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The precipitation series in La Plata, Argentina and its possible relationship with geomagnetic activity

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RESUMEN

En este trabajo se estudian los registros pluviométricos de la estación La Plata (Prov. de Buenos Aires, Argentina) durante el periodo 1909-1999 para determinar el comportamiento y distribución de la lluvia en relación con el índice geomagnético aa, el cual indica el estado de perturbación geomagnética en la atmósfera. Luego de un análisis cualitativo de la serie de precipitación se trata de explicar los máximos y mínimos en términos de las variaciones del campo geomagnético. La dependencia entre los fenómenos atmosféricos y geomagnéticos puede resultar difícil de determinar, pero tras la observación del comportamiento de las series temporales analizadas se puede identificar una interacción entre ambos fenómenos.

PALABRAS CLAVE: precipitación, actividad geomagnética, índice aa.

ABSTRACT

We study the precipitation records from La Plata (Province of Buenos Aires, Argentina) during 1909-1999 in order to determine the distribution of rainfall and its relationship with the geomagnetic aa index. We attempt to explain the maxima and minima by the geomagnetic field variations. We suggest an interaction between both phenomena.

KEY WORDS: precipitation, geomagnetic activity, aa index.

INTRODUCTION

Precipitation is related to the random nature of climate, and is linked to the hydrologic cycle (Marsily, 1990). In this paper we describe the possible interrelation between pluvial precipitation and the geomagnetic activity for a period of 90 years. The time series of precipitation at the meteorological station of La Plata, Province of Buenos Aires, Argentina (ϕ = 34º 55' S; λ = 57° 56' W, elevation 15 m above sea level) is analysed in relation with the geomagnetic activity, represented by the aa planetary index.

The geomagnetic index describes the level of geomagnetic activity and of Sun-Earth interactions. Markson (1979) discusses the role of atmospheric electricity in solar-terrestrial relationships and suggests electric mechanisms bound to solar variations that may affect climatic parameters. Perez-Peraza *et al* (1999) analyse the influence of solar activity on the pluvial precipitation in the Baltic region using data of sunspot areas and suggest a frequency dependence between heliophysical and hydrogeological processes.

DATA AND METHODOLOGY

According to the classification of Thornthwaite (1948), the climate in La Plata city is "wet, mesothermal, with null or small water deficiency". The precipitation pattern in the region consists of alternating dry and humid periods, with the first half of the century being drier than the second. The annual mean precipitation is 1010 mm and approximately 36% correspond to the December-March period. March is the rainiest month (106 mm). The least precipitation takes place in winter, and June has the lowest rainfall (64 mm).

The annual mean temperature is 16°C. January is the hottest month with 22.4 °C and July the coldest month with 9.9 °C. The annual average relative humidity is 70%, with a minimum in January (60%) and a maximum in July (85%).

The geomagnetic K index is related to the energy density imbedded in geomagnetic variations. It is calculated using the horizontal component and declination of the geomagnetic field (Menvielle and Bertheilier, 1991). The K-derived planetary indices were designed and accepted by the International Association of Geomagnetism and

Aeronomy (IAGA). In this work we used the aa planetary index, derived from the K index of antipodal observatories that constitutes a very long series from 1868. For each 3-hour interval, the aa index is the weighted average of the northern and southern values of the K index (Menvielle and Bertheilier, 1991).

In the IAGA bulletins the values of the indices are published. From these data we may determine the five quietest days of each month. Generally, 24-hour calm intervals are centred on the Greenwich meridian. In other time zone, the calm intervals may cover parts of two consecutive days. Mayaud (1969) proposed to select 48-hour calm intervals of geomagnetic activity in such a way that a 24-hour calm interval is always available.

In this study we use 48-hours calm intervals. The average interval and the statistical weights are computed as in IAGA Bulletin 32s, page 22, with respect to the aa index.

From the geomagnetic aa index we determine the monthly quantity “C” of 48 calm hours of the geomagnetic field. It is found that a quiet day has a daily aa index smaller than 13.

The pluviometric records are monthly accumulated precipitation values from 1909 to 1999. The aa index constitutes a homogeneous series of monthly average values from 1868 to the present.

The determination of spectra for both temporary series –rainfall and aa index- used FFT with application of low-pass filters to eliminate the high frequencies from seasonal and random phenomena. We applied a smoothing filter that utilizes a semi-parametric algorithm (Press *et al.,* 1992).

RESULTS

Figures 1 and 2 show the filter window for each series in the frequency domain. The original and filtered aa index and rainfall series in the time domain are shown in Figures 3 and 4.

We superimposed both smoothed series to examine the temporal variations and the graphical fit (Figure 5).

Inspection of Figure 5 suggests a change in the dependence between precipitation and aa index after the year 1922. This may indicate the beginning of a coincidence among the local minima of both series (year 1935 and 1969). The same pattern is repeated for the years 1935-1969 and 1969-1999, suggesting a 35-year cycle. This may reflect a relationship between the pluviometric and geomagnetic phenomena in the region.

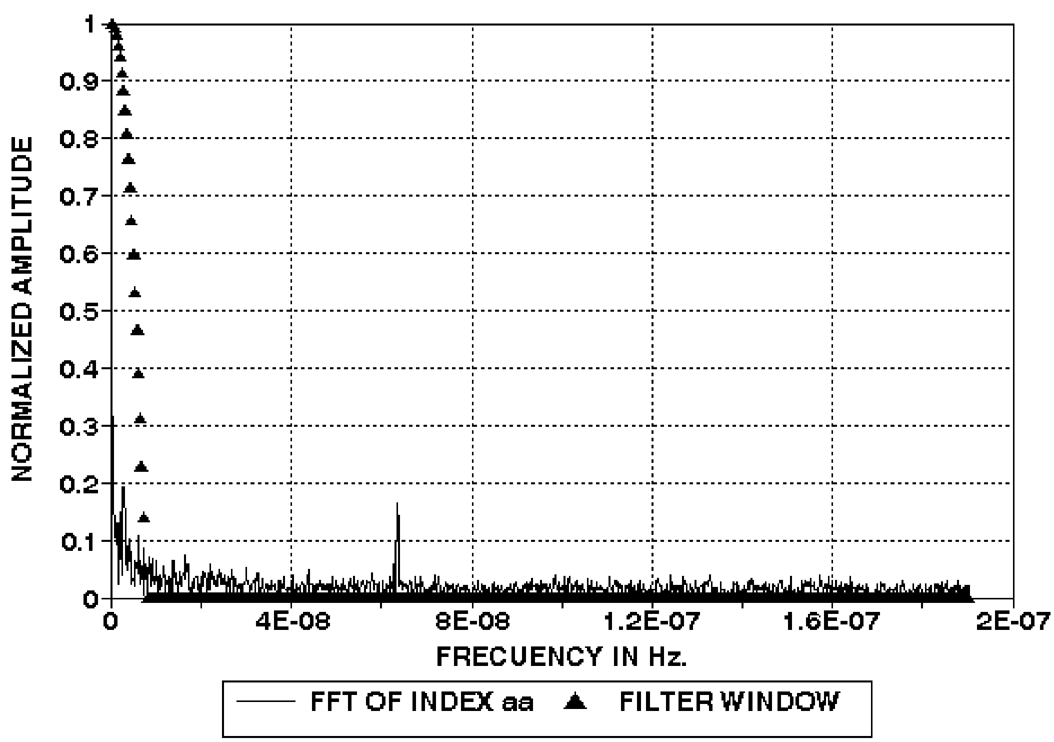

Fig. 1. Low pass filter applied to the aa index series.

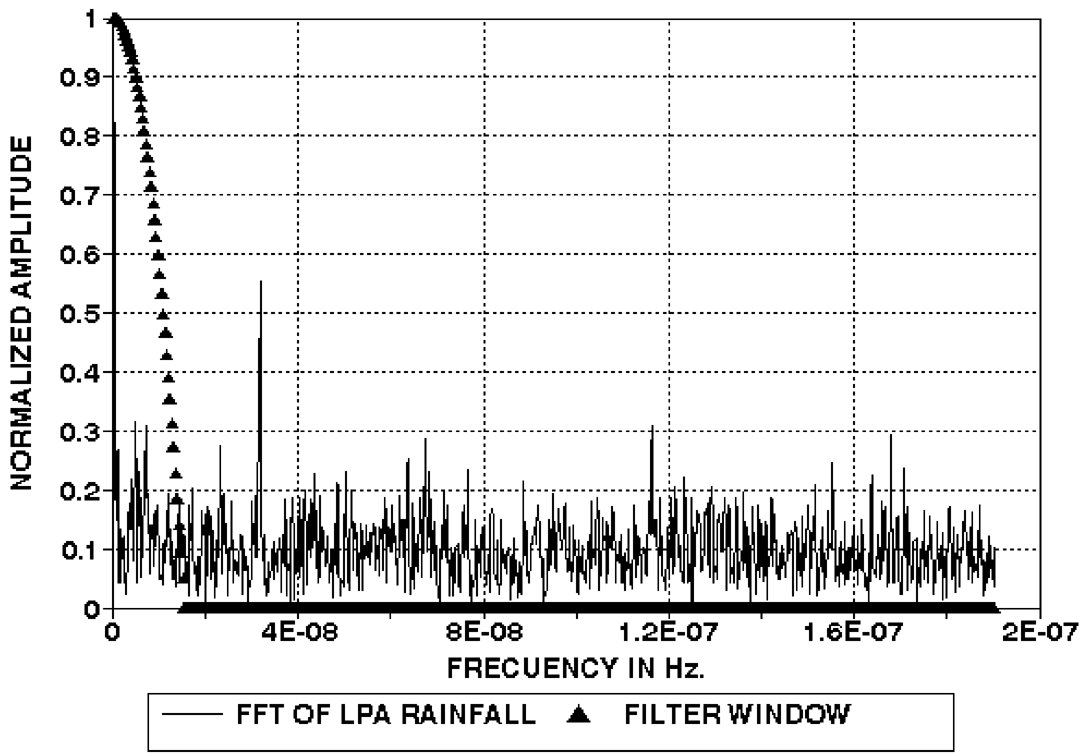

Fig. 2. Low pass filter applied to the rainfall series.

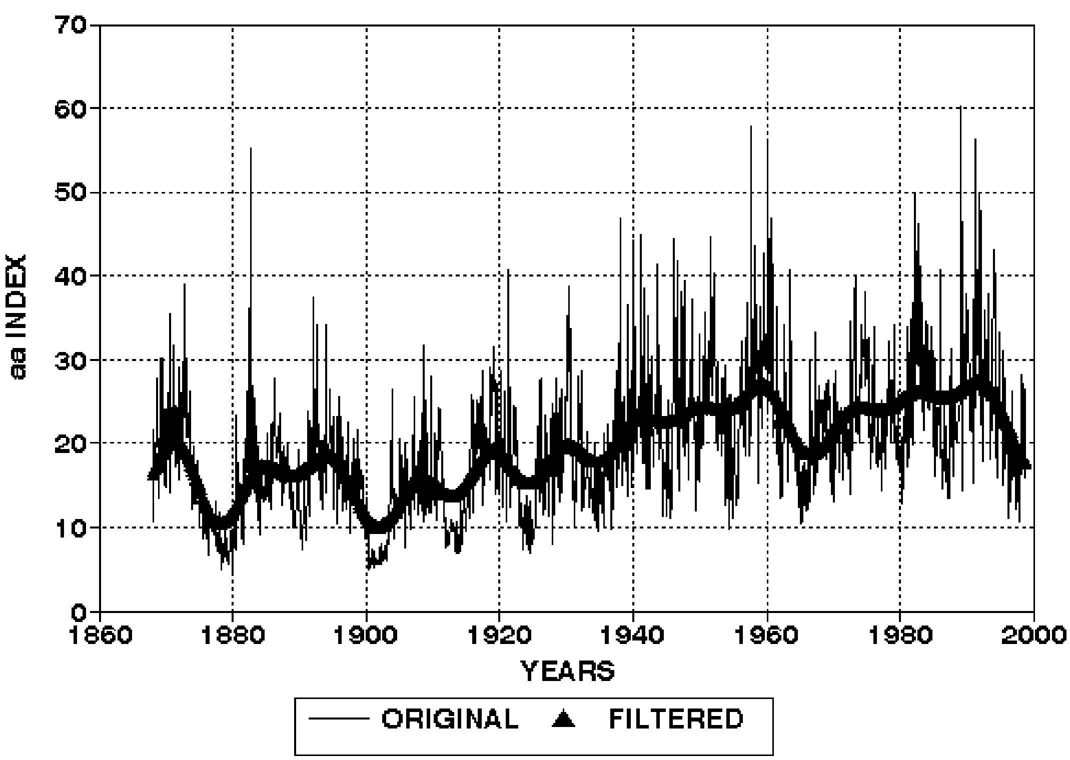

Fig. 3. The original and filtered aa index serie.

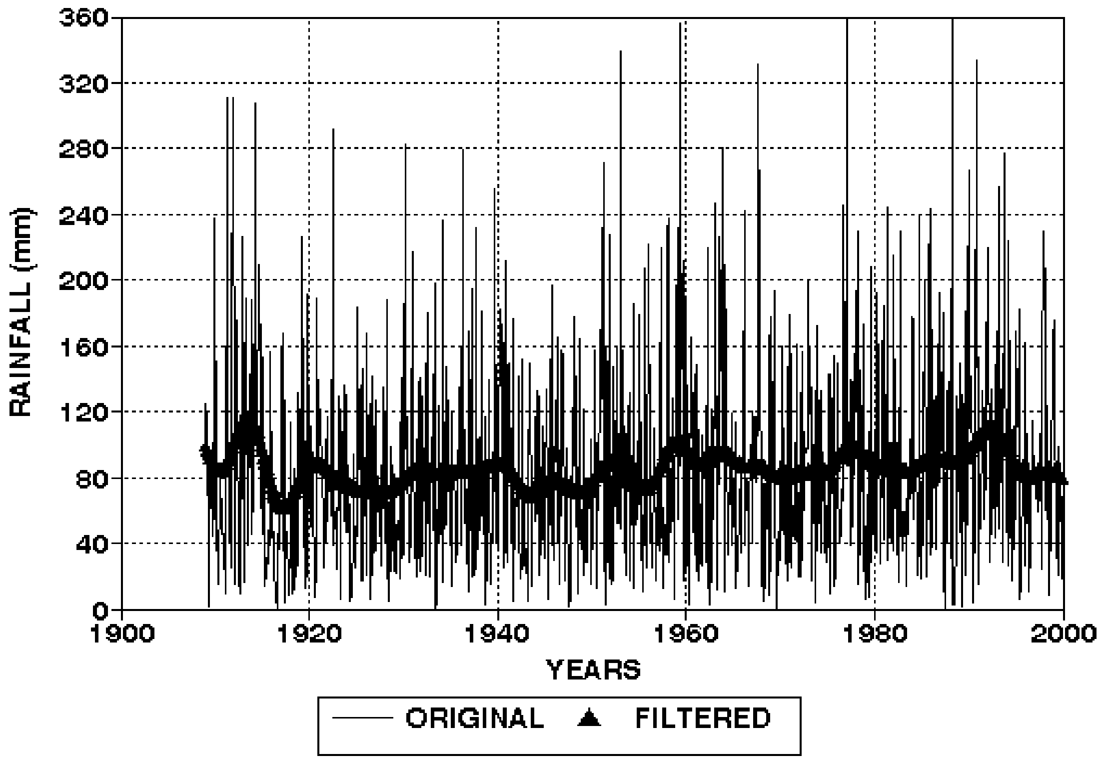

Fig. 4. The original and filtered rainfall serie.

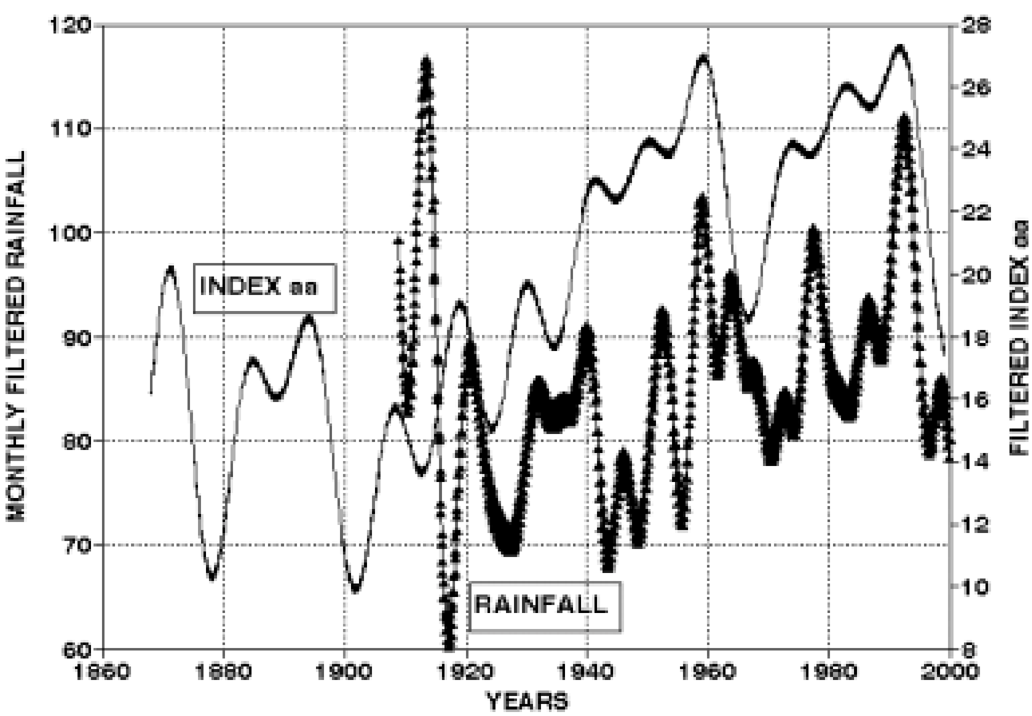

Fig. 5. Rainfall and aa index series.

We analyze the 48-hours calm period distribution in 1868-1999 from smoothing curve (Figure 6).

It appears that in 1920 the solar activity (represented by C) increases up to a stationary period, which starts in 1940. After 1940 C makes a complete cycle of 30 years (1940-1970) and another half cycle which would finish with the present (2000).

In the aa index serie, the same cycles may be recognized. There are three cycles: 1900-1935, 1935-1970 and 1970-2000, the latter to be confirmed with data from next year.

The sunspot series shows periods close to 11 years (Figure 7). The sunspot number of each 11-year period increases from 1922 together with a decrease of the monthly C of 48 calm hours of the geomagnetic field. However, the sunspot oscillations show a stationary behaviour as in the C series and we may recognize the presence of a cycle of 30 years from 1940.

The high fluctuation of rainfall between 1909 and 1922 may be related to strong changes in the geomagnetic activity after 1922, when a lower rate of quiet days (or a greater activity of the geomgnetic field) begins (see Figure 6). However, this fluctuation may not be real.

Let us calculate the correlation coefficient (from -1 to +1) between the filtered rainfall data and the aa data.

We consider the period 1909-1999. We find a correlation coefficient of 0.20, which is low. But if we only consider the period 1922-1999 (thus omitting the rainfall fluctuations between 1909 and 1922) we obtain a correlation coeficient of 0.5. This result suggests that some changes in the geomagnetic activity could be correlated with changes in the long period components of the rainfall, particularly after 1922.

CONCLUSIONS

A comparison of the pluviometric series in the city of La Plata with the aa geomagnetic planetary index during the period 1909-1999 is presented.

A long-term (order of decades) qualitative correlation between the geomagnetic activity and the rainfall occurrence is suggested, because of in the existence of cycles of the same amplitude. A possible interaction between both phenomena is suggested by a periodic behavior with cycles of 30 years after 1922. A correlation between precipitation and geomagnetic activity is also detected when the number of calm days indicating a change in the terrestrial-solar relationships.

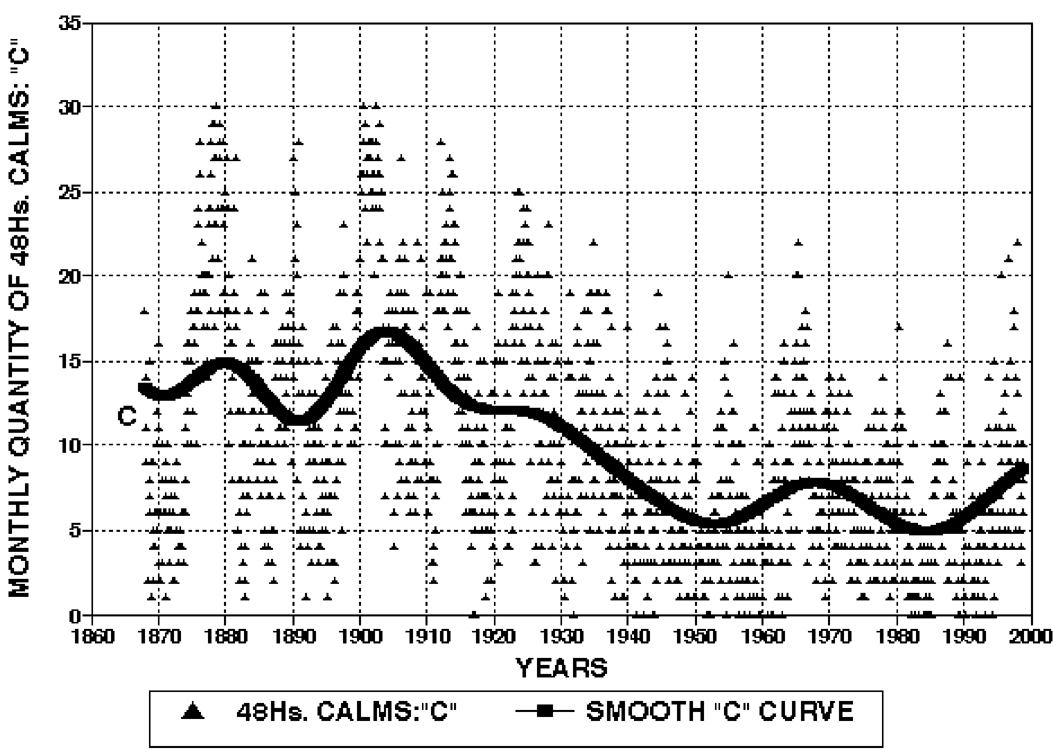

Fig. 6. Monthly quantity "C" of 48 calm hours of the geomagnetic field.

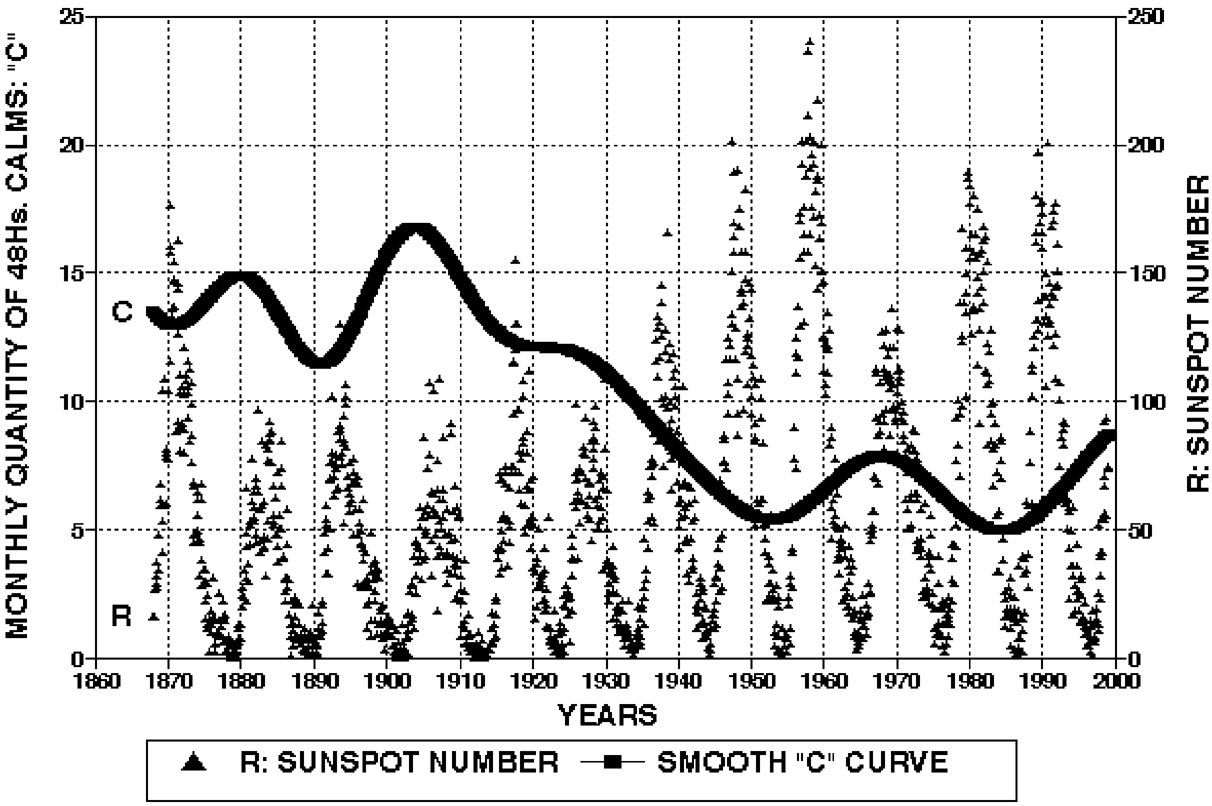

Fig. 7. Smooth curve "C" and sunspot number.

Correlation coefficients of up to 0.5 confirm that some part of the long-period variability of the rainfall could be explained by geomagnetic activity. It would be interesting to attempt estimating the long-term rainfall occurrence from the variations in the aa index.

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