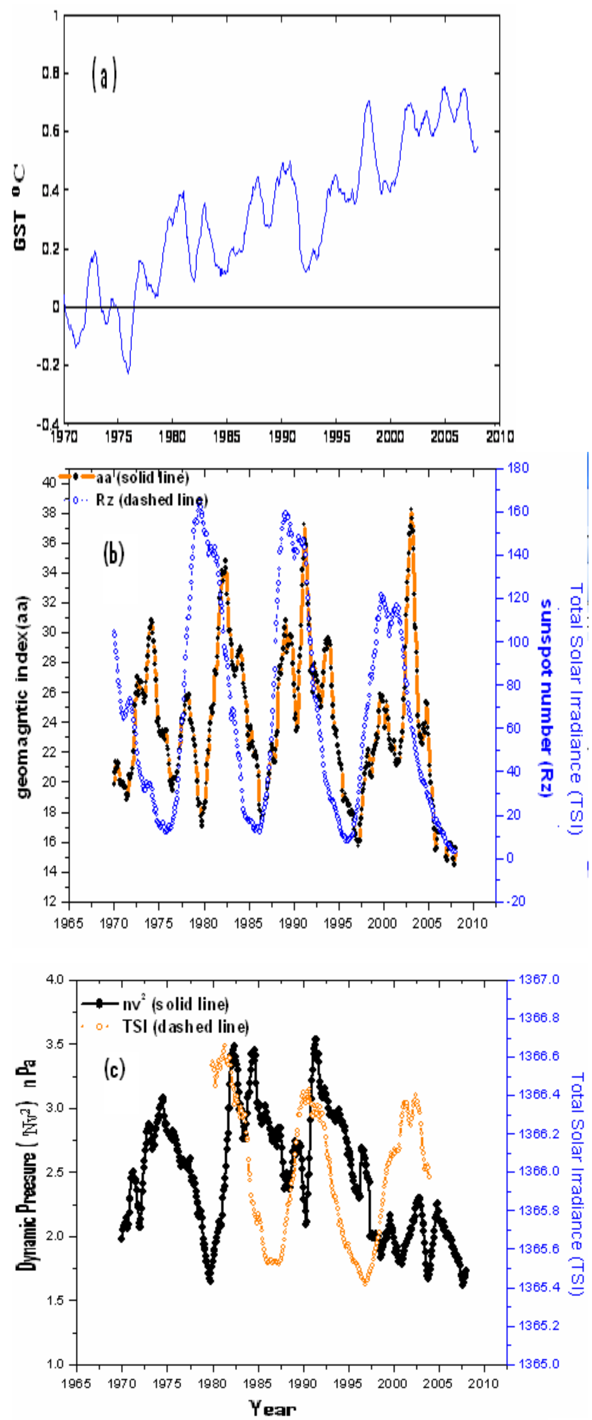

Fig. 3 Monthly variations of GST, aa, *Rz*, nv^2, and *TSI* with time series (1970-2008)

first peak before or in solar maximum and the other two in the descending phase of solar activity cycle.

During the period 1970-2008, the second warming portion, the aa geomagnetic magnitudes values have greatly increased than the two previous periods [12]. The largest peak, over the considered period, was in 1991 and the warmest year was 1998, of 7-yr apart. The second and third largest peaks were in 2003 and 1994, respectively. For comparison, the separation-time between the second warmest year in 2002 and the third greatest geomagnetic is 7 yr.

When we use the straight-line fit method, it indicates a close correlation between Rz and GST, the correlation coefficient is r = +0.48. The corresponding correlation between nv2 and TSI with temperature have gave r = +0.48 and 0.6, respectively. Also this correlation increased with lag time, such as The largest correlation coefficients for aa-GT become r= 0.4 with a lag of 2-3 year, Adding to this the biggest positive correction between nv^2-GT was appeared with a lag of 4-5 year which equal r = 0.5 as shown in figure 4.

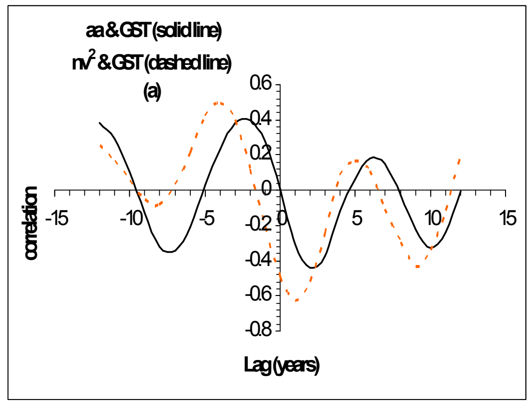

Fig.4. Running cross-correlation (based on the 3-year running averages) between *GST* with aa index and nv^2

Then the power spectrum density shows that the global surface temperatures are strongly sensitive again to the 8.5 yr, 4.2yr and 3.5 yr variations that observed in the considered geomagnetic and solar parameters spectra. Furthermore, the results of PSDs have displayed that the leading spectra of *aa*, Rz and *TSI* spectra precedes the leading peak of *GST* spectra, by a few years. Table 1 represents The significant peak for *GST, aa, Rz,* nv^2 and *TSI* with confidence interval through this period. (M.A. El-Borie, et al, 2010)

Table 1 The significant peak for *GST, aa, Rz,* nv^2 and *TSI* with confidence interval.

Period 1970-2008 monthly	Main Period existence significant				
	aa	Rz	*GST*	nv^2	*TSI*
10.7	+<99	+<99	------	------	+<99
8.5	------	------	+<99	+<99	------
5.3	+<95	------	------	------	------
4.2-4.7	+<95	------	+≥90	+≥90	------
3.5	------	------	+<99	------	------
3.04	+≥90	------	------	------	------

C. Solar and geomagnetic activity on the regional climate

` Here we try to study the relation between the solar, geomagnetic activity and the climate by another way which was chosen many numbers of countries around the world with different latitude and longitude (such as Egypt, Canda, USA, Japan …etc) then find the effect for the solar parameters on the regional temperatures trough each country. Now we will explain our result just for two countries for example Egypt and Canada.

- **For Egypt (M.A. El-Borie, et al, 2012 b)**

18 climate stations have been selected in Egypt, which cover different areas in the country and selected upon several criteria, namely: different heights and locations. Egypt surface air temperature (ESAT) has been considered for the period from January 1881 to December 2009, which covers 12 solar cycles (12-23). And the monthly sunspot number , solar flare, solar flux and total solar irradiance TSI as solar activity indicators as well as the geomagnetic index aa was used to compare with the ESAT.

By studying the ESAT, it shows a series of warming and cooling ending with a high significant warming trend of $1.392^{\circ}C$ along the last four decades. No trend is observed for the whole period from 1912 to 2009. Negative correlation for the entire period between ESAT and solar- geomagnetic activity indices are observed at lag time ~(–6yrs), except total solar irradiance that reveals positive correlation (0.4%) with ESAT. After the segmentation that applied to the data sets according to the solar cycle lengths, it shows that the sign of the correlation between ESAT and Rz depends on North–South sunspot area, being positive when the Northern solar hemisphere is predominantly more active, and negative when more active is the southern hemisphere except for the cycle 13.

From the other point spectral analysis of ESAT reveals significant periods of 25.6yr, 10.7yr, 8yr, and 2–5yr, confirming a remarkable role of solar and geomagnetic activities on Egypt's temperatures. Figure 5 shows the power spectrum density for ESAT. (M.A. El-Borie, et al, 2012 b)

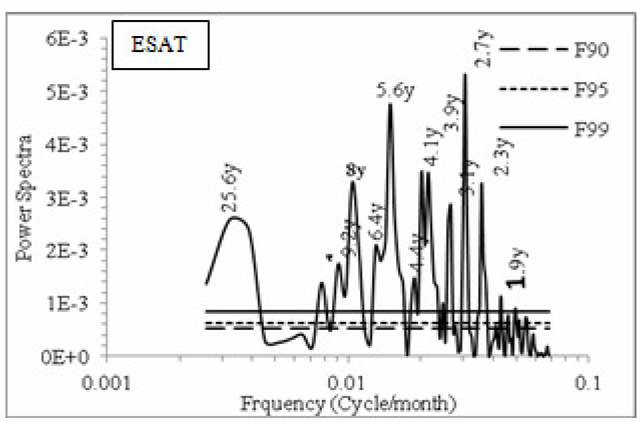

Figure 5: Power spectra of ESAT

- **For Canada (M.A. El-Borie, et al, 2012 a)**

The temperature data (stations) used in Canada cover 45-820latitudinal and 54-1270 longitudinal regions. The distribution of these meteorological stations is shown in Fig (6). This station was selected to cover Canada city. The data stations separated into four sub- regions (from G1 to G4), corresponding to its elevations values.

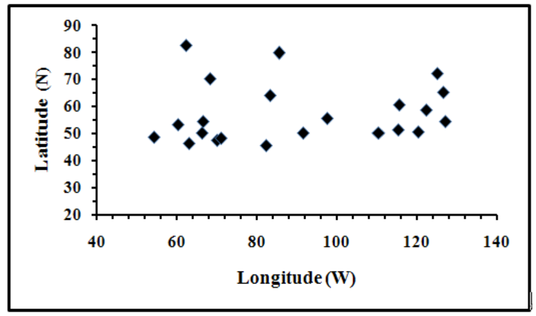

Figure 6 Distribution of stations in Canada that used in our calculations

The Cross correlation analysis between each parameter (*aa & Rz*) and the four sub-region (*G1, G2, G3* and *G4*) for the ST in Canda*.* This analysis revealed that the *aa* index is well correlated with the anomalies G1, r = 0.28±0.09 during this period with 12.5-14.2 yr lag time, it also has a high anticorrelation between aa and G4 through cycle 13 with magnitude r = -0.678 ± 0.084. We also, found a modulate correlation between the sunspot number *Rz* and G1 (r = 0.32 ± 0.09), when *Rz* lag the *GST* by 12.5 years.

Table 2 show the correlation between the geomagnetic index and the regional temperature in Canada trough different solar cycle.

Table 2. The Correlations coefficient between (global Temperature and Geomagnetic index (aa) for different solar cycle)

Solar Cycle number	Correlations coefficient R			
	Group 1	Group 2	Group 3	Group 4
13	-----	0.647±0.084	-----	-0.678±0.084
14	-----	-0.049±0.085	0.167±0.085	0.336±0.085
15	-0.095±0.091	-0.332±0.091	-0.443±0.091	-0.449±0.091
16	-0.347±0.091	-0.241±0.091	0.038±0.091	0.173±0.091
17	-0.271±0.089	0.56±0.089	-0.324±0.089	0.092±0.089
18	-0.562±0.090	-0.168±0.090	-0.481±0.090	-0.412±0.090
19	-0.048±0.089	0.159±0.089	0.307±0.089	0.373±0.089
20	0.007±0.084	-0.106±0.084	-0.190±0.085	0.417±0.084
21	-0.238±0.090	-0.231±0.090	-0.253±0.090	-0.256±0.089
22	-0.219±0.092	-0.254±0.092	-0.147±0.092	-0.021±0.092
23	-0.132±0.102	0.376±0.099	-0.264±0.099	-----

From this result we can conclude that the solar and geomantic index play an important rule in the change in the regional surface temperature.

D. Cosmic Ray and the Climate change

Many authors have considered the influence of galactic and solar CR on the Earth's climate. Cosmic radiation is the main source of air ionization below 40–35 km (only near the ground level, lower than 1 km, are radioactive gases from the soil also important in air ionization. The first who suggest a possible influence of air ionization by CR on the climate was Ney.

(**M.A. El-Borie, elshenawy paper that not publish)** investigate the relation between monthly data for the (CRI) and the Global surface temperature (GST), by comparing the periodicity and the variation of (CRI) that was measured from high latitude neutron monitor (NM) for different countries, with (RST) for this country such as ([IMAX-NM ,USA] , [CALGARY-NM,CANDA] ,[MT_ NORIKURA-NM,JAPAN]and [POTCHEFSTROOM-NM, SOUTHAFRICA]).

From comparing the power spectrum between them, it shows that the most prominent spectral peaks have similar periodicities for example (3.2-3.7 yr, 5.8 yr and 8-9.1 yr). Beside that it confirmed that with different way of calculating the mean (monthly or yearly over the considered period) of the same data base, the same peaks will appear but may be with shifted in location.

4. Conclusion

We believe that The Sun is the source of the energy that causes the motion of the compact atmosphere and thereby controls weather and climate and in turn, any change in the energy received at the Earth's surface will therefore affect climate. During stable conditions there has to be a balance between the energy received from the Sun and the energy that the Earth radiates back into space.

Through the years the conflict between researchers about whether global warming is a human-generated phenomena or a result of solar variability has raised many question marks. The aim of this work is to try to answer some of these questions by studying the possible role of some solar variability parameters such as the aa geomagnetic index, the sunspot number Rz, the total solar irradiance TSI, the dynamic pressure nv2 , the solar flares and the cosmic ray on the regional and the global surface temperature changes.

From our results we believe that the solar activity and the geomagnetic indices could be a real reason for the change that happening in the climate of the earth today. Beside that We think that the solar and anthropogenic greenhouse forcing are roughly equal contributors to the rise in global temperature during the recent years and their effect together may produce a dangerous factor that threatening the human life in the future.

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