## SHORT COMMUNICATIONS

### 40-DAY MODE OF EQUATORIAL TROUGH FOR LONG-RANGE FORECASTING OF INDIAN SUMMER MONSOON ONSET

P. V. JOSEPH and P. V. PILLAI
*India Meteorological Department, Pune 411 005, India.*

STUDYING the weekly rainfall of the meteorological sub-divisions of India, south of latitude 13° N from 1 March to 31 May for the years 1960 to 1984, we found that a peak in the rainfall activity in these sub-divisions occurs about six weeks before the date of onset of the monsoon over Kerala in almost all these years. This observation can be made use of for predicting the date of onset of the southwest monsoon over Kerala. The methodology employed and the results we obtained are briefly presented here.

The normal (climatic) date of onset of monsoon rains in Kerala (the southernmost meteorological sub-division of India) is 1 June[1–3]. During individual years the date of onset varies widely; the earliest was 11 May (in 1918) and the most delayed was 18 June (in 1972). The available studies[4–9] on the problem of long range forecasting of monsoon onset have used atmospheric and oceanic parameters antecedent to the monsoon from a large area of the globe.

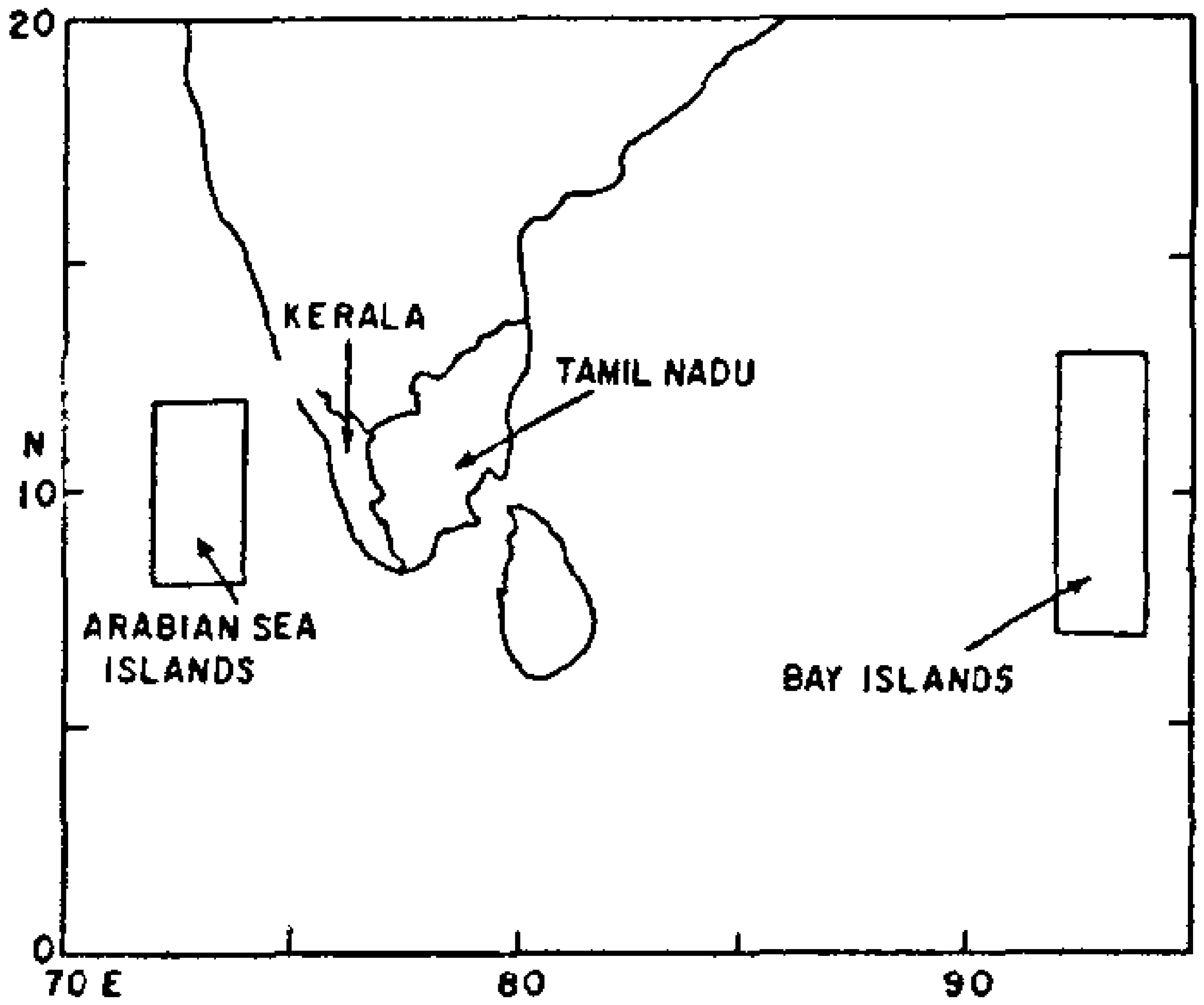


**Figure 1.** The four southernmost meteorological sub-divisions of India, viz. Arabian Sea Islands, Kerala, Tamil Nadu and Bay Islands are shown here. For the two island sub-divisions the boundaries marked are rectangles that cover the island stations whose rainfall reports have been used in the study.

Yasunari[10] and Sikka and Gadgil[11] have shown that the monsoon season June to September, is characterized by a northward propagating low frequency mode in cloudiness of period of around 40 days. Using FGGE MONEX wind data of 850 mb level, Krishnamurti and Subramanyam[12] found that the 40-day mode existed in 1979 even in May, prior to the onset of the monsoon over Kerala.

The 'Weekly Weather Report' published every week from Pune by the India Meteorological Department gives the rainfall of each meteorological sub-division of India for the week ending at 0830 hours, Indian Standard Time (0300 GMT) of Wednesday as an average of the rainfall recorded at a number of selected representative stations in the

**Table 1** *Rainfall ratios $\bar{R}$ representing weekly rainfall activity in the latitudinal band covering the meteorological sub-divisions Arabian Sea Islands, Kerala, Tamil Nadu and Bay Islands*

| Number of week | 1961 | 1972 | 1975 | 1984 | 1977 |
|---|---|---|---|---|---|
| 1 | 0.4 | 0.0 | 1.3 | 2.9 | 0.0 |
| 2 | 0.0 | 0.0 | 2.3 | 2.3 | 1.2 |
| 3 | 0.8 | 0.0 | 0.8 | 0.0 | 0.3 |
| 4 | 0.1 | 0.0 | 0.3 | 0.5 | 1.6 |
| 5 | 0.2 | 0.1 | 0.1 | 1.5 | 0.7 |
| 6 | *1.7 | 0.8 | 0.6 | 1.1 | 0.4 |
| 7 | 0.1 | 1.0 | 0.6 | 1.7 | 0.2 |
| 8 | 0.9 | 0.8 | 0.5 | *2.1 | 0.5 |
| 9 | 0.4 | 0.2 | *2.2 | 0.7 | *1.8 |
| 10 | 1.3 | 0.7 | 1.4 | 0.0 | 0.5 |
| 11 | 1.4 | *1.9 | 0.4 | 0.1 | 2.4 |
| 12 | 0.9 | 1.9 | 0.6 | 0.8 | 1.5 |
| 13 | 1.9 | 0.3 | 0.7 | 0.3 | 1.0 |
| 14 | 1.8 | 0.5 | 1.6 | 0.9 | 1.0 |
| Middle date of week of rain peak during period 1 April to 10 May* | 02 April | 07 May | 27 April | 22 April | 24 April |
| Date of monsoon onset as declared by IMD | 18 May | 18 June | 31 May | 31 May | 30 May |

sub-division. On the basis of long period data, the weekly normal rainfall of the sub-division are also given in the publication. For the present study we have worked out the ratio $R = A/N$ of the actual (A) to the normal ($N$) weekly rainfall during the months March to May for the period 1960–1984 with respect to the four southernmost meteorological sub-divisions (figure 1). These are the Arabian Sea Islands, Kerala, Tamil Nadu and the Bay Islands. The $R$ values of the four sub-divisions were averaged to obtain a single figure $\bar{R}$, representative of the weekly rainfall activity over the entire east-west belt (8° N to 13° N and 70° E to 95° E) which is associated with the equatorial trough. $\bar{R}$ occasionally has very large values. In order that $\bar{R}$ may represent the rainfall associated with the equatorial trough over the entire east-west belt studied, values of $R$ greater than 3 were taken as equal to 3.

The $\bar{R}$ series reveal that high rainfall activity occurs over the zonal belt studied at intervals of 5 to 7 weeks, showing a quasi-periodicity of around 40 days in the activity of the equatorial trough during March to May.

It is known that the onset of the monsoon in Kerala occurs with a spectacular increase of rain in

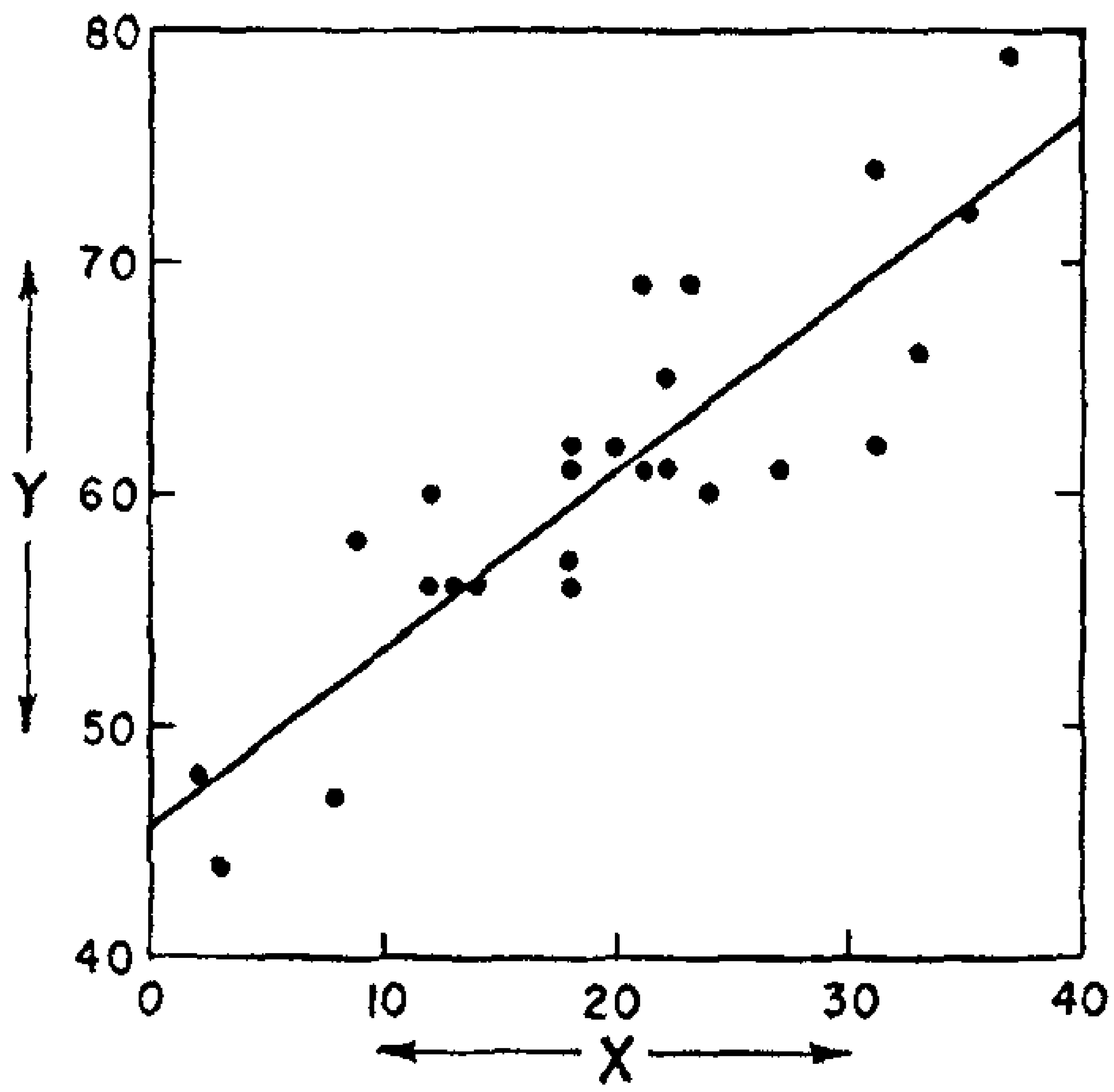


**Figure 2.** A scatter diagram between $X$ and $Y$ is given here. $X$ is the day of rain peak in the period 1 April to 10 May counted from 1 April as day 1 and $Y$ is the day of monsoon onset as declared by the India Meteorological Department, also counted from 1 April. The straight line of best fit between $X$ and $Y$ is also marked.

**Table 2** *Dates of Pre-Monsoon Rainfall Peak (PMRP) and monsoon onset over Kerala as declared by IMD are given as X and Y respectively, counted from 1 April as 1. Estimated onset date Ye based on this study and the error of the estimate (Y − Ye) are also given*

| Year | PMRP $X$ | Actual onset $Y$ | Estimated onset $Ye$ | Error $(Y-Ye)$ |
|---|---|---|---|---|
| 1960 | 03 | 44 | 48 | −4 |
| 1961 | 02 | 48 | 48 | 0 |
| 1962 | 08 | 47 | 52 | −5 |
| 1963 | 21 | 61 | 62 | −1 |
| 1964 | 33 | 66 | 71 | −5 |
| 1965 | 18 | 56 | 60 | −4 |
| 1966 | 31 | 62 | 69 | −7 |
| 1967 | 23 | 69 | 63 | 6 |
| 1968 | 21 | 69 | 62 | 7 |
| 1969 | 13 | 56 | 56 | 0 |
| 1970 | 12 | 56 | 55 | 1 |
| 1971 | 18 | 57 | 60 | −3 |
| 1972 | 37 | 79 | 74 | 5 |
| 1973 | 22 | 65 | 63 | 2 |
| 1974 | 14 | 56 | 57 | −1 |
| 1975 | 27 | 61 | 66 | −5 |
| 1976 | 18 | 61 | 60 | 1 |
| 1977 | 24 | 60 | 64 | −4 |
| 1978 | 09 | 58 | 53 | 5 |
| 1979 | 35 | 72 | 72 | 0 |
| 1980 | 20 | 62 | 61 | 1 |
| 1981 | 12 | 60 | 55 | 5 |
| 1982 | 18 | 62 | 60 | 2 |
| 1983 | 31 | 74 | 69 | 5 |
| 1984 | 22 | 61 | 63 | −2 |

Kerala and also in the latitudes of Kerala to its west and east. After the onset of monsoon in Kerala, this zonal rainfall belt moves northwards. Since a 40-day mode is found to exist prior to the monsoon onset associated with the equatorial trough rainfall, the increase in rainfall a cycle earlier to the monsoon onset was looked for in the period from 1 April to 10 May. As the 40-day mode has considerable zonal extension, the rainfall peaks were looked for in the mean weekly rainfall ratios $\bar{R}$.

For each year, the midday of the week giving a sharp rainfall peak in the $\bar{R}$ series during 1 April to 10 May was taken as the peak of the 40-day mode, one cycle prior to the monsoon onset. This is called the Pre-Monsoon Rainfall Peak (PMRP). These dates are counted from 1 April as day 1 and they form the $X$-series for the years 1960–1984. The date of onset of the monsoon over Kerala as declared by

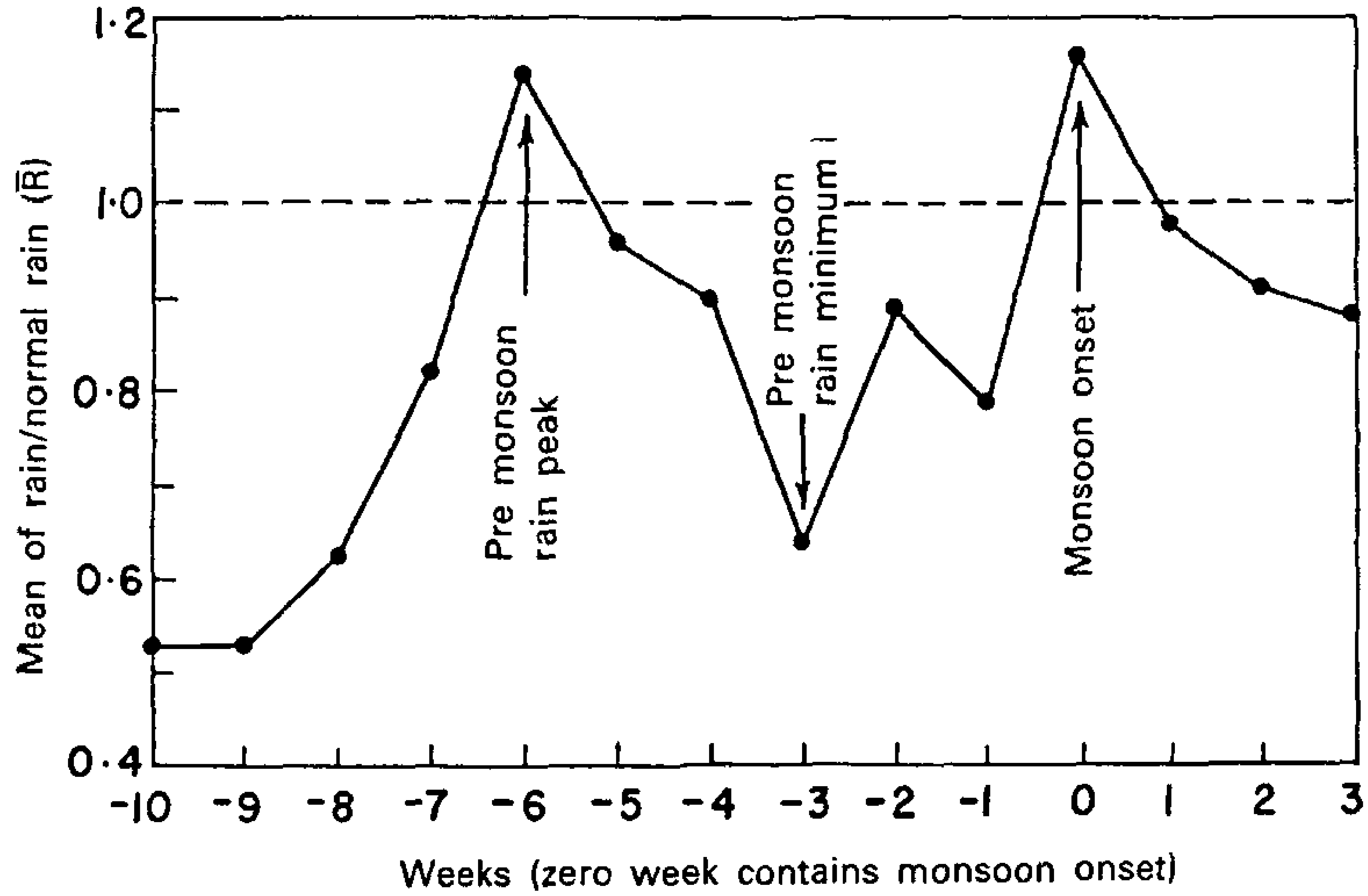


**Figure 3.** A superposed epoch diagram with zero week containing monsoon onset over Kerala during the 25 years 1960–1984 showing mean of $\bar{R}$ for the period 10 weeks prior to monsoon onset to 3 weeks after.

the India Meteorological Department and counted from the same 1 April as day 1 form the $Y$-series. Table 1 gives the weekly rainfall ratios $\bar{R}$ for five typical years. The peaks of rainfall are underlined and the PMRP by an asterisk sign. In 1961 and 1972 there was very little rainfall in March; however there is a peak during 1 April to 10 May. In 1975 and 1984 there is a peak during 1 April to 10 May; in addition there is a peak about six weeks earlier, in March. In 1977 there are two peaks during 1 April to 10 May. It may be seen that during 1977 similar double peaks are seen even a cycle earlier i.e. in March. In such years, which are very few, PMRP is arbitrarily chosen.

The scatter diagram between $X$ and $Y$ for these 25 years is given in figure 2. The straight line shows best fit to the data by the least square deviations method. The linear correlation coefficient between $X$ and $Y$ is obtained as $r = 0.87$ which is statistically highly significant. The regression equation between $X$ and $Y$ is

$$Y = 0.75X + 46.19.$$

Using this regression equation the dates of onset were estimated for the 25 years using the PMRP values and compared with the actual dates of onset ($Y$). The standard (root mean square) error of the estimate is obtained as 3.9 days (table 2). This regression equation may therefore be used for the long range forecasting of the date of onset of monsoon over Kerala.

From the regression equation it is found that when the PMRP occurs on 1 April ($X = 1$), the monsoon onset is 46 days later (on 17 May) and when the PMRP is on May 10 ($X = 40$), the monsoon onset is only 36 days later (on 15 June). Thus $Y$ minus $X$, the period of the 40-day mode is dependent on the calendar date and therefore apparently on the seasonal changes in atmosphere and ocean. This result is considered important in relation to the mechanism of the 40-day mode.

The weekly rainfall ratio ($\bar{R}$) series were used to obtain a mean picture of the temporal changes in the rainfall over the east-west belt 8° N–13° N before the monsoon onset. Superposed epoch method was used. The week containing the date of onset of monsoon over Kerala was taken as the zero week. Mean rainfall using $\bar{R}$ values were calculated for the 25 years 1960–1984, for weeks − 10 to 3 and are shown in figure 3. The peaks corresponding to monsoon onset over Kerala and PMRP are clearly seen. PMRP is on the average 6 weeks prior to the monsoon onset. Rainfall activity in the area covered by the four sub-divisions i.e. Arabian Sea Islands, Kerala, Tamil Nadu and Bay Islands is a minimum 3 weeks prior to the monsoon onset over Kerala.

The authors thank Mr B. C. Rathod for help in data collection.

30 May 1988

1. Ananthakrishnan, R., Acharya, U. R. and Ramakrishnan, A. R., *India Meteorological Dept. Forecasting Manual*, Part IV, 18, 1967.
2. Subramayya, I. and Bhanu Kumar, S. R. U., *Meteorol. Mag.*, 1978, **107**, 37.
3. Ananthakrishnan, R. and Soman, M. K., *J. Climatol.*, 1988, **8**, (in press).
4. De La Mothe, P. D. and Wright, P. D., *Meteorol. Mag.*, 1969, **98**, 145.
5. Koteswaram, P., *Tellus*, 1958, **10**, 43.
6. Maung Tun Yin, *J. Meteorol.*, 1945, **6**, 393.
7. Ramdas, L. A., Jagannathan, P. and Gopal Rao, S., *Indian J. Meteorol. Geophys.*, 1954, **5**, 303.
8. Wright, P. B., *Meteorol. Mag.*, 1967, **96**, 302.
9. Kung, C. and Sherif, T. A., *J. Meteorol. Soc. Jpn.*, 1982, **60**, 672.
10. Yasunari, T., *J. Meteorol. Soc. Jpn.*, 1980, **58**, 225.
11. Sikka, D. R. and Gadgil, S., *Mon. Weather Rev.*, 1980, **108**, 1840.
12. Krishnamurti, T. N. and Subramaniam, D., *J. Atmos. Sci.*, 1982, **38**, 2088.

## A PRELIMINARY NOTE ON THE NATURE OF BOUNDARY BETWEEN THE VINDHYANS AND THE METAMORPHICS TO THE NORTH OF SEJHARI, SHAHDOL DISTRICT, MP

P. K. NAGARIA
*Department of Applied Geology, Dr H. S. Gour Vishwavidyalaya, Sagar 470 003, India.*

THE available literature, does not convincingly prove the contact relationship between the Vindhyans and older metamorphics in the Son Valley. Earlier researchers who have extensively worked on geology have not however given any particular attention to the fundamental boundary fault between the Vindhyans and older metamorphics. After a critical field and contact relationship study the present author feels that the boundary between the Vindhyans and the older metamorphics is a *faulted contact*.

The lithology to the north of Sejhari (Lat: 24°8′52″, Long: 81°20′9°, 63H/8) represents the chlorite-talc-schists belonging to older metamorphics and the quartzites and conglomerates represent the basal stage of Semri Series of Lower Vindhyans.

The following is the stratigraphic sequence:

Semri Series: Basal Stage: Quartzites and Conglomerates
------------ Boundary Fault ------------
Older metamorphics: Chlorite-talc-schists

The boundary between the Lower Vindhyans and the older metamorphics is a faulted contact with evidences of thrusting as proved by the presence of "Zone of highly cleaved quartzites" showing drag folds within the Lower Vindhyans. The chlorite-talc-schists are subjected to cataclastic effects as evidenced by the imprints of cataclastic features. Besides, the above conglomerates of the Lower Vindhyans are highly compacted within the matrix assuming a quartzitic nature.

27 January 1988; Revised 26 April 1988

1. Oldham, R. D., Datta, P. N. and Vredenburg, E., *Mem. Geol. India*, 1901, **31**, 1.
2. Fox, C. S., *GSI Rep.*, 1926.
3. Auden, J. B., *Mem. Geol. Surv. India*, 1933, **62**, 141.
4. Ahmad, F., *Rec. Geol. Surv. India*, 1971, **96**, 1.

## PALYNOLOGICAL EVIDENCE ON THE AGE OF JABALPUR AND LAMETA FORMATIONS IN THE TYPE AREA

N. N. DOGRA*, R. Y. SINGH and S. K. KULSHRESTHA
*CAS in Geology, Punjab University, Chandigarh 160 014, India.*
** Department of Earth Sciences, Kurukshetra University, Kurukshetra 132 119, India.*

THE Jabalpur and Lameta Formations comprise important Infratrappean stratigraphic sequences in Jabalpur (Madhya Pradesh). The Jabalpur Formation also outcrops as isolated areas at Chaugan and Bansa localities of Madhya Pradesh[1]. The name Jabalpur Formation was given by Oldham[2] to the outcrops in the vicinity of Jabalpur city (23°10′30″N: 79°58′E) in a quarry cutting of Chui Hill near the Jabalpur railway station. The formation comprises thick, soft yellow, brown sandstones falsely or irregularly bedded. These sandstones are overlain by fire clays and soft argillaceous and sandy