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ON SOME CHARACTERISTICS OF ONSET OF SW MONSOON OVER INDIA AND THE ASSOCIATED RAINFALL FEATURES

1. The monsoon normally advances over Kerala and northwestern parts of India by 1st June and middle of July respectively. There is however a large variability in the year to year onset dates over the two areas. An attempt has been made to find presence of trend in the date of the two onsets. For this, Indian Summer Monsoon Rainfall (ISMR) data of 51 years (1951-2001) and onset dates over Kerala and west Rajasthan have been used. The data was subjected to trend analysis and also the same was correlated to ISMR. The total duration of days in "breaks" during the monsoon is worked out and also effect of El Nino on the onset and ISMR are studied.

The delay in the onset over west Rajasthan and the interval between the onsets over Kerala and west Rajasthan affect the ISMR over the country. No significant trend in arrival of monsoon could be conspicuously noticed. El Nino does not exert significant influence over onset of monsoon over Kerala.

2. Every year the onset of south west monsoon over Kerala is watched by the meteorologists, farmers and the administrators with great awe and anxiety. This is because agriculture is the main occupation of a vast majority of our population. Lack of adequate irrigation facilities increases the dependence of farming on the monsoon rains.

The monsoon normally advances over the southern tip of the country *i.e.*, Kerala by the 1st June. However, the extreme northwestern parts of India receive monsoon rains last, by about middle of July. After advance over Kerala, its onward march over the Peninsula, the Indo-Gangetic plains and the northwest India is intimately linked with development of synoptic systems. Because of this, in many years, it has been found that it gets stagnated after covering some areas. In 1982 and recently 2002 the monsoon, though arriving in time over Kerala, could reach northwest India as late as on 22nd July and on 15th August respectively.

People at large are interested to know whether the monsoon rainfall in their areas will be normal if the advance over Kerala is normal, or if it advances abnormally late, the prospects of the rains being normal or deficient. There is also a widespread perception that climatic change is taking place in many parts of the globe which is reflected in the recently observed abnormal behavior of the monsoon.

In the present work, the authors have examined any shift in the onset dates over Kerala and the northwest India *i.e.*, west Rajasthan. An attempt has also been made to relate the onset over the two regions (Kerala and west Rajasthan) and the intervening period between these two onsets bears any relationship with Indian Summer Monsoon Rainfall (ISMR). Number of days of "breaks" in monsoon has also been studied *vis-a-vis* ISMR.

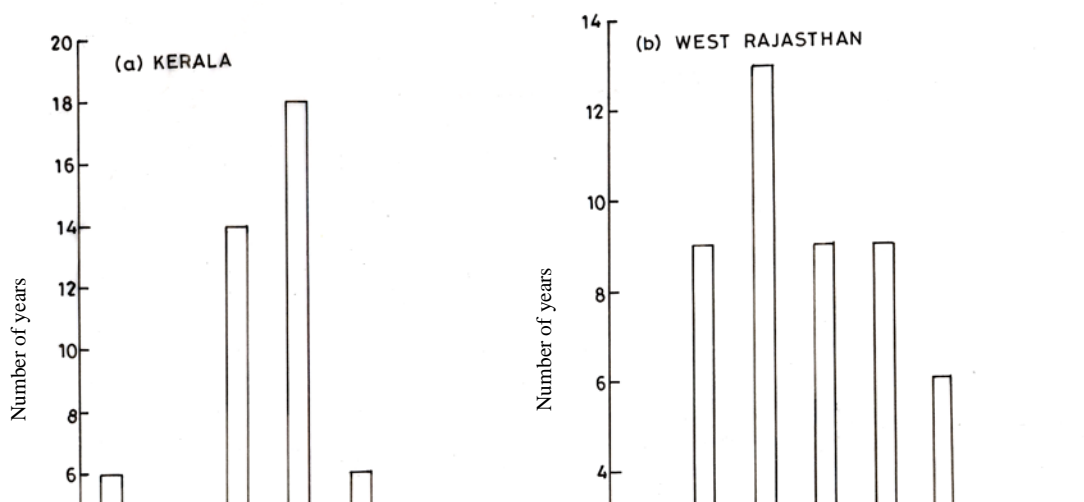
3. For the present study, data of 51 years (1951-2001), pertaining to ISMR and dates of onset over Kerala and west Rajasthan has been used. From the onset dates over Kerala and west Rajasthan, the interval between these two were computed. These dates and the mean Indian Summer Monsoon Rainfall (ISMR) and dates of "breaks" in monsoon were collected from the records of India Meteorological Department, Pune.

First an attempt was made to examine presence of trend in the dates of onsets. For this purpose, the base for counting was taken as 15th May for Kerala and 20th June over west Rajasthan. Thus, 16 May, 17 May were then sequentially assigned dummy values of 1, 2 in case of Kerala. Similar values were assigned in case of west Rajasthan in which base for calculating the dummy variables are taken as 20th June. Thus, the date of onset for each year for each of the two areas has a numerical value. These and the "interval" between the two onsets *i.e.*, over Kerala and west Rajasthan each year are subjected to trend analysis. Correlations were also worked out separately between the onset dates and the time "interval" with ISMR and the results discussed.

"Breaks" in monsoon are intimately connected with ISMR. A large number of "breaks" particularly of longer duration is well recognized as major cause of deficient ISMR. In the present paper, the numbers of "breaks" and their duration have been separately correlated with ISMR and the results discussed.

4. The South Asian branch of northern hemispheric summer monsoon strikes southern tip of India *i.e.*, over Kerala around 1st June. There is however lack of consistency in its arrival in different years. Favorable wind flow pattern in May results in early monsoon, with its prolonged absence delays it, sometimes abnormally.

The maximum delay in the onset over Kerala was seen on 18th June in 1972 while the earliest was on 16 May in 1969. The onset dates in the period under study fluctuated widely between these two dates. These variations present frequency of the dates of onset in 5 day interval from 16th May to 20th June for the 51 years period [Fig. 1 (a)]. The largest frequency of 18 (or 35% of cases) belonged to the interval 31st May - 5th June. In a similar



Figs. 1(a&b). Frequency of onset dates (1951-2001), (a) Kerala and (b) west Rajasthan

study, Ananthkrishnan *et al.* (1983) has also found largest frequency of 20 or 39% of cases in the 5 days interval to 31st May to 4th June. In our study, in 22 years (or 42 % of occasions), the onset over Kerala occurred before 31st May and in 11 years (or 21 % of occasions) after 5th June. The mean date of onset over Kerala worked out from the data was 31st May with a standard deviation of nearly 7 days. Apparently chances of advance of monsoon over Kerala before 5th June are very high; occurrence subsequent to 5th June may just be an aberration.

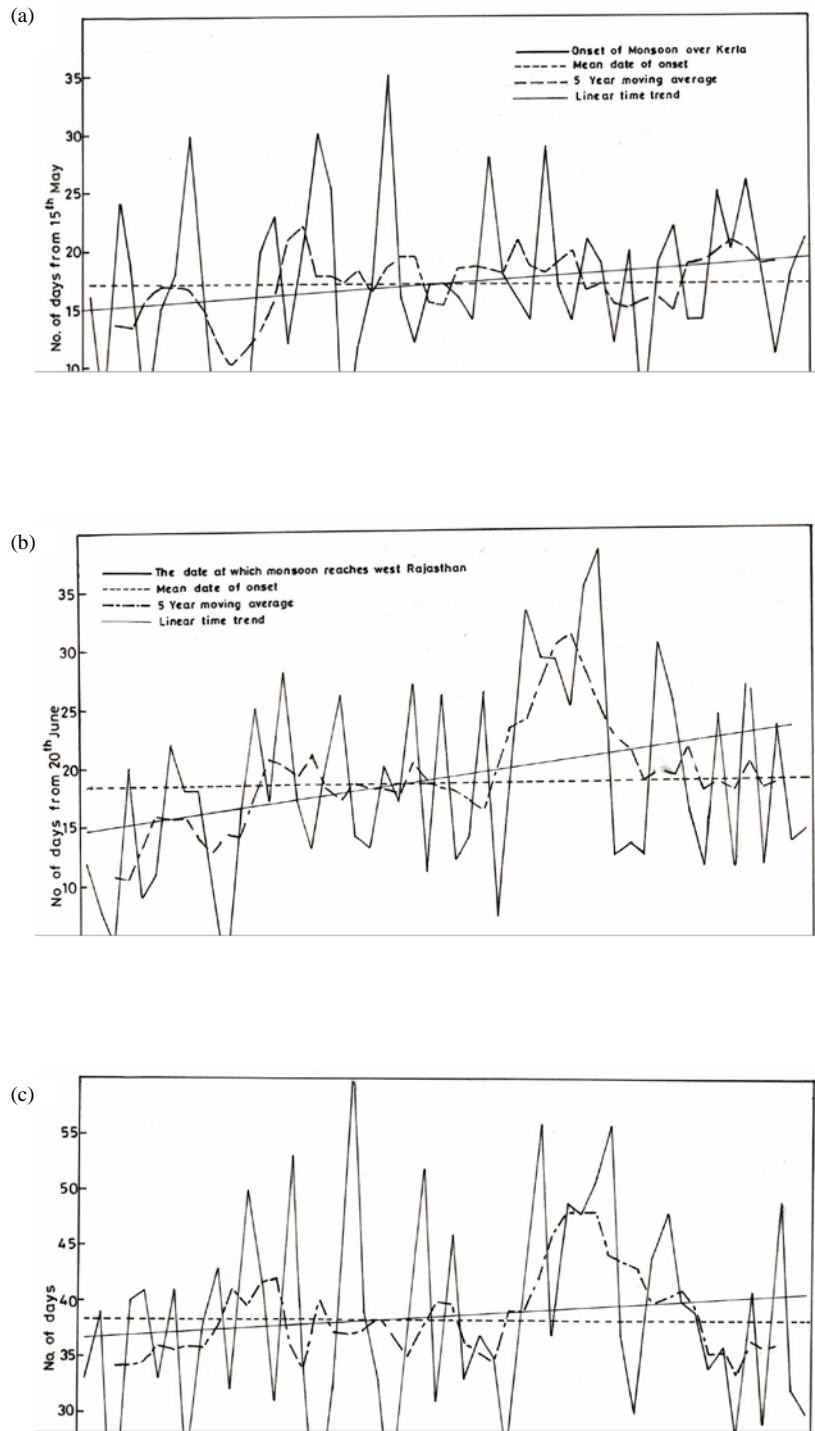
After onset over Kerala, the monsoon travels northwards gradually. The last area to be reached by the southwest monsoon is west Rajasthan where normally it arrives around 15th July. As in case of Kerala and other parts of India, the dates of onset over west Rajasthan also varies from year to year.

The maximum delay in onset over west Rajasthan in this study was seen on 27th July in 1987 and the earliest onset occurred on 21st June in 1961. The onset dates in case of west Rajasthan also fluctuated between these two dates as seen in Fig. 1(b) which presents frequency of the dates of onset in 5 day interval from 20th June to 30th July. The largest frequency of 13 years *i.e.*, nearly a quarter of

the years belonged to the interval 1st July - 5th July. In 12 years (or 23% of cases), the onset occurred before 1st July and in 27 years (or 53% cases), after 5th July. Thus more than half of the years considered, the onset over west Rajasthan occurred after 5th July. The mean date of onset worked out was 7th July.

An attempt was also made to find out simultaneous occurrence of early/delayed onset of monsoon over Kerala and west Rajasthan as also associated ISMR. For this purpose, the standard deviation (σ) obtained in the study for these two cases *viz.*, 7 & 8 days respectively were used. Early onset is defined as the date when onset of monsoon is on date which is 1 σ earlier to the mean date. Similarly late onset is that when it occurs later than 1 σ . The statistics on the following combinations were worked out:

- (i) Early onset over both Kerala and west Rajasthan
- (ii) Delayed onset over both Kerala and west Rajasthan
- (iii) Early onset over Kerala and delayed over west Rajasthan and
- (iv) Delayed onset over Kerala and early over west Rajasthan



Figs. 2(a-c). Yearly variation of dates of onset over (a) Kerala, (b) West Rajasthan, (c) Yearly variation (days) of interval between onset over Kerala & West Rajasthan

Surprisingly, no cases were observed in (b) and (c) categories while only 3 cases of (d) were obtained. More surprising fact is that ISMR in these 3 cases of delayed onset over Kerala and early onset over west Rajasthan [category (d)] and 8 cases of early onset over both regions [category (a)] was 107% of long period normal it may be inferred that the ISMR is above normal; when the monsoon over west Rajasthan is early, irrespective of whether onset over Kerala is early or delayed. In the two cases of simultaneous occurrence in the two regions, other types of onset *viz.*, delayed one over west Rajasthan and early/delay over Kerala, there are chances that ISMR could be normal.

We have seen above that the onset fluctuates widely from year to year *e.g.*, it arrived over Kerala in 1969 as early as on 16th May while its onset was as late as on 18th June in 1972. Fig. 2(a) shows the time series of year to year fluctuations in the date of its arrival. The variations were smoothened by fitting 5 years moving average and also shown in the figure.

It may be seen that in last 25 to 30 years, in general, the monsoon has been arriving over Kerala later than its normal date except between 1986 to 1993 when it arrived 2 to 3 days earlier. The figure suggests that between 1977 to 2000 the onset has been delayed by atleast three days. From Fig. 2(a), an absence of large trend, during entire period under consideration, perhaps can be inferred.

As seen earlier the standard deviation (σ) of the date of onset over Kerala was 7 days. The coefficient of variation of 42 % of onset over Kerala was significantly large and brings out its high uncertainty over Kerala.

Like the onset over Kerala the monsoon also shows variation in its arrival over west Rajasthan. The coefficient of variation (CV) of 45% of the onset over west Rajasthan compares well with that over Kerala. This high CV bring to the fore the precarious nature of advance of monsoon over India. However, one feature which distinguishes it from the former is that the fluctuations in dates of onset are much than that over Kerala [Fig. 2(b)]. The earliest onset that has occurred was on 21st June in 1961 whereas in 1987, it was late by 12 days from its IMD normal of 15th July and by over 3 weeks from the mean date we have worked out in this study. Another similarity between the two onsets is that in 1978 to 1990, the monsoon has been generally arriving late as can be inferred from the 5 year moving average particularly between 1978-84 [Fig. 2(b)]. The figure also confirms that there exist no marked trends in the arrival of monsoon over west Rajasthan.

We have mentioned above that even if the onset over Kerala is early, its arrival over west Rajasthan often gets delayed in the absence of favorable synoptic situations, which are responsible for progress of monsoon.

Unmistakable rising trend on dates of onset over Kerala and west Rajasthan has been found above. Naturally one expects that the time interval between these two onsets should also show a positive tendency. A glance in Fig. 2(c) confirms this conclusion. The smoothened curve seems to follow that for the west Rajasthan, particularly the period after 1980 or so.

Though, the normal interval between the two arrivals is about 38 days, delay as large as 60 days has been observed. It is also seen that in recent years, say after 1993, there is a tendency for the duration to be less than normal, although between 1980 till 1993, they were significantly above normal. The increase in the time interval is also seen when a linear regression is fitted between the years and the duration, though the slope is not large. Increase in the time interval between monsoon onset at Kerala and west Rajasthan is also confirmed when it was subjected to Spearman Rank test. The statistics obtained is found significant at the mandatory 5 % level.

Number of "breaks" in monsoon has always been a cause of concern in India. A large number of "breaks" with longer duration leads to deficient rainfall for the country except Tamil Nadu and foothills of Himalayas. The rainfall departure during the breaks has been worked out by Ramamurthy (1969) who found except the foothills, northeast India, Tamil Nadu and adjoining areas, the rainfall departure was generally negative. Values of -60% of normal are often seen over northwest India and parts of central Peninsula in association with "breaks".

In the present study, 2 to 3 "breaks" in each year was the characteristic feature observed. As such, the total duration (in days) of "breaks", during the monsoon period was worked out. On an average such days could be about 7 days and they vary within narrow limits. However, no unambiguous time trend was seen in the data. A maximum duration of 27 days of "breaks" is observed in 1979, followed by 24 days in 1972 and 15 days each in 1965 and 1966. Needless to emphasize, all these years have been well documented drought years in India. Thus a large number of days of "break" invariably leads to deficient monsoon rain over the country and hence drought.

The rainfall during summer monsoon depends on many factors, chief among them being synoptic situations. The synoptic situations directly or indirectly influence each of the factors mentioned above. As such, it may be worthwhile to find out the extent to which the ISMR (Y)

is dependent on these factors. With this aim in view, linear correlations are worked out between the ISMR and those factors. The correlations are given below. The correlations were low and insignificant in most of the cases except the following:

- (i) ISMR and onset date over west Rajasthan (X_1) – (-0.54)
- (ii) ISMR and duration of breaks (X_2) – (-0.39)
- (iii) ISMR and the time interval between the onset over the two areas (X_3) – (-0.31)

The first two correlations are significant at 1 % level of significance while the third one at 5 % level.

Unfortunately, in spite of significant correlation, the factor X_2 has little forecasting value. This is because the number of ‘breaks’ is known only after the monsoon season is over. Moreover, the contribution of this factor to the total variance in the multiple regressions was negligibly low. In view of these, this factor was ultimately deleted in the analysis.

It is thus clear that a delay in onset over west Rajasthan definitely affects the ISMR over the country. The more the delay, lesser is the ISMR. Similarly, if the duration of the “breaks” is large, the rainfall is likely to be less.

This paper also examines the efficacy of the above three parameters in forecasting ISMR through (i) and (iii).

The equation obtained was:

$$Y = 149.4 - 1.061 X_1 - 0.799 X_3$$

The Multiple Correlation Coefficient (MCC) was 0.68 while the F value obtained was significant at 1 % level of significance. The equation was tested on 5 years data (1997 - 2001). In three cases the estimates were within $\pm 10\%$ of the actual rainfall and in 2 cases within $\pm 20\%$.

That the El Nino effects rainfall over different parts of globe, is now well recognised fact (Ropalewski and

Halpert, 1987; Sinha Ray and Shewale, 2001; Shewale *et al.*, 2004; etc.). Not much information seems to be available whether it also affects onsets of monsoon over different parts of India. This aspect has been examined in this study for the two areas *i.e.*, Kerala and west Rajasthan. During the period under consideration, 7 cases of El Nino episodes were observed *viz.*, 1965, 1972, 1976, 1982, 1987, 1991 and 1997. Out of these cases, in 6 cases, the onset over Kerala occurred within $\pm\sigma$ where σ was standard deviation, *i.e.*, 7 days. Only in 1972, the monsoon onset over Kerala was abnormally delayed by more than 2σ . Thus it appears that El Nino does not exert significant influence over onset of monsoon over Kerala.

An altogether different picture emerged when association of El Nino with onset over west Rajasthan is sought. Surprisingly, the onset was within the normal expectable limits in 1972. In the rest of the 6 cases, the onset over west Rajasthan was delayed, sometimes even more than 2σ , σ in this case being 8 days.

Thus, it may be inferred that onset over west Rajasthan could be delayed, sometimes inordinately, when equatorial eastern Pacific was warm.

The following conclusions can be drawn from the study:

- (i) The delay in the onset over west Rajasthan and the interval between the onsets over Kerala and west Rajasthan affect the ISMR over the country.
- (ii) There is a distinct trend for the monsoon onsets over the two regions to get delayed in recent years.
- (iii) In a good number of occasions when the onset over Kerala is early, the same over west Rajasthan too is simultaneously early.
- (iv) El Nino does not exert significant influence over onset of monsoon over Kerala.
- (v) During El Nino years, the onset of monsoon over west Rajasthan could be delayed by more than 7 days.
- (vi) The ISMR is generally above normal when onset of monsoon over west Rajasthan is early.

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K. V. PADGALWAR
M. P. SHEWALE

Meteorological Office, Pune, India
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