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The solar influence on the monsoon rainfall over Tamil Nadu

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ABSTRACT
We use 100 years data for studying correlative effects between solar cycle and rainfall over Tamil Nadu. For the period of different solar cycles, we compute the correlation coefficients for the seasonal months of Jan-Feb (JF), Mar-May (MAM), June-Sept (JJAS) and Oct-Dec (OND) and annual mean data. We find that: (i) with a moderate - to high significance; Tamil Nadu rainfall is correlated with the sunspot activity and (ii) there is an overall trend that during the period of high sunspot activity, occurrence of rainfall is low compared to the period of low sunspot activity.

We speculate in this study a possible physical connection between the occurrence of the rainfall and the sunspot activities and the flux of galactic cosmic rays. Some of the negative correlations between the occurrences of the sunspot and rainfall activities obtained for different solar cycle periods are interpreted as effects of aerosols on the rain forming clouds due to either intermittent volcanic eruptions or due to intrusion of interstellar dust particles in the earth's atmosphere.

INTRODUCTION

Fluctuations in solar activity are undoubtedly a factor affecting weather and climate. Although the results of some of the studies are conflicting, Indian weather and climate, in general is inversely related to sunspots (Bhalme et al 1981).Several papers are documented to find out the association between solar activity and rainfall. Recently Hiremath 2006 made a correlation study between sunspot number and Indian rainfall. According to him, the weak solar activity leads to heavy rainfall in Indian region. Sunspot number is one of the best indicators of solar activity. Here, smoothed sunspot number is taken as an indicator of solar activity.

The possible linkage between the daily rainfall of Tamil Nadu and the daily values of the sum of k-indices during geomagnetic great storms and magnetically quiet days has been investigated making use of superposed epoch methods, frequency distribution, power spectral and cross spectral analyses. Geomagnetic activity during great storms and rainfall have a common 15-day periodicity which is significant at the 99 per cent level (Reddy et al 1984).The k-index is a code that is related to the maximum fluctuations of horizontal components observed on a magnetometer relative to a quite day, during a three-hour interval. It is found that strong solar activity, to some extent, increases the seasonal wind pattern and thereby increases the Tamil Nadu rainfall. In the present study, we investigate the effect of the solar activity for a short term (~ 11yrs) scale and study the cycle-to-cycle variations of the influence of the solar activity on the rainfall over Tamil Nadu.

DATA AND ANALYSIS

We consider 100 years (1901-2000) data of the sunspot number and the rainfall over Tamil Nadu. The sunspot number data is obtained from the website ftp.ngdc.noaa.gov/ STP/SOLAR_DATA/ SUNSPOT_NUMBERS and the rainfall data is obtained from the Regional Meteorological Centre, Chennai. In the present analysis, we use the seasonal (including the spring, the southwest, the northeast and the winter monsoon) and the annual (averaged for the period of 12 months) rainfall data.

We compute to find out probable relationship between Tamil Nadu rainfall and solar activity. The different nomenclatures for the seasonal rainfall occurrences are given as follows. We combine the winter rainfall data for the months of January and February and denote it as JF. For the combined months of the March, April and May, spring rainfall data set, we denote it as MAM. In the rest of the months, the rainfall variability is dominated by the southwest (June, July, August and September) and northeast (October, November and December) monsoons, which we denote as JJAS and OND respectively. For a particular year, we compute the average of all the 12 months rainfall data and call it as annual mean of the rainfall data. For similar combined months (JF, MAM, JJAS, OND), we collect the sunspot data. For each year, by using 12 months data, we compute annual mean of the sunspots. In Table 1, we present the Spearman Rank-order correlation coefficients computed between the occurrences of sunspot and rainfall activities from the data. This method (Press et al. 1992) of finding the correlation between two variabilities is more robust than the usual method (i.e., by linear correlation). The first column represents the solar cycle period and the second column the length of the solar cycle. In the third to last columns, the results for the combined seasonal months of JF (winter), MAM (summer), JJAS (southwest), OND (northeast) and the annual mean correlation coefficients are presented.

Fig.1 Illustrates the relationship between the annual rainfall and annual sunspot number. The graph is plotted taking the year along the x axis and the annual rainfall in mm and the annual sunspot number taken along the y axis for comparison.

Fig 2 Illustrates the relationship between the

Table 1. Cycle-to-Cycle variation of correlation coefficients for the seasonal months (JF, MAM, JJAS and OND) and annual raw data respectively.

Year	Length	JF	MAM	JJAS	OND	Annual
1901-1911	11	-0.15	0.14	-0.4	0.44	-0.34
1912-1922	11	0.37	0.43	0.51	-0.63	0.01
1923-1933	11	0.24	-0.13	-0.08	-0.08	-0.3
1934-1944	11	-0.32	0.4	-0.01	-0.15	-0.15
1945-1955	11	-0.01	-0.23	0.09	-0.07	-0.01
1956-1966	11	0.3	0.38	-0.43	0.17	-0.23
1967-1977	11	0.45	0.15	-0.23	0.18	0.18
1978-1988	11	-0.26	0.10	-0.06	0.23	-0.24
1989-2000	12	0.04	-0.18	0.13	-0.32	-0.41

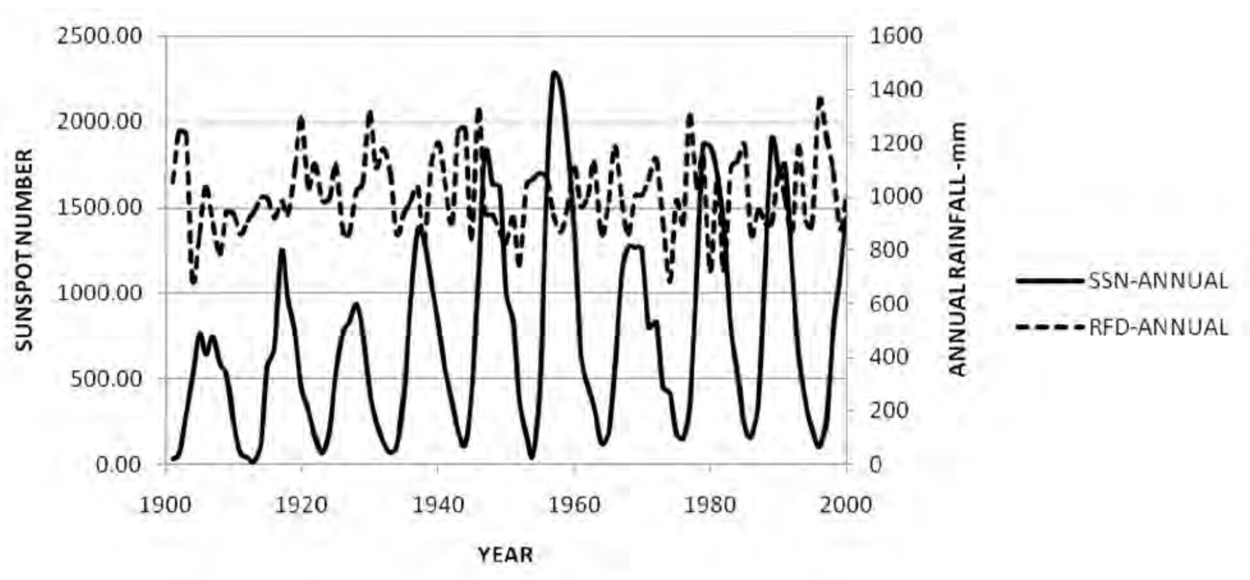

Figure 1. Relationship between Annual Rainfall and Annual SunSpot Number

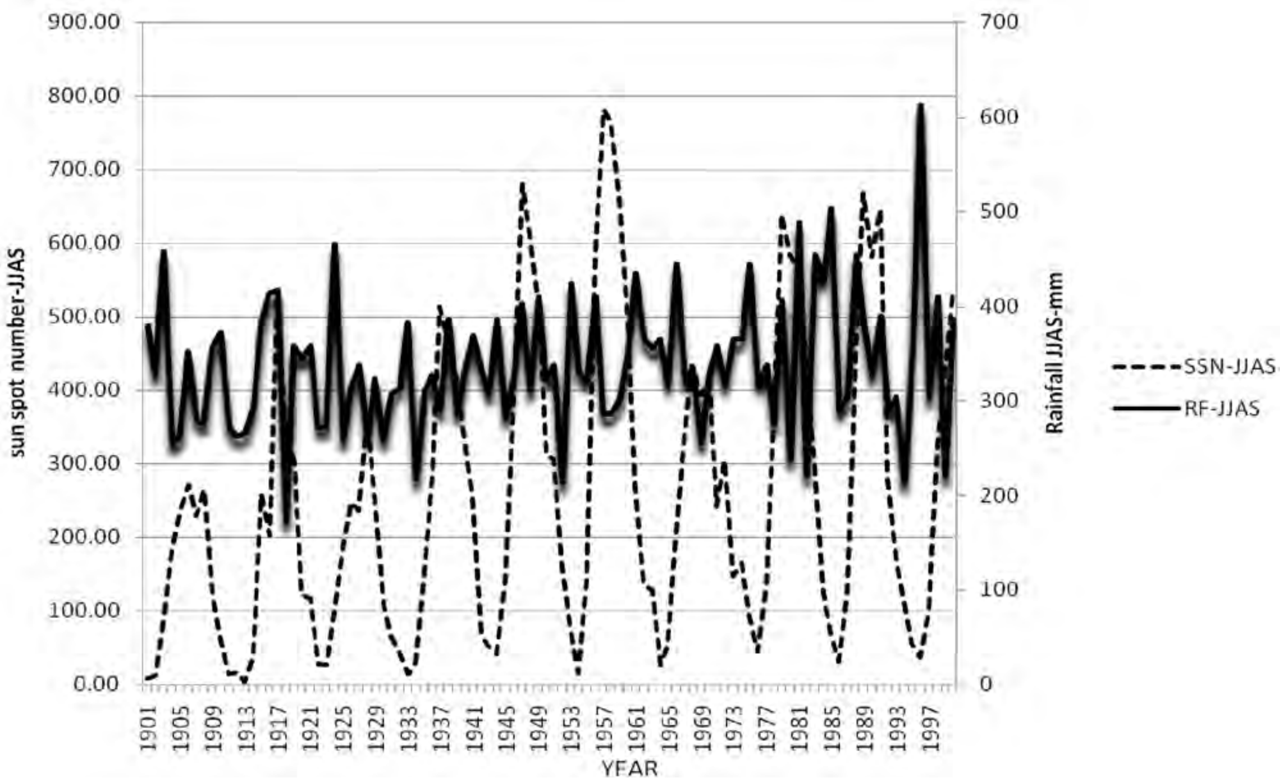

Figure 2. Relationship between Rainfall and Sunspot Number for SOUTH WEST MONSOON

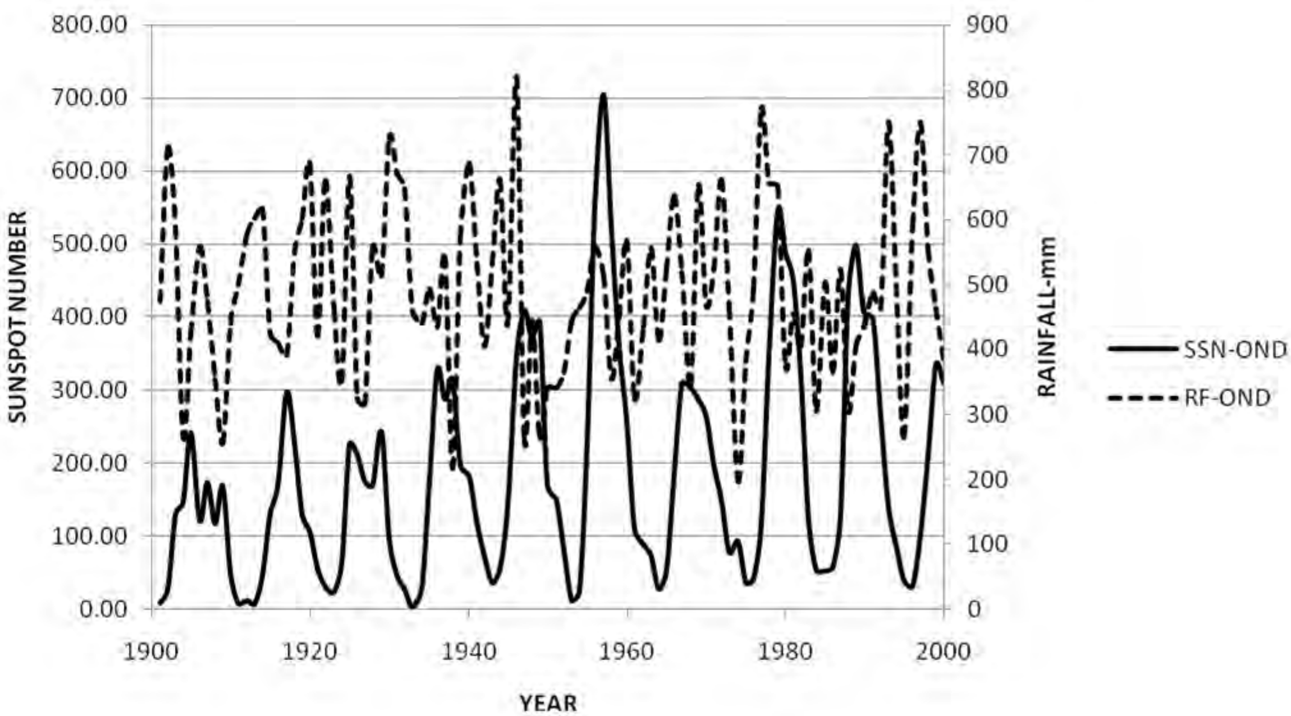

Figure 3. Relationship between Rainfall and Sunspot Number for NORTHEAST MONSOON

rainfall and sunspot number for south west monsoon (june to September). The graph is plotted taking the year along the x axis and the rainfall in mm and the sunspot number along the y axis for comparison.

In Fig.3 illustrates the relationship between the rainfall and sunspot number for the seasonal month October- December. The graph is plotted taking the year along the x axis and the rainfall in mm and the sunspot number along the y axis for comparison.

One can argue that the correlations (present in table 1) within a cycle are rarely significant to draw any conclusion. The following are the two most likely reasons for the low significance of correlation coefficients (CC). The first problem is estimation of the significance of correlation coefficients (CC). The best and correct way is to have measured uncertainties in the rainfall data and compute the CC and their significances. Unfortunately, we do not have any measured uncertainties in the rainfall data, considered in this study. The second problem is the low accuracy of the rainfall data that are measured from the rain gauges.

Though the uncertainties in the derived coefficients are large, we can draw the following conclusions: for a particular solar cycle period, there appears to be an overall trend that irrespective of signs of the correlation coefficients, the monsoon rainfall variability is strongly correlated during the weak sunspot activity and weakly correlated during the strong sunspot activity. That means, during the 11-year solar cycle, a weak sunspot activity leads to a strong Tamil Nadu rainfall variability and vice versa.

CONCLUSIONS AND DISCUSSION

From the correlative analysis of 100 years data of the sunspot and the Tamil Nadu monsoon rainfall activities, the following conclusions are made:

- With a moderate-to-high significance, sunspot activity is correlated with the Tamil Nadu rainfall activity and
- Irrespective of signs of the correlation coefficients, for a particular period of a solar cycle, there appears to be an overall trend that, rainfall variability is low during the high solar activity than the low solar activity.

There is a causal relationship between the sunspot activity, galactic cosmic rays (GCR) and the rainfall. The GCR activity is the source of ions in the Earth's atmosphere. We know that the condensation of water vapour into water drops is mediated by the ions in the atmosphere. Thus, any change in the GCR activity, correspondingly affects the rainfall variability. As the intensity of the GCR is inversely proportional to the solar activity, increase in solar activity results

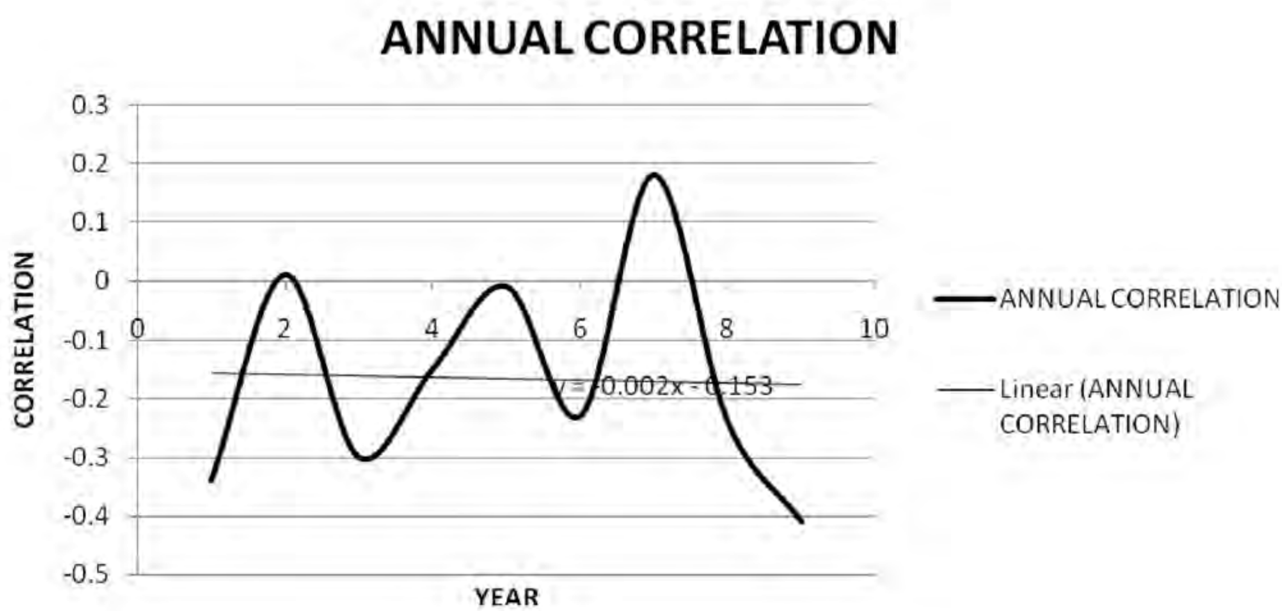

Figure 4. Correlation coefficient for the Annual rainfall and Annual sunspot number

in reducing the intensity of the GCR flux. This ultimately results in both reducing the activity in nucleation of the cloud particles and suppressing the rainfall variability (Parker 1999). That means, during high sunspot activity, we should get a small correlation coefficient (considered as absolute value) between the occurrence of sunspot and the rainfall variabilities.

The negative correlations in some of the cycle periods could be due to the changing spatial and the temporal occurrence pattern of the aerosol particles or due to intrusion of interstellar dust particles in the atmosphere. The recent study (Vinoj et al. 2004) shows the rain-deficit of the summer monsoon due to large aerosol optical depths. In fact there is a constant accretion ~(4.0 ± 2.6) 10v Kg/year) of cosmic dust due to extra terrestrial origin on the earth's atmosphere (Lone & Brownlee 1993; Yada et al .2000; Lal & Jull 2002). A mechanism has been proposed that involves coupling between the ionosphere and troposphere (Manish Tiwari et al 2007). Ionosphere is the region in the atmosphere (at the altitude of ~80-250 km) where the atoms absorb the incoming solar energy in the UV band and produce ions and free electrons. The varying solar activity also varies with the ionospheric charge, which is intimately coupled with tropospheric thunderstorms. Variations in ionospheric electric field will thus affect the electric charge on the clouds, which in turn play an important role in coalescence of droplets and condensation of water vapour.

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