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Amando Leyva-Contreras, J. Pérez-Peraza, I.Ya. Libin *, M. Valdés-Barrón
Instituto de Geofísica, UNAM, Cd. Universitaria
04510 México, D.F., México

C. Salinas-Zabala
Centro de Investigaciones Biológicas del Noroeste
Unidad Guaymas
A.P. 349, Guaymas
85480 Son., México

P. Mosiño-Alemán
Centro de Ciencias de la Atmósfera, UNAM, Cd. Universitaria
04510 México, D.F., Mexico

V. Fomichev
Institute of Geomagnetism, Ionosphere, and Radio Wave Propagation
Troitzk, Moscow Region, Russia

Instituto de Geofísica UNAM
Ciudad Universitaria
04510 México, D. F.
México

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Temperature variations in the northwest of Mexico in the course of solar and geomagnetic activity cycles

By

A. Leyva-Contreras, J. Pérez-Peraza, I.Ya. Libin(*), M. Valdés-Barrón
Instituto de Geofisica, UNAM
México D.F. 04510

C. Salinas-Zavala
Centro de Investigaciones Biológicas del Noroeste,
Unidad Guaymas,
A.P. 349, Guaymas, Son., (85480)

P. Mosiño-Alemán,
Centro de Ciencias de la Atmósfera, UNAM
México D.F. 04510

V. Fomichev,
Institute of Geomagnetism, Ionosphere, and Radio Wave Propagation
Troitzk, Moscow Region, Russia

Abstract

A possible effect of solar activity on the behavior of the earth ground-level temperature has been studied on basis of measurements of superficial temperature in North-West of Mexico. Both the conventional methods of spectral analysis and autoregression methods have been used to determine common cyclicities. Preliminar results of the temperature and cosmic ray intensity and the predominance of a 22-year cycle (proposed by the Pudovkin-model) has been confirmed. We conclude that the proposed physical mechanism in [3] of the continuous influence of Solar Activity (SA) and Geomagnetic Activity (GA) on the weather and climate is correct.

(*) Visitant researcher.

INTRODUCTION.

In [1], very interesting and important results were reported about studies performed during the 1930's years on the relationship of climate elements and solar activity. As reported by H. H. Clayton in [1], W. B. Schostakowitsch analyzed the mean values of aire temperature, pressure and rainfall at surface level in 5-year period, embracing the periods of maximunm solar activity and comparing them with similar means of 5-year periods containing the periods of minimum solar activity. So, Schostakowitsch found that in some regions the departures of the weather elements from their normal values run parallely with the sunspot changes, while in other regions they are reversed. In particular, according to the obtained maps, the mexican zone is inside the region when temperature averaged higher and precipitation averages less at sunspot maximum than at minimum.

In work [2] was shown, on the basis to the model of influence of the solar activity over the lower atmosphere [3], that it is possible to expect the presence of a definite 22-year cycle in the variation of the air temperature, as a consequence of several factors: the variations of the galactic cosmic rays, the general level of the solar activity (characterized by the numbers of Wolf), as well as the magnetic activity (related with the development of recurrent disturbances). In the course of the odd 11-year cycles of the solar activity both processes correlate well between, while in the even cycles this correlation disapears (because the behavior of the galactic cosmic rays, that exerts an influence defined in the atmospheric temperature [3]) results different in even cycles to that observed in odd cycles. This asymmetry in the behavior of the galactic cosmic rays leads necessarily to an asymmetry in the behavior of the atmospheric transparency [4], which with the time can be translated in the presence of a cycle of 22 year in meteorological parameters.

Eddy [4] in a deatiled study of long-term variations drew attention to the coincidence of the so-called Maunder minimum in solar activity with the coldest excursion of the "Little Ice Age", already noted by many who had looked at the possible relationships between the Sun and terrestrial climate. This together with other coincidences mentioned might suggest a possible relationship between the overall envelope of solar activity and terrestrial climate. Eddy pointed out that this apparent long-term relationship might be due to changes in the total solar irradiance.

Reid [5,6] noticed a striking similarity between the globally averaged sea surface temperature (SST) and the long-term variation of solar activity represented by the 11-year running mean Zürich sunspot number. He pointed out that the two time series had several features in common. Most noteworthy was the prominent minimum in the early decades of this century, the steep rise to a maximum in the 1950s, a brief drop during the 1960s and early 1970s followed by a final rise. Based on this comparison, Reid suggested that the solar irradiance may have varied by approximately 0.6 % from 1910 to 1960 in phase with the 80~90 years cycle (the Gleissberg period) of solar activity representad by the envelope of the 11-year solar activity cycle. Using a simple one-dimensioal ocean thermal model of Hoffert el al. [7], Reid found that the necessary range of variation in the solar constant during the 130 year period is less than 1 %. This magnitude is consistent with the long-term trend which could be derived from existing observations of the solar irradiance during the recent years by means of satellites, rockets, and baloons. Only recently, during the satellite era, reliable measurements of the Sun's irradiance variability have been presented [8].

The statistical correlation between the two time series used by Reid was reported to be 0.75. Although this is apparently better than the correlation between the observed mean global temperature and modelled temperature caused by the increased greenhouse effect, Friis-Christensen and Lassen [9] pointed out a major difficulty with this interpretation. They examined the Northern Hemisphere land air temperature and noted that this record was shifted both the SST record and the sunspot record by as much as 20 years as seen in Fig. 1. From this discrepancy they conclude that if a cause and effect relation between solar activity and terrestrial climate is to be maintained it is unlikely that long-term variations of solar activity can be sufficiently well represented by some average value of the sunspot number itself. They further pointed out that the long-term variation of the variable length of the "11-year" sunspot cycle was well correlated with the Northern Hemisphere land surface temperature during the entire interval of systematic temperature measurements and proposed that the solar cycle length could provide an indicator of long-term variations in solar luminosity.

In Fig. 2 the variations of sunspot cycle length together with 11-year running mean of the North Hemisphere temperature are shown. The 11-year running mean filter was chosen in order to suppres the temperature variations within a solar cycle which obviusly can not be ascribed to a possible long-term external forcing. The filtered temperature record appears to closely follow the Glessber filtered [11] (1-2-2-2-1 filter) record of the sunspot cycle length. The choice of this particular temperature record was based on the assumption of Friis-Christensen and Lassen [9] that the Northern Hemisphere land air temperature is determined from the most abundant and most reliable data set. The limited extent of instrumental temperature records and the possible complex behavior of a solar-climate relationship that makes a filtering of the time series necessary, means that the statistical significance of the correlation is not sufficiently large to prove that the found correlation is not just a coincidence. Since the short term variations in solar activity and temperature may have quite different characteristics the only possible way to obtain an increased significance is to try to use longer time series of temperature data.

The objective of the present work is, by a part, to investigate the behavior of the air temperature in the northwest of the Mexican Republic for possible estimates of the regional natural resources and, by other, to try checking some of the hypothesis of the theory of influence of solar activity and galactic cosmic rays in such meteorological parameter.

DESCRIPTION OF THE ZONE.

The zone of study was found in Northwest of Mexican Republic, between the parallels 23° and 33° north, thus as inside of 106° and 117° West latitude. The zone is constituted by two units morphologically differents: the Peninsula of Baja California and the continental part, formed basically by the states of Sonora and Sinaloa.

a). Peninsula of Baja California. It is formed, by the states of Baja California and Baja California Sur, and it is situated in the extreme northwest of Mexican Republic. It is a strip of long and narrow earth that extends in a southeast to northwest direction, in over 10° of latitude, parallelly to the continental coastline. It is united to the continent by the extreme north and bathed by the Pacific Ocean to the west and by the Gulf of California to the east, the which separates the peninsula of the continent. The tropic of Cancer cross the peninsula in the south part, so that the extreme south remains inside of the tropical zone and the remainder inside of the subtropical zone of the Hemisphere North.

The relief of the peninsula consist in a series of mountainous chains that follow one to other almost in a longitudinal direction, separated frequently by ports of relatively low altitude. These chains travel the peninsula in all its longitude and still always very close to the coastline of the Gulf of California. They are formed by parallel sierras, between which some little lengthenned valleys are extended. The highness of these sierras reduces toward the west, where they become flat more or less enlarged along the edge of the Pacific Ocean.

b). The continental part. This has a latitudinal distribution, similar to that of the Peninsula of Baja California. Formed administratively by two, Sonora to the north and of Sinaloa in the portion south, is a coastal flatity that limits to the West with Gulf of California, in the which the coast line ran of northwest to southeast, while that to the east limits with the Sierra Madre Occidental. This sierra, in these latitudes, approximately distributes from north to south. Whereas in the north portion it reaches major wideness than 250 km, in the south portion it only reaches no more than 50 km (without presence of abrupt topography). The Tropic of Cancer also crosses this zone, permiting the influence of phenomena of tropical and subtropical systems.

Both units can be grouped in one region, becaue of physiographycal reasons, principally due to the climatic regime that they share. In all this region predominates the very arid climates (BWh and Bwk), with some splotches at the north and south of the Peninsula de Baja California of arid (BSo, BSh and BSk) and semiarid (BS) climates. In the continental portion the arid and semiarid climates are present in the foothills of the Sierra Madre Occidental (east limit of the zone of study) where due to the highness and to the conditions of humidity, the climates become more humid (CW).

Because of its geographical situation, the zone of the study suffers the influence of both high and low latitude phenomena. In one hand, it is located in the high pressure belt, under the influence of the semipermanent cell of high pressure of the Northeast Pacific. On the other hand, during the summer season it is under the influence of the cyclonic activity of the Pacific Ocean. It must be considered also the influence of the California Current, which contribute to reforce the arid conditions of the zone. P. Mosiño (1966) postulated that the climate changes in the northwest region of México depend more on the phenomena observed in the high atmosphere than on meteorological phenomena observed at surface level.

So, during the summer the cyclonic activity introduces moist air masses that cause rains, especially in the moderate sierras that run parallel to the coasts. During the winter, the low temperatures permit the condensation of the atmospheric moisture in large stratocumulus extension and in consequence the presence of a winter mode in the annual distribution of the precipitation. Even so, the predominant high pressures define the zone as arid in general with permanent desert zone located in the Baja California State (North Baja California).

DATA AND USED METHODOLOGY.

With the purpose of discovering cyclicities in the behavior of the air temperature, the data of 65 climatological stations were analyzed in a general period of 40 years. The data was chosen on the following basis: firstly, by their homogeneity and by checking not to have hollows of information, making them representative and valid for the goals of our investigation. Secondly, they were obtained for close regions, both geographic and climatological, what gives the possibility of obtaining a bidimensional matrix, which results of great utility from the point of view of the processing and calculation of errors.

The analysis was done by means of methods of spectral self-regresive analysis [2]. The calculations realized for all and each one of the stations are presented here by graphics, though these do not reflect, by no way, all the obtained results.

DESCRIPTION OF RESULTS.

The analysis of solar activity parametres (the number of Wolf- W, the sunspots surface-S and HL-index [12], the cosmic ray intensity (I) and the temperature (T) was previously carried out by means of different methods of spectral analysis [13-15] and autoregressive (ARMA) analysis [16-17].

The analysis was carried out over the monthly averages of the measurements of superficial temperature in the North-West of Mexico (Baja-California Sur, Baja-California Norte, Sonora and Sinaloa) for the period 1912-1994. These data are characterized by uniformity, duration, and contain almost no gaps, which makes them quite relievable.

Taking into account the fact that weather during the summer and winter months reacts in a significantly different way to variations of solar activity [3, 18] and in this connection the summer temperatures are more stable [3] due to the intense action of solar electromagnetic radiation than are the winter ones, the variations of winter tenperature $<t_w>$ (from May to Septenber, inclusively), were subjected to a detailed ARMA analysis which results are presented in Fig.3.

The spectra of the solar activity (S), cosmic ray intensity (I) and the geomagnetic activity (Kp) are given in the same figure for the goal of comparison. The pretty good correspondence of the spectra draws attention to itself: peaks of periods 3-5, 10.12 and 20.23 years are observed on the five curves. This good correspondence of the spectral results fits analogous results, as those of the work [3]. The spectra of the summer temperature have considerable differences with others spectral results.

The relative amplitudes of the spectral peaks for the different curves turn out to be as follous: for I, Kp and T the 22-years peak is the predominant one, whereas for SA the predominant is the 11-year period.

As well, we calculated the ARMA spectra of T, I, S and Kp for the even and odd solar cycles, separately In Fig.4 a-b, we present spectral results corresponding to even (a) and add (b) cycles of the solar activity. It is clearly evident, that in odd cycles a high correlation is observed between S and T, whereas in even cycles this correllation is weak.

A more detailed study of the behavior of T was done by the ARMA method for the montly and annual data of the different stations. The results of ARMA spectral investigations of the behavior of the temperature during cycles 18-21 of solar activity are presented in Fig. 5 (a-d), 6 (a.d) and 7(a-d). The presence of a 12-month cycle (seasons changes), 3-4 years, 10-12 years and 22-years cycles in the temperature spectral densities is quite clear (the coherence between the behavior of the temperature spectral density and the solar activity spectral density is 0,7 in both cases).

For 22-year cycle, the change of the spectral densities ***P*** occurs one to two years before the onset of the epoch of the minimum ***SA*** following an old maximum, and occurs two to four years before onset of the ***SA*** epoch of the minimum following an even maximum.

It is highly significant that analogous results are obtained with the measurements of temperature in other places. On the Earth, the results of these calculations lead to the establishment of a probable intercorrelation between the processes in the Sun (SA), interplanetary space (GCR) and the Eearth K_p (geomanetic activity, behavior of the lakes levels and the wind velocity) [19].

CONCLUSIONS.

Our calculations, based in experimental data, can be interpreted within the frame of the mechanism of action of Solar and Geomagnetic activities on the State of the lower atmosphere and meteorological parametres (Pudovkin-Raspopov) [3].

Actually, the similarity of the spectral results of the temperature and cosmic ray intensity and the predominance of a 22-year cycle (proposed by the Pudovkin-model) has confirmed the proposed physical mechanism in [3] of the continuous influence of SA and GA on the weather and climate.

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FIGURE CAPTIONS.

Figure 1. 11-year running mean of the annual average Northern Hemisphere surface air temperature anomalies, relative to the 1951-1980 average temperature [10], and the 11-year running mean of the yearly sunspot number *W*.

Figure 2. 11-year running mean of the annual average Northern Hemisphere surface air temperature anomalies, relative to the average temperature 1951-1980 [10], and the filtered length of the sunspot 11-year cycle.

Figure 3. Results of ARMA analysis of the winter (a) and summer (b) temperature, cosmic ray intensity (c), solar (d) and geomagnetic (e) activity in the 1949-1994 period.

Figure 4. Results of the spectral analysis of the temperature data for the even and odd solar activity cycles. (a), (b) - amplitude spectra; (c), (d) - coherence spectra.

Figure 5. Results of the spectral ARMA analysis of the temperature of North Baja California: amplitude spectra for monthly (a) and annual (b) series, and coherence spectra for monthly (c) and annual (d) series.

Figure 6. Idem as in Fig. 5, for South Baja California stations.

Figure 7. Idem ass in Fig. 5, for Sonora stations.