29th International Cosmic Ray Conference Pune (2005) **00**, 101-104

Possible solar signals in historical droughts in central and southeastern Mexico

B. Mendoza[a], E. Jáuregui[b], V. Velasco[a], V. García-Acosta[c] .
(a) Instituto de Geofísica UNAM, Ciudad Universitaria 04510, México D.F. México
(b)Centro de Ciencias de la Atmósfera UNAM, Ciudad Universitaria 04510, México D.F. México
(c)Centro de Investigaciones y Estudios Superiores en antropología Social, Juárez 87, 1400, México D.F. México
Presenter: B. Mendoza (blanca@geofisica.unam.mx), mex-mendoza-B-abs1-SH35-poster

We use a catalogue containing an unprecedented amount of historical data in Mexico covering almost six centuries (1400-1900). This catalogue of agricultural disasters includes events associated with hydro meteorological phenomena or hazards whose effects were mainly felt in the agricultural sector, such as droughts. Analyzing the periodicities of the drought time series using the wavelet technique, we found that in central Mexico the most conspicuous ones are the 3, 5, 15, 24 and 50 years for the time span of 1450-1900. For the south eastern part of Mexico and from 1502 to 1899, the most prominent frequencies are ~ 3, 4, 7, 12, 20, 43 and 70 years. A further study of coherence shows that there are common signal along time between droughts and various solar activity phenomena, in particular Be^{10}, a proxy of cosmic rays. This implies that open and closed magnetic field region on the Sun contribute to modulate droughts.

1. Introduction

The study of climate with historical series (centuries or millennia) allows a temporal perspective for the interpretation of present climatic patterns and suggests future climatic scenarios. Long series of climatic parameters are fundamental for documenting the historical natural variability. In most places instrumental records are available for no more than a couple of centuries, then climatic indices such as tree-rings, ice cores or human sources are used to reconstruct the past climate. In Mexico, temperature measurements exist since the end of the 19th century. There is much discussion on whether solar irradiance (associated to solar closed magnetic field regions on the Sun) or cosmic rays (associated to open magnetic field regions on the Sun) are affecting climate, and works supporting one or the other point of view have been developed. The historical series are one option to study the climate and its possible relation to solar activity from a secular perspective and can help to elucidate a possible mechanism for the Sun-Earth relations.

2. Data

We use the Catálogo Histórico de Desastres Agrícolas en México [3] for the period 1450-1900. It includes frost, hailstorm, droughts, flood, plague, epidemics, etc. The oldest records come from codexes and annals, some of them written before the Spanish conquest (1521), but the main sources were archives, chronicles and old newspapers as well as iconographical and bibliographical material. The area of study can be observed in Figures 1 and 2. Figure 1shows the central part, the original series has 388 annual reports along 1450-1900 but the actual series has 70 droughts. Figure 2 shows the southeastern region, the original series has 80 annual reports along 1502-1899 and the actual series has 42 droughts.

We also use the series of total solar irradiance [5], Be10 [1] and sunspots. For the total solar irradiance, we found better results using the series that has no long-term trend as defined in [5].

3. Method, results and discussion

In order to find the main frequencies of the series we apply the wavelet method using the Morlet wavelet [2, 4]. We attended to those frequencies that reached the 95% level of confidence. The uncertainties of every peak position in the global wavelet spectrum were obtained from the peak full width at half maximum, assuming that the peaks have a Gaussian shape. The main periodicities of the series for central Mexico were ~ 3-5 years, ~ 15, 24 and 55 years. For Southeastern Mexico they were ~ 3-4 and 7 years , ~ 12, 20, 43 and 70 years.

In order to identify both, frequency bands and time intervals within which the droughts and the solar phenomena considered are covarying, we use the wavelet squared coherence [6, 4]. Only coherences of 0.5 or larger appear in the figures. We shall discuss those coherences that are at the 95% confidence. The wavelet coherence is specially useful in showing the time intervals where, in spite of the minimal power presented by the wavelet power spectral density of two phenomena, they still have a strong interaction. The small black arrows in the figures indicate phase differences between droughts and the solar phenomena, but in these cases no interesting results are observed.

The coherence spectra for the southeastern part of Mexico appear in Figure 3 while those for central Mexico are shown in Figure 4. Both coherence spectra indicate that the interaction between droughts and solar activity is not high for sunspots. However, droughts and irradiance share signals in a more consistent way for the band of 64 years in central Mexico and droughts and Be 10 tend to share signals for the band of 6-16 years in the southeast. Solar irradiance is related to closed magnetic field regions on the Sun, while Be10 is modulated by the interplanetary magnetic field originated in open solar magnetic regions on the Sun (coronal holes). Then it seems that both types of solar regions and their associated phenomena contribute to affect droughts and therefore climate.

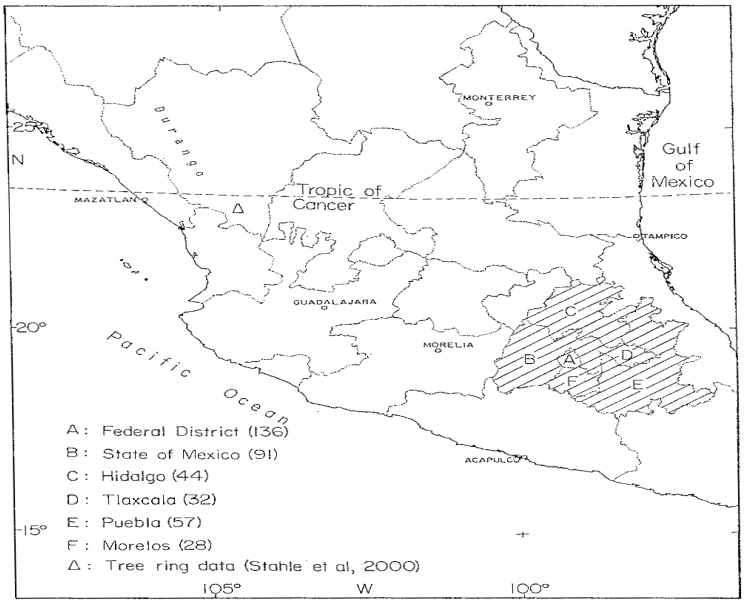

Figure 1. Area of study for the central part of Mexico. On the map appear the states and the number of droughts reported there.

Figure 2. Area of study for the southeastern part of Mexico. On the map appear the states and the number of droughts reported there.

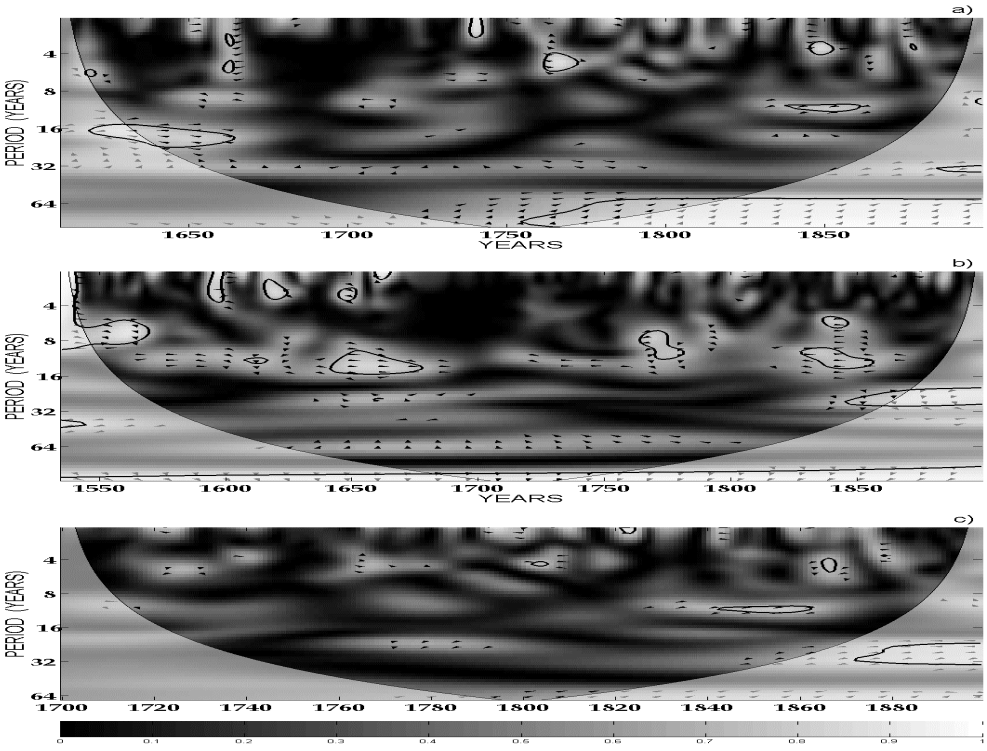

Figure 3. Coherence spectra for the southeastern part of Mexico between droughts and (a) Total solar irradiance, (b) Be 10 and (c) Sunspots. Coherences at the 95% confidence level appear inside the black contours.

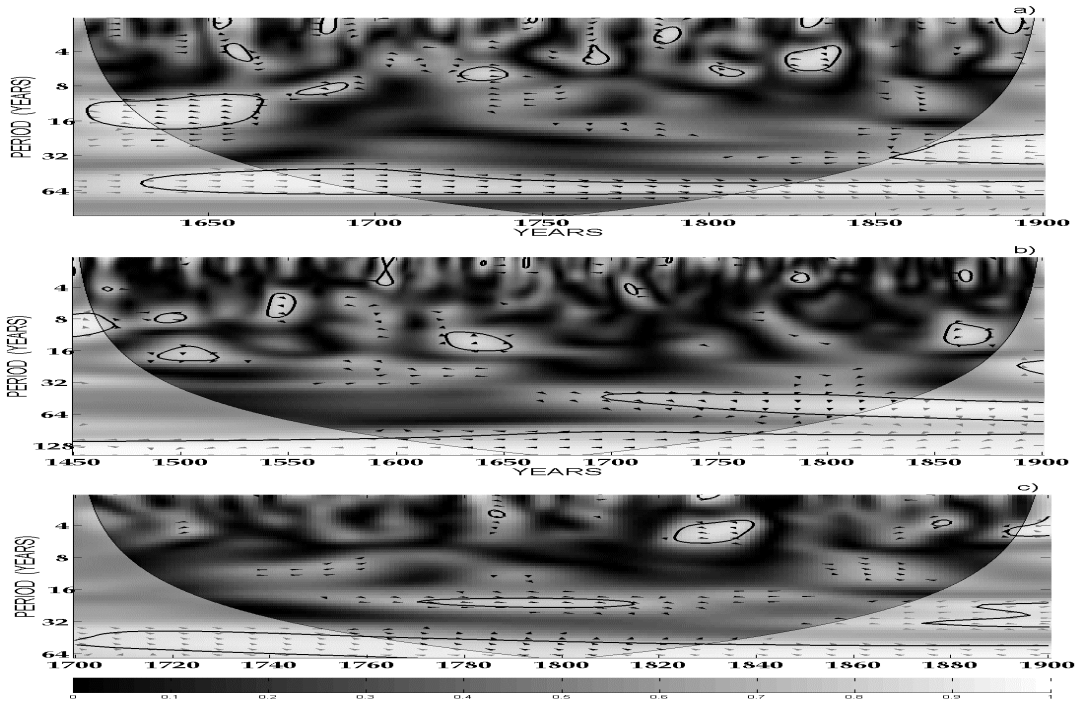

Figure 4. Coherence spectra for the central part of Mexico between droughts and (a) Total solar irradiance, (b) Be 10, and (c) Sunspots. Coherences at the 95% confidence level appear inside the black contours.

4. Conclusions

The spectral analysis of the historical series indicates that the most conspicuous frequencies are ~ 3-5, 15 and 24 years for central Mexico and for the southeast they are ~ 3-4, 7, 12, 20, 43 y 70 years. This periodicities are compatible with, among other natural frequencies, solar activity.

The coherence between droughts and solar activity is not high for sunspots. Droughts and irradiance share signals in a more consistent way for the band of 64 years in central Mexico and droughts and Be 10 share signals for the band of 6-16 years in the southeast. This implies that open and closed magnetic field region on the Sun contribute to modulate droughts.

References

[1] J. Beer, Space Sci. Rev. 94, 53 (2000).
[2] I. Daubechies, IEEE Trans. Inform. Theory 36, 90 (1990).

[3] V. García-Acosta et al., Fondo de Cultura Económica and CIESAS, México (2004).

[4] A. Grinsted et al., Nonlinear Processes in Geophysics 11, 561 (2004).

[5] J. Lean, GRL 27, 2425 (2000).
[6] C. Torrence and P. Webster, J Clim. 12, 2679 (1999).