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# Letters to the Editor

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## INTER ANNUAL AND INTRA DECADAL BEHAVIOUR OF MONSOON RAINFALL OVER JALPAIGURI

1. Strong seasonality is the main characteristic of monsoon regimes and Indian sub-continent falls under such regime. Understanding nature and organization of monsoon seasonal rainfall (Jun-Sep) over wide range of temporal and spatial time scales is very important in the context of high dependency of varied economic activities on such seasonal rainfall. Many researchers (Mooley and Parthasarathy, 1984, Srivastava *et al.*, 1992 & 1998, Subramaniam *et al.*, 1992, Kane 1999 & 2001) have studied the rainfall at different time and spatial scales for trends and periodicities with a view to understand its stochastic behaviour. These types of study are useful for dynamical/statistical model building, which is a tool for forecasting rainfall at various lead times. In India, the trends and periodicities in the annual rainfall at different spatial scales have been studied by Parathasarathy and Dhar (1976), Sarkar and Thapliyal (1988) and Thapliyal and Kulshrestha (1991). Walker (1910) studied the rainfall data for conspicuous trends and periodicities for the period 1841-1908. Subbaramayya and Naidu (1992) making use of rainfall data for the period 1871-1988, found decreasing significant trend in monsoon rainfall towards the end of previous century which ended by 1904 in West Central India, while increased rainfall from 1940-46. In this paper, an attempt has been made to determine the long term trends and periodicities in the seasonal rainfall over Jalpaiguri using data for the period 1901-2000.

The monsoon seasonal rainfall data over Jalpaiguri for the period (1901-2000) has been collected from the records of Flood Meteorological Office, India Meteorological Department, Jalpaiguri. The long period (1901-2000) average of the seasonal rainfall is 2669.5 mm with standard deviation of 524.7 mm. The long period (1901-2000) average annual rainfall is 3306.8 mm with standard deviation of 563.9 mm. The station receives 79 percent of the annual rainfall during the monsoon season. Examination of the data showed that during 73 years, the monsoon seasonal rainfall over Jalpaiguri is within one standard deviation from long period average (1901-2000) and hardly two values exceeding two standard deviations with no single value falling below one standard deviation.

The normal (1951-80) annual and monsoon seasonal rainfall being 3249.7 mm and 2540.0 mm respectively. The percentage departures from normal (1951-80) in respect of monsoon seasonal rainfall for the period 1901-2000 are depicted in Fig. 1. During the period (1901-2000) the station has received excess rainfall on 24 occasions, normal on 64 occasions and deficient rainfall on 12 occasions. The seasonal rainfall is said to be excess when the percentage departure from normal rainfall exceeds +19 percent. It is normal when the percentage departure from normal seasonal rainfall is within −19 percent to + 19 percent and it is said to be deficient when the percentage departure from normal is within -20 percent to −56 percent. The computed 30 years means and decadal means with their standard deviations, coefficient of variations are presented in Table 1. The student's *t*-test statistic was applied to see whether the 30 years means and the decadal means significantly differ from the long term average computed from the data period 1901-2000. The results were insignificant at 95% level of confidence in confirmation with Null-hypothesis that the samples are drawn from the same population and means do not significantly differ from one another. The computed Student's *t*-test statistic values are presented in the last column.

2. To start with the temporal analysis of monsoon seasonal rainfall series, a powerful Mann-Kendall rank test statistics has been applied as an alternative to randomness for linear and non-linear trends. The Mann-Kendall rank test statistics is given by $T = 4\ \Sigma n_i / [N(N-1)] - 1$ where '$n_i$' is the no. of observations above its occurrence in succession and N being the total no. of observations. The Mann-Kendall rank test statistics has been applied to the complete data set 1901-2000 and also for each of the 30 years period 1901-30, 1931-60, 1961-90. The individual decades 1901-10, 1911-20, 1921-30, 1931-40, 1941-50, 1951-60, 1961-70, 1971-80, 1981-90, 1991-2000 are also been subjected to the Mann-Kendall rank test statistics. In addition, the test statistics has been applied to study the inter-decadal (from decade to decade) trend. The computed values of Mann-Kendall rank statistics are mentioned in Table 2. If the value of 'T' is +1, then there is a systematic upward trend and if the value of 'T' is −1, then there is a systematic downward trend. If the value of 'T' is very near to zero then there is no trend. A test statistic given as $t = tg\ \sqrt{(4N+10)/9N(N-1)}$ where '$t_g$' is the value of test statistic at appropriate probability point in the Gaussian distribution. The probability point of 0.05 has been selected in this paper. The computed Mann-Kendall rank test statistic values for entire data period (1901-2000) and also for each of 30 years periods 1901-30, 1931-60, 1961-90 are all insignificant at 5% level of significance which means no trend. When applied for inter-decadal

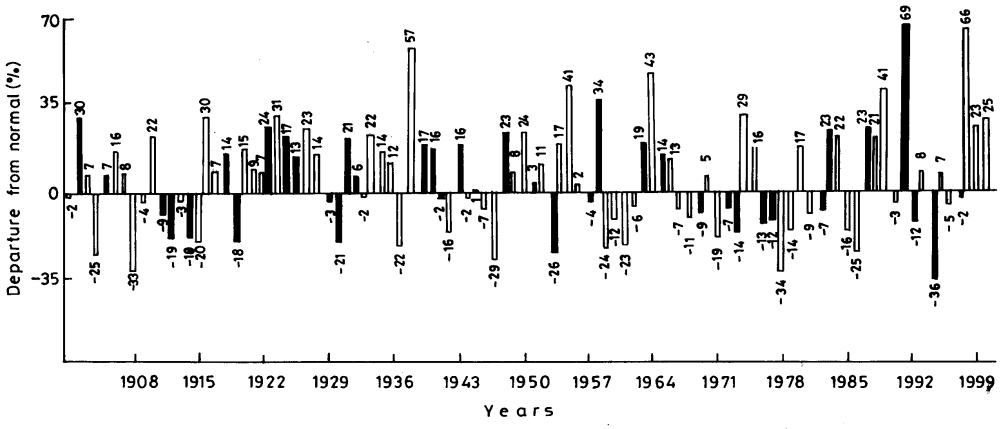


**Fig. 1.** The seasonal rainfall over Jalpaiguri expressed as percentage departure from normal (1951-80) for the period (1901-2000). Bar corresponding to El Nino years are shown shaded

**TABLE 1**

**Monsoon seasonal rainfall (June-September) statistics, Student's *t*-values**

| Period | Mean (mm) | Standard deviation (mm) | Coefficient of variation (%) | Student's *t*-test value |
|---|---|---|---|---|
| 1901-2000 | 2669.5 | 524.7 | 20 | – |
| 1901-1930 | 2644.1 | 450.8 | 17 | –0.1707 * |
| 1931-1960 | 2705.5 | 501.5 | 19 | –0.2175* |
| 1961-1990 | 2589.4 | 499.3 | 19 | –0.4861* |
| 1901-1910 | 2603.8 | 475.4 | 18 | –0.4188* |
| 1911-1920 | 2487.7 | 427.4 | 17 | –0.2961* |
| 1921-1930 | 2841.7 | 368.3 | 13 | +1.4168* |
| 1931-1940 | 2896.4 | 486.1 | 17 | +1.4145* |
| 1941-1950 | 2574.7 | 407.6 | 16 | –0.7048* |
| 1951-1960 | 2645.4 | 543.2 | 20 | -0.1339* |
| 1961-1970 | 2637.0 | 458.1 | 17 | –0.2150* |
| 1971-1980 | 2413.4 | 471.1 | 19 | –1.6473* |
| 1981-1990 | 2717.9 | 516.1 | 19 | +0.2842* |
| 1991-2000 | 2878.1 | 756.6 | 26 | +0.8355* |

* Values insignificant at 5 % significant level.

**TABLE 2**

**Showing the Mann-Kendall rank statistic values**

| | | | | |
|---|---|---|---|---|
| 1901-2000 | 1901-1930 | 1931-1960 | 1961-1990 | Inter-decadal |
| +0.0109 | +0.1494 | –0.0989 | +0.0575 | +0.1555 |
| 1901-1910 | 1911-1920 | 1921-1930 | 1931-1940 | 1941-1950 |
| +0.0222 | +0.3333 | –0.2444 | +0.0667 | +0.3333 |
| 1951-1960 | 1961-1970 | 1971-1980 | 1981-1990 | 1991-2000 |
| –0.2000 | –0.1556 | +0.0667 | +0.2000 | +0.2444 |

trend (from decade to decade) the test revealed again statistically insignificant value at 95 % level of confidence indicating no trend. On the intra-decadal time scale(within each decade), all the ten periods 1901-10, 1911-20, 1921-30, 1931-40, 1941-50, 1951-60, 1961-70, 1971-80, 1981-90, 1991-2000 have shown no trend. The results, in this paper, are in confirmation with the earlier studies. In this paper, the test is conducted for seasonal

rainfall. Parathasarathy and Dhar, 1976. Thapliyal and Kulshrestha, 1991 who concluded that the annual rainfall of India exhibits considerable year to year variation, but, doesn't show any definite increasing or decreasing trends throughout the period, in addition, all India rainfall exhibits fluctuations epochal increasing and decreasing trends during the period of study which means the decadal means alternate above or below the normal value. The seasonal rainfall series studied in this paper has not shown any epochal trend. Srivastava *et al*. (1998) through their study concluded that the Sub-Himalayan West Bengal & Sikkim has no trend in both annual and seasonal rainfall.

3. The monsoon seasonal rainfall has also been subjected to the Harmonic analysis with a view to delineate the regular periodic fluctuations in rainfall. The best estimates of sine and cosine amplitudes and their standard errors were obtained by the method of least square fit. From these estimates the amplitude and standard error was estimated. Any value of the amplitude exceeding twice the standard error limit was accepted as significant at 5 percent level of significance. The study of the periodogram so generated revealed that no statistically significant periodic fluctuations are present in the monsoon rainfall series. However, two prominent peaks at 8.3 years and 1.3 years are noticed in the spectrum of monsoon seasonal rainfall over Jalpaiguri and out of which only 1.3 years peak is significant at 95 percent confidence level. The periodogram and spectrum of monsoon seasonal rainfall on Intra-decadal (within each decade of study) scale also did not suggest any statistically significant periodic fluctuations. Earlier research studies (Parthasarathy and Sontakke, 1988, Mooley, 1997, Kane, 1997a, 1999 & 2001) indicated inverse relationship between El nino events and monsoon seasonal rainfall. Quinn *et al.* (1987), Rasmusson and Carpenter (1983) have documented the El nino events based on their own criteria of SST anomalies off Peru-Ecuador coasts. In the Fig. 1 the rainfall bars corresponding to El nino years are shown shaded. During the period 1901-2000, there were 37 El nino years. During 37 El nino years, the station Jalpaiguri has received excess rainfall on 8 occasions (1902, 1923, 1931,1948, 1958, 1983, 1987, 1991) and deficient rainfall on 3 occasions (1930, 1953, 1994). During the remaining 26 events, the station has received normal rainfall.

4. The study of monsoon seasonal rainfall over Jalpaiguri for a period of 100 years (1901-2000) suggest that the monsoon rainfall series do not exhibit any persistent trend and is marked by the absence of any well - Known atmospheric periodicities both on inter annual and intra decadal periods. It is also observed that no significant inverse relationship exists between seasonal rainfall over Jalpaiguri and El nino. Nevertheless, alternating fluctuations in rainfall above and below normal on decadal scale have been observed during the period of study.

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