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COMMON CYCLES IN AIR TEMPERATURE AND SOLAR ACTIVITY IN THE MEXICAN NORTHWEST REGION

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ABSTRACT

A possible effect of cosmophysical processes on the variability of the Earth's surface air layer temperature in the zone of the Mexican Northwest, an arid zone located in the latitudinal high pressures belt, around the Gulf of California. Both, the conventional spectral analysis and the autoregressive methods have been used to determine common cycles in cosmophysical and surface air layer temperature series. The predominance of a 22-y cycle in the air temperature and then the continuous influence of solar and geomagnetic activity on the Earth's weather and climate has been confirmed.

INTRODUCTION

In [1] H. H. Clayton reported very interesting and important results about studies performed by W. B. Schostakowitch during the 1930's on the relationship of climate elements and solar activity. As reported in [1], W. B. Schostakowitsch analyzed the mean values of air temperature, pressure and rainfall during a 5-y periods embracing the maximum of solar activity and comparing them with similar results for 5-y periods embracing the minimum. So, Schostakowitsch found that in some regions the departures of the climate elements from their normal values run parallel with the sunspot changes, while in other regions they are reversed. In particular, according to the obtained results, the Mexican zone is inside of a region when the temperature averages higher and precipitation does lesser at sunspot maximum than at minimum.

On the basis of the model of influence of solar activity on the lower atmosphere proposed in [2] Perez-Peraza et al. [3] show that it is possible to expect the presence of a 22-y cycle in the variability of the air temperature because of the action of several external factors: the galactic cosmic rays, the level of solar activity, and the geomagnetic activity. In the course of the odd 11-y cycles the climate and the extra-terrestrial processes correlate well, while in the even cycles the correlation reduces, resulting in a 22-y periodicity that could be translated into lower atmosphere climate parameters.

J. A. Eddy [4] noticed that this 22-y variability could be due to a similar behavior of the galactic cosmic rays, leading to variation of the atmospheric transparency and then to an external influence on the weather and climatic parameters. Also, in a detailed study of long-term variations, J. A. Eddy drew attention to the coincidence of the so-called Maunder minimum in solar activity with the occurrence of the "Little Ice Age". J. A. Eddy pointed out that this apparent long-term relationship might be due to changes in the total solar irradiance (see also [5]).

G. C. Reid [6] noticed a striking similarity between the globally averaged sea surface temperature (SST) and the long-term variation of the solar activity, represented by the 11-y running mean Zurich sunspot number. He pointed out that the two time series had several features in common, as those of the important minimum in the early decades of the XX century, the steep rise to a maximum in the 1950's, a brief drop during the 1960's and early 1970's followed by a final rise. Based on this comparison, G. C. Reid suggested that the solar irradiance may have varied by approximately 0.6 % from 1910 to 1960, in phase with the 80-y Gleissberg cycle of the solar activity, represented by the envelope of the 11-y solar cycle [7]. Using a simple one-dimensional ocean thermal model [8], G. C. Reid found that the necessary range of variation in the solar constant during the 130 years 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 recent years, i.e. during the satellite era when reliable and continued measurements of the solar irradiance are available [9].

The statistical correlation between the two time series used by G. C. Reid was reported to be 0.75. Although this is apparently better than the correlation between the observed mean global temperature and modeled temperature caused by the increased greenhouse effect, Friis-Christensen and K. Lassen [10] pointed out a major difficulty with this interpretation. They examined the Northern Hemisphere air temperature and noted that this record was shifted to the running mean of the yearly sunspot number by approximately 20 years. From this discrepancy they concluded that if a cause-effect relation between solar activity and terrestrial climate exists it is unlikely that long-term variations of solar activity can be sufficiently well represented by some average value of the sunspot number itself. Further, they pointed out that the long-term variation of the variable length of the "11-year" sunspot cycle was well correlated with the Northern Hemisphere air temperature during the entire interval of systematic measurements and proposed that the solar cycle length could provide an indicator of long-term variations in solar luminosity. The filtered temperature record appears closely following the record of the sunspot cycle length. 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 sufficient to prove that the found correlation is not just a coincidence. This, together with other coincidences mentioned might suggest a possible relationship between the overall envelope of solar activity and terrestrial climate.

The objective of the present work is to investigate the variability of the air temperature in the Mexican northwest in order to contribute to the knowledge of the natural resources of this economically important zone of the country. On the other hand, to try to check some of the hypothesis of the theory on the influence of external factors in the variability of the weather and the climate of Earth, taking into account that the zone of study belongs to the planetary latitudinal belt of the high pressures, where the influence of the high atmosphere and so of the cosmic and interplanetary processes is highly possible.

ZONE OF STUDY

The zone of study is located between the 23 and 33 ° N latitudes and the 106 and 117 ° W longitudes. It is constituted by two units morphologically different: the Baja California Peninsula and the continental watershed of the Gulf of California, and it includes basically four Mexican states: Baja California Sur, Baja California, Sonora and Sinaloa. The peninsula is a strip of long and narrow terrain that extends in a southeast-northwest direction, parallel to the continental coastline. It is united to the continent by the north and bathed by the Pacific Ocean to the west and by the Gulf of California to the east. This last separates the peninsula from the continent. The relief of the peninsula consists in a series of mountainous chains that follows one to other, formed by parallel sierras, between which some little lengthened valleys are extended. The highness of these sierras reduces toward the west. The continental part, formed administratively by two states, Sonora in its northern and Sinaloa in its southern portions, is a coastal flat land that limits to the west with the Gulf of California, while to east it does with the Sierra Madre.

The Tropic of Cancer crosses the zone of study, and because of that it has the influence of both tropical and subtropical synoptic systems. In fact, both units can be grouped in one region, mainly due to the climatic regime that they share. In all this region predominates very arid climates (BWh and BWk), with some splotches at the north and south of the Baja California Peninsula 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 (east limit of the zone of study) where due to the highness and to the transport of water vapor from the Pacific Ocean during summer, the climates become more humid (CW). Being in the latitudinal planetary belt of the high pressures, the zone is under the influence of the semi permanent cell of high pressure of the Northeast Pacific. During summer it is under the effects of the cyclonic activity of the Pacific Ocean. So, during the summer the cyclonic activity introduces moist air masses that causes rains in the moderate sierras that run parallel to the coasts. During winter, the low temperatures permit the condensation of the atmospheric moisture in clouds of large extension, permitting the existence of a winter mode in the annual distribution of the precipitation and determine the Mediterranean climate, characteristic of the zone. It must be considered also the influence of the California Current, which contributes to reinforce the arid conditions of this region.

DATA AND METHODS

With the purpose of determining periodicities in the behavior of the air temperature, 40 years of data of 65 meteorological stations were analyzed. The data was chosen on the following basis: firstly, by their homogeneity and by checking not to have gaps of information, making them representative and valid for goals of our investigation and, secondly, they were chosen for geographically and climatologically near

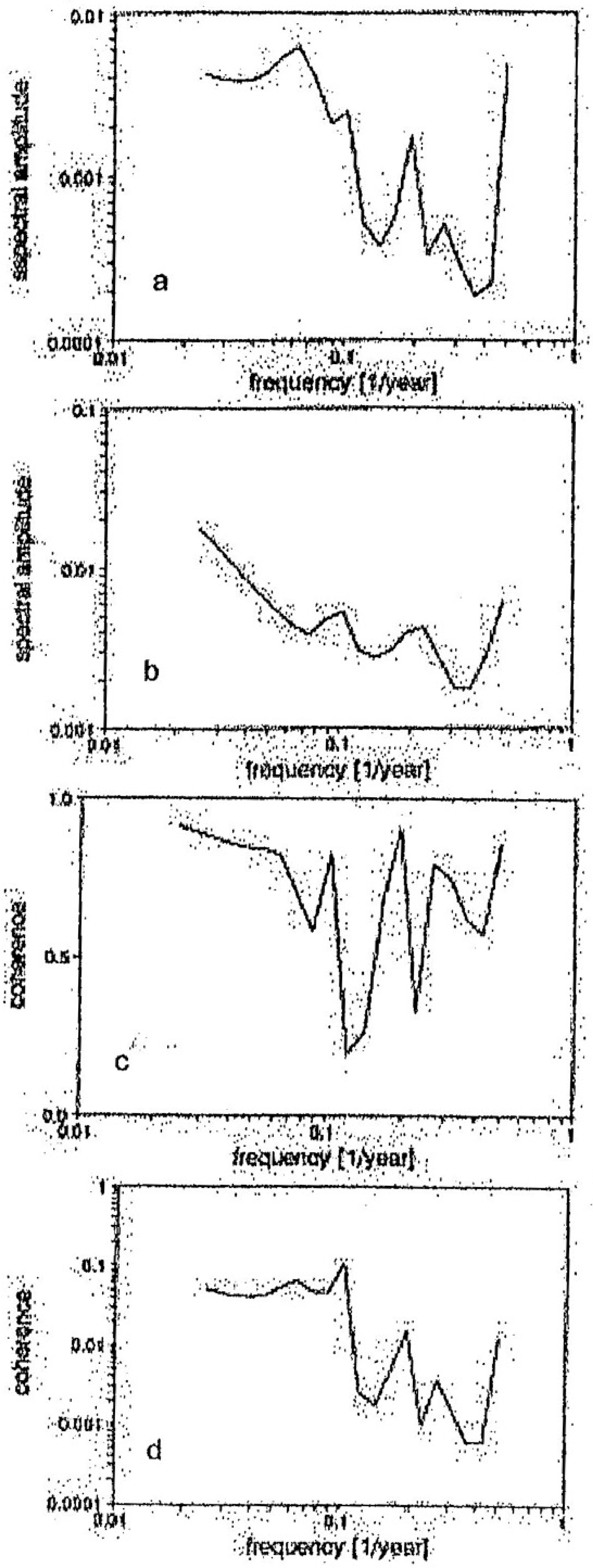

Fig. 3. Spectral amplitudes of the annual MNW temperatures for even (a) and odd (b) 11-y solar cycles, and their corresponding spectral coherence (c), (d).

A more detailed study of the variability of T was done by means of the ARMA analysis for the annual series of northern and southern parts of the Baja California peninsula. There were obtained several oscillations with spectral coherence greater than 0.5, being of 10,

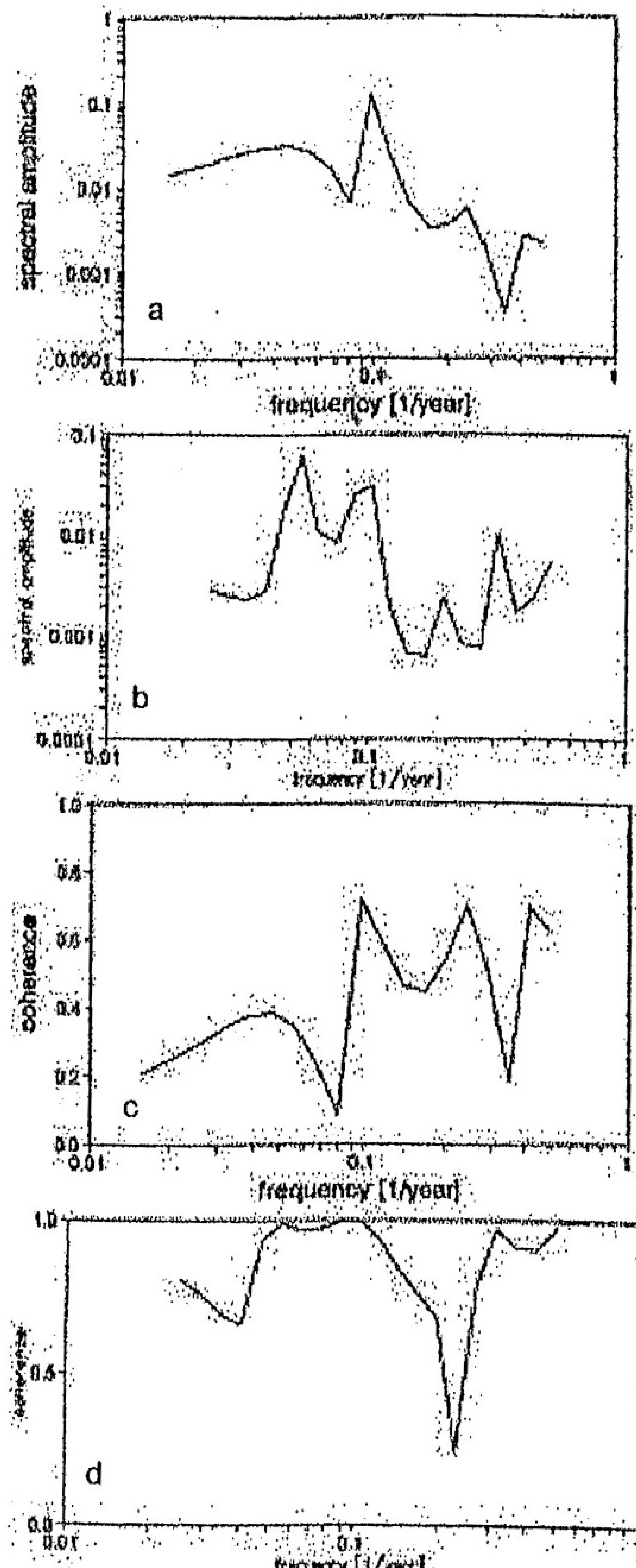

Fig. 4.- Spectral amplitudes of the annual temperatures of the northern (a) and southern parts of the Baja California peninsula, and their corresponding spectral coherence (c, d).

4.5, and 2.5 y in the northern part of the peninsula (Fig. 4a), and of 19, 10, 5 and 3.5 y in the southern part (Fig. 4b). It draw the attention that in the northern part of the peninsula there are two oscillations: 25 y (with spectral coherence lesser than 0.5) and 2.5 y (the Quasi Biannual Cycle), related to cosmophysical processes. Also, it is interesting to note that the spectral analysis of the annual series for the peninsula show a significant oscillation with period of ≈ 10 y, regions, what gives the possibility of obtaining 2D matrices what results of great utility from the point of view of the processing and calculation of the errors.

There were analyzed the sunspot surface (SSS), the geomagnetic activity (Kp index, [11]), the cosmic ray intensity (CRI) and the surface air layer temperature (T) in the Mexican northwest region (MNW). The analysis was previously carried out by means of different methods of spectral analysis [12,13,14] and of ARMA analysis [15,16]. The analysis was carried out over the monthly and annual series. Also, taking into account that weather could reacts different to variations of the external factors during winter than during summer [2,17], the winter (average from November to February) and summer (average from June to September) temperatures were subjected to the ARMA analysis.

RESULTS

According to obtained results, the cosmic ray intensity (Fig. 1a) has oscillations in the decadal range: 12 – 18

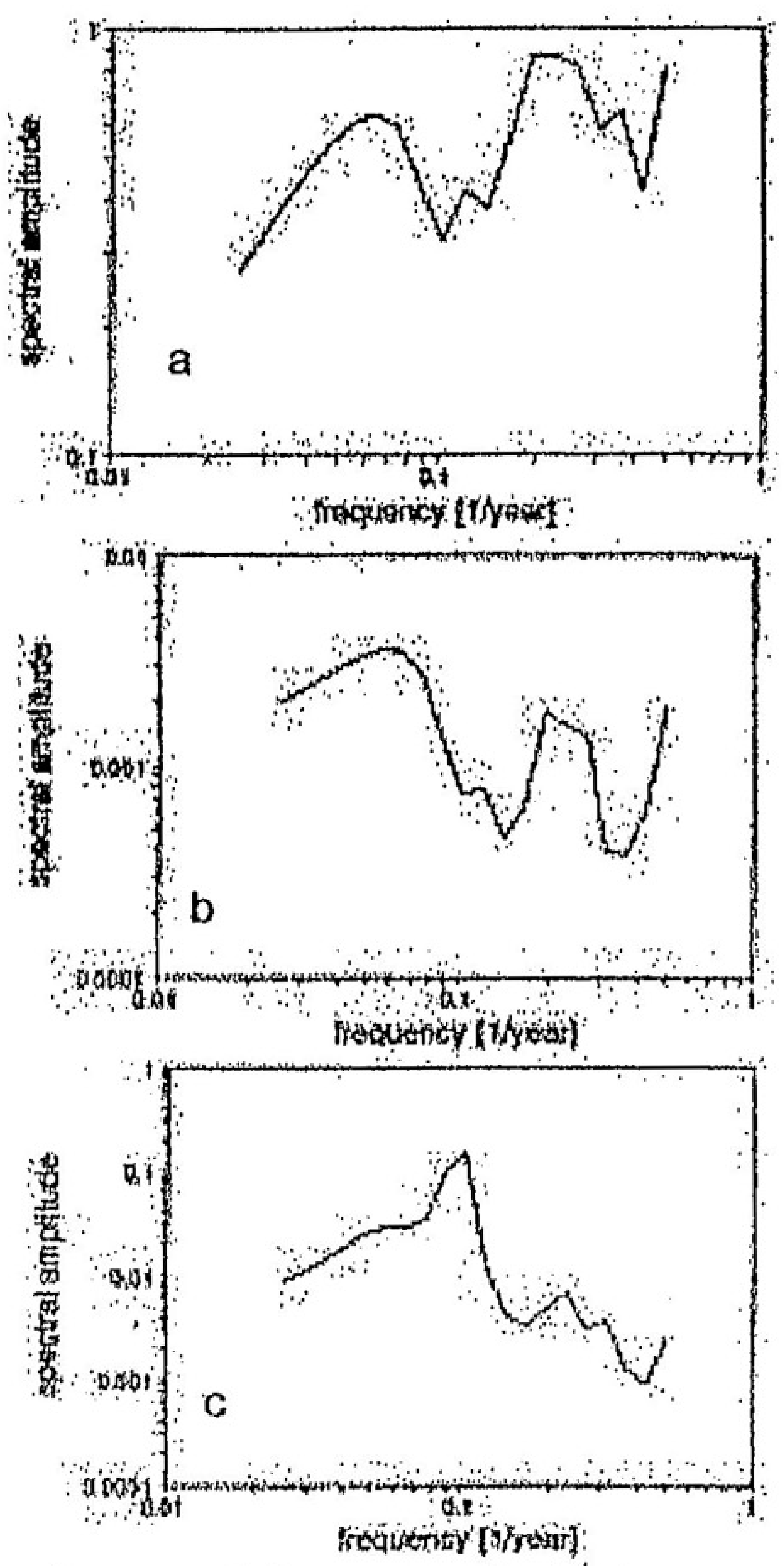

Fig. 1.- Spectra of the cosmophysical parameters: a) cosmic ray intensity; b) Kp geomagnetic index; c) surface sunspot.

y, and in the interannual range: 3 – 5 y, respectively. The same is observed in the Kp results (Fig. 1b), except that in CRI the interannual variability prevails while in the Kp spectrum the decadal variability does. As it is shown in Fig. 1c, the 11-y solar cycle clearly dominates the variability of the SSS series.

The spectra of the MNW temperature (Fig. 2a and 2b) show predominant periodicities in the decadal range and secondary maxima in the interannual range. The decadal periodicity of the winter temperature is observed in the 20 – 30 y range, while the summer temperature the decadal periodicity prevails in the 12.5 – 20 y interval. In both cases the 11-y solar cycle is practically inexistent and the interannual variability is expressed through periodical oscillations in the range of 4 – 5 y. They have important coincidences with the spectra of the cosmophysical parameters.

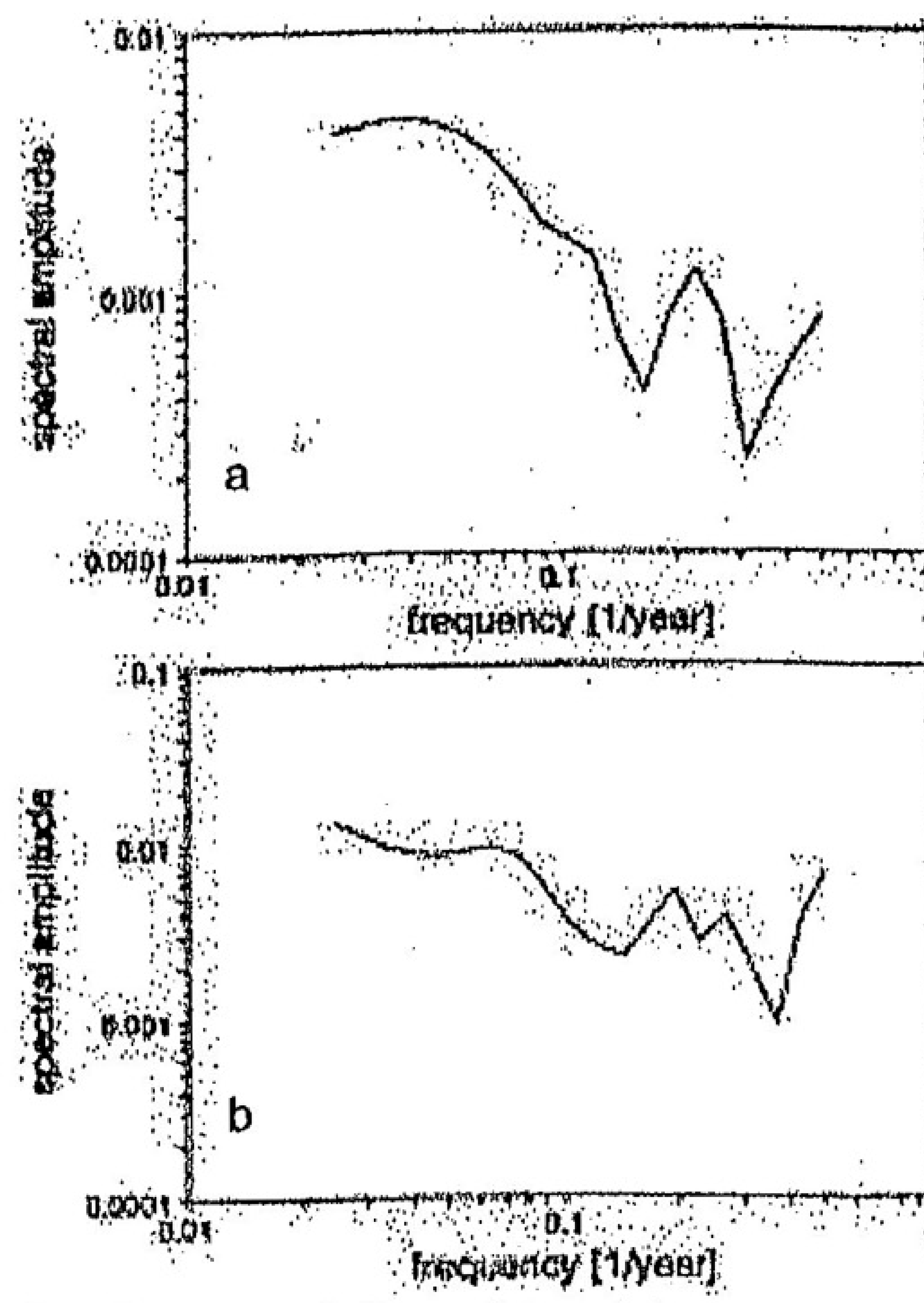

Fig. 2.- Spectra of the winter (a) and summer (b) annual MNW temperatures.

When the temperature series are analyzed for different 11-y solar cycles (Fig. 2a and 2b), it is obtained clearly prevailing 12.5 – 25, 5.5 and 4 y periods, in even cycles, and 10 and 4.5 y periods, in odd cycles. However, meanwhile the spectral coherence of the prevailing in even cycles oscillations is over 0.7, it is one – two orders lesser during the odd cycles (Fig. 4c and 4d). This effect must necessarily reflects in a near to 22-y period oscillation in the temperature variability.

close to the basic solar cycle, which appeared damped in the analysis of the winter and summer temperatures.

CONCLUSIONS

The results obtained by means of the spectral analysis of the surface air layer temperature in the northwest region of Mexico show a high similarity with the spectral composition of several cosmophysical processes. The length of the series permit to determine oscillations with periods from 2 to 30 y. There were found coincident cycles in 2.5 and 3 – 5 y (interannual variability), in 15 – 17 and 20 – 30 y (decadal variability). In our results, the 15 – 17 y oscillation is characteristic of the cosmic ray intensity and the geomagnetic activity. Also, it was determined the presence of a near to 11-y oscillation in the temperature of the southern part of the Baja California peninsula.

The obtained results can be interpreted within the frame of the mechanism of action of the solar and geomagnetic activities on the state of the lower atmosphere proposed by M. I. Pudovkin and O. M. Raspopov. The high coherence of the temperature oscillations during the even cycles and the lost of coherence during the odd cycles can be part of the mechanisms which lead to the 22-y climate cycle, as proposed in the Pudovkin-Raspopov model.

It is highly significant that analogous results has been determined on the basis of analysis of other geophysical variables, as those of the level of lakes and wind velocity (Perez-Peraza et al., 1996). In [19], analyzing time series of sea high level and also of surface sea level there were determined significant peaks of 5.0 and 3.6 y in the interannual and of 17-25 y in the decadal range of variability. In [20], by means of the analysis of long-term fluctuations of rainfall series in the Sonora fluvial basins there were determined periods of 8, 10, 12, 19 and 21 y. These results lead to the establishment of a relationship between the processes in the Northwest Region of Mexico and the cosmophysical processes.

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