

Objective determination of northeast monsoon onset dates over coastal Tamil Nadu for the period 1901-90

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सारा — 1901-90 तक के वर्षों के लिए वस्तुपरक पद्धति अपनाते हुए तटीय तमिलनाडू पर उत्तरपूर्वी मानसून के आरम्भ की तारीखें निर्धारित की गईं। मानसून के आरम्भ की तारीखों से सम्बद्ध विभिन्न सांख्यिकीय प्राचलों का परिकलन व व्याख्या की गई। तमिलनाडू पर पूर्वाभिमुख और उत्तरपूर्व मानसून के आरम्भ की तारीखों के मध्य सम्बन्ध का परीक्षण किया गया। तटीय तमिलनाडू के सामान्य दैनिक वर्षा की विशेषताओं के साथ बृहत रूप से अनुकूल और प्राप्त सामान्य तारीख दर्शाई गई है। आरम्भ होने की तारीख के सन्दर्भ के साथ माध्य वर्षा के परिकलन के लिए अध्यारोपित कालावधि पद्धति का उपयोग किया गया और मानसून के प्रारम्भ होने पर वर्षा में अचानक वृद्धि को स्पष्ट रूप से दिखाया गया है। प्रारम्भ होने के समय वर्षा का स्थानिक वितरण और तीव्रता की चर्चा की गई। कुछ वर्षों से प्रभावशाली प्रारम्भ के साथ ही साथ पिछले कुछ वर्षों से मन्द (subdued) प्रारम्भ के लिए दैनिक वर्षा आलेखी रूप से प्रस्तुत की गई है।

ABSTRACT. The onset dates of northeast monsoon over coastal Tamil Nadu have been determined by adopting an objective method for the years 1901-90. The various statistical parameters associated with onset dates have been computed and interpreted. Relation between onset dates of easterlies and northeast monsoon over Tamil Nadu has been examined. The normal date obtained has been shown to be by and large consistent with the characteristics of normal daily rainfall of coastal Tamil Nadu. The superposed epoch method has been used to compute the mean rainfall with reference to onset date and the abrupt increase in rainfall at onset has been clearly brought out. The spatial distribution and intensity of rainfall at the time of onset have also been discussed. Daily rainfall has been graphically presented for some years with spectacular onset as well as for some years with subdued onset.

Key words — Northeast monsoon, Spatial distribution of rainfall, Intensity of rainfall

1. Introduction

1.1. India experiences two monsoons, the main one being the southwest monsoon which contributes nearly 76% of the annual rainfall of India during the four month period of June-September. There is another monsoon-albeit of a smaller scale-experienced in the southern parts of India during October-December. This is popularly known as the northeast monsoon. For Tamil Nadu the northeast monsoon is the major contributor of rainfall giving 475.3 mm (47.1%) out of an annual rainfall of 1008.1 mm (IMD 1962). Over the coastal districts the contribution of northeast monsoon rainfall is higher, nearly 65-75% of annual rainfall. Vedaranyam located in the central coastal Tamil Nadu receives a normal rainfall of 1027.7 mm which is by far the highest by any station in India during the northeast monsoon season. Description of northeast monsoon could be found in Krishna Rao and Jagannathan (1953), Rao (1963), IMD (1973 a & b) etc.

1.2. Onset of northeast monsoon

The southwest monsoon starts withdrawing from India in September in association with the southward

movement of equatorial trough which till then is located along the Ganganagar-Calcutta axis. The reversal of winds from southwest to northeast is associated with the cessation of southwest monsoon rainfall over north India. However, in Tamil Nadu the establishment of northeasterlies causes an increase in rainfall in October which is considered as the onset of northeast monsoon. According to IMD report (1973a) there was no well defined criterion for the ushering in of northeast monsoon over Tamil Nadu. Mention of onset of northeast monsoon over Tamil Nadu could however be found in the IMD publications of *Indian Daily Weather Report (IDWR)* and *Weekly Weather Report (WWR)* of certain years.

Raj and Jamadar (1990) determined the normal onset and withdrawal dates of northeast monsoon over Tamil Nadu, by analysing the daily normal rainfall (based on 1901-50) of several representative stations. They considered the 5-day weighted moving average filter and constructed the difference filter to precisely locate the normal onset date. According to this study the normal onset date of northeast monsoon over Tamil Nadu is 20 October and the withdrawal date

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is 7 December. However the determination of northeast monsoon onset dates for various years has not been systematically attempted so far.

1.3. Objective criteria for declaration of onset of northeast monsoon

The Tenth conference of Forecasting Officers (of IMD) held in Pune in March 1987 deliberated on this subject and suggested the following criteria for declaration of onset of northeast monsoon over Tamil Nadu. These are :

- (i) Withdrawal of southwest monsoon up to 15° N,
- (ii) Onset of persistent easterlies from surface up to 850 hPa over Tamil Nadu coast,
- (iii) Fairly widespread rainfall over coastal Tamil Nadu and adjoining areas,
- (iv) Onset not to be declared before 10 October even if conditions (i) and (ii) are satisfied.

These suggestions were subsequently accepted by IMD. It may be pertinent to point out here that as for onset of southwest monsoon over Kerala is concerned, a criteria on more or less similar lines was formulated by Ananthakrishnan *et al.* (1967).

1.4. Objective of the study

The objective of the study is to determine the year-to-year northeast monsoon onset dates over coastal Tamil Nadu over a long period of time by following, to the extent possible, a uniform criterion and to study their statistical characteristics.

2. Methodology and data

2.1. Methodology

The rules laid down by the Forecasting Officer's conference quoted in Sec. 1.4 are not completely independent of one another. Obviously (i) has to be satisfied if (ii) is satisfied as onset of surface easterlies over Tamil Nadu means onset of easterlies over the region north of 15° N, which also means withdrawal of southwest monsoon therefrom. Rule (iv) was included perhaps to preclude the declaration of onset in the beginning of October when easterlies might establish temporarily and a spurt in rainfall might result, but westerlies might re-establish again later. As the north to south movement of equatorial trough is pulsatory in nature, rule (iv) ensures that such temporary phases are not considered as northeast monsoon onset. However, in a diagnostic study of this type such a rule is redundant because it can always be verified whether the appearance of easterlies is temporary or permanent as data for the entire season are available. Further a detailed analysis of rainfall, upper winds and surface charts is possible in a diagnostic study. As for the withdrawal of southwest monsoon up to 15° N, the date of withdrawal as given in IDWR/WWR could be used if explicitly given. The date of onset of deep easterlies can be determined with the help of upper air wind data for the period for which such data are available. The establishment of seasonal low over south Bay of Bengal can be determined from surface

charts and this generally follows the withdrawal of southwest monsoon up to 15° N.

The onset date determined by adopting any objective method may turn out to be completely unsatisfactory for some years. For example, consider following sequence: Dates associated with rules (i) and (ii) are 10 and 15 October respectively, first date of fairly widespread rainfall is 18 October, dry period from 19-25 October and widespread rain on every day for several days from 26 October. Herein 26 October, is obviously the most suitable onset date rather than 18 October.

Taking all these aspects into consideration the following five rules were formulated to determine the onset date of northeast monsoon over coastal Tamil Nadu for a given year. These form a slightly modified version of the rules quoted in Sec. 1.4.

- R₁ Southwest monsoon should have withdrawn up to coastal Andhra Pradesh.
- R₂ Deep easterlies should have set in over Tamil Nadu or seasonal low should have established in south Bay adjacent to Tamil Nadu coast.
- R₃ After R₁ and R₂ are satisfied, the first day of fairly widespread rainfall (*i.e.*, more than 50% of the stations should report rain) over coastal Tamil Nadu would be the day of northeast monsoon onset.
- R₄ If the date arrived at by R₃ happens to be earlier than 10 October the wind/surface charts are to be scrutinised to decide as to whether the onset of easterlies is temporary or permanent. If it is permanent the date of R₃ would be the final date. If the easterly onset is temporary in nature and if westerlies appear again in the lower troposphere over coastal Tamil Nadu the date of permanent onset of easterlies is to be determined and R₃ to be applied again.
- R₅ In case the date fixed is completely unsatisfactory, a review is to be made and the next date of fairly widespread rainfall is to be considered as onset date.

2.2. Data

The 90-year period of 1901-90 was chosen as the period of study. Six stations (Madras, Cuddalore, Nagapattinam, Vedaranyam, Pamban and Tuticorin) were selected to represent coastal Tamil Nadu. To firmly establish the withdrawal dates of southwest monsoon, three stations from coastal Andhra, two each from Karnataka and Kerala and one from Konkan were selected. Daily rainfall data for the period 1 September to 31 December for 1901-86 were obtained from the National Data Centre, Meteorological Office, Pune for the fourteen selected stations. Table 1 provides the names of stations subdivisionwise and the data availability for each station during 1901-86. Fig. 1 presents the spatial distribution of the stations. The determination of northeast monsoon onset dates was based only on

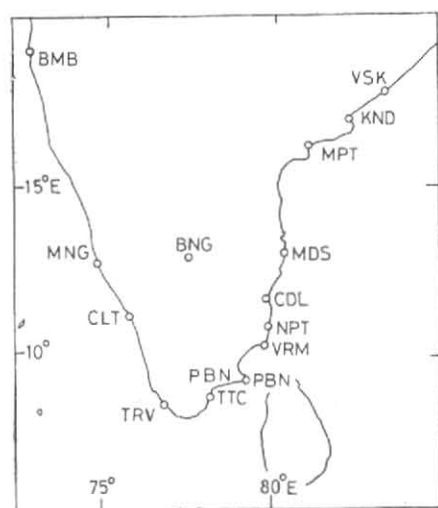


Fig. 1. Spatial distributions of stations considered in the study

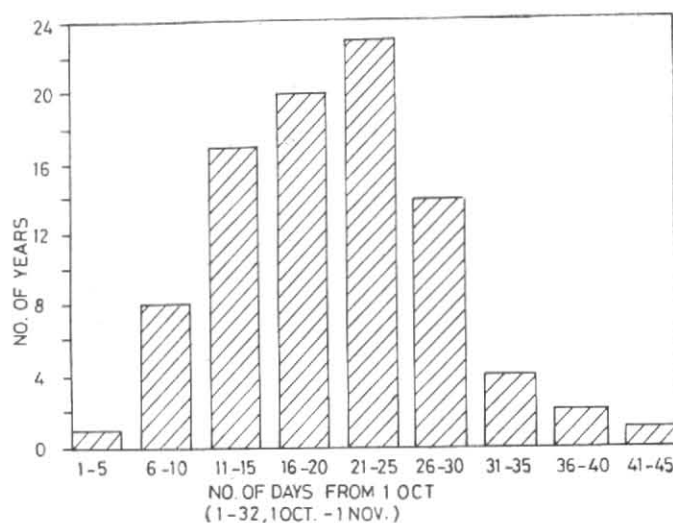


Fig. 2. Frequency distribution of northeast monsoon onset dates over coastal Tamil Nadu, 1901-90

the rainfall data of coastal Tamil Nadu which had four stations with complete data and two stations with data during the latter half of the period of study. The rainfall data for these stations during the four year period 1987-90 was extracted from IDWR or from the climatological records of Meteorological Office, Pune.

The 1.5 km asl wind at 0530 IST over Madras for 1-31 October for the period 1956-86 was also supplied by National Data Centre, IMD, Pune. Besides these, IDWR, WWR, monsoon rainfall summary and several other IMD publications were referred. IDWR and WWR from 1901 and monsoon summaries from 1941 onwards are available at the Main Library, IMD, Pune.

3. Determination of northeast monsoon onset dates

3.1. As per the criteria we have laid down in Sec. 2.1, daily rainfall data, date of onset of easterlies over Tamil Nadu, date of withdrawal of southwest monsoon from coastal Andhra are needed to determine the onset dates of northeast monsoon. The mode of determination of these in the present study is discussed below.

3.2. Onset of easterlies over Tamil Nadu

For the period 1901-42 the dates of onset of easterlies were determined solely on the basis of surface pressure charts. The day-to-day movement of equatorial trough was monitored and the occasion when the seasonal trough/low was firmly established over south Bay of Bengal adjacent to coastal Tamil Nadu was taken as the period of easterly onset. Wind reports from ships were also of use in locating the position of the trough. Complete upper wind data were available in the IDWRs of 1942-55 and these were utilised to locate the date. The IDWR of 50's and 60's displayed the flow pattern at 1.5 km asl, and this was also of help. For 1956-86, the 1.5 km asl wind data of October was utilised to locate the date of easterly onset. For 1986-90 upper wind data was collected from records. Even for the years for

TABLE I

Stations considered in the study and rainfall data availability during 1901-86

| Sub-division State | Stations | Year |
|--------------------|---------------|------------------|
| Coastal Tamil Nadu | Madras | 1901-86 |
| | Cuddalore | 1901-86 |
| | Nagapattinam | 1901-86 |
| | Vedaranyam | 1960-65, 1967-78 |
| | Pamban | 1901-86 |
| | Tuticorin | 1954-80 |
| Karnataka | Bangalore | |
| | Mangalore | |
| Coastal Andhra | Visakhapatnam | |
| | Masulipatnam | 1901-86 |
| | Kakinada | |
| Kerala | Calicut | |
| | Trivandrum | |
| Konkan | Bombay | |

which upper wind data were available, surface charts were always referred before fixing the date of easterly onset over Madras. The dates thus obtained are listed in Table 3.

3.3. Southwest monsoon withdrawal dates from coastal Andhra

Since the year 1946 the date of withdrawal of southwest monsoon from Coastal Andhra was by and large, explicitly mentioned in IDWR/WWR and so could be directly extracted. Prior to 1946, in certain years IDWR did mention withdrawal from Andhra but in most of the years there was no explicit mention.

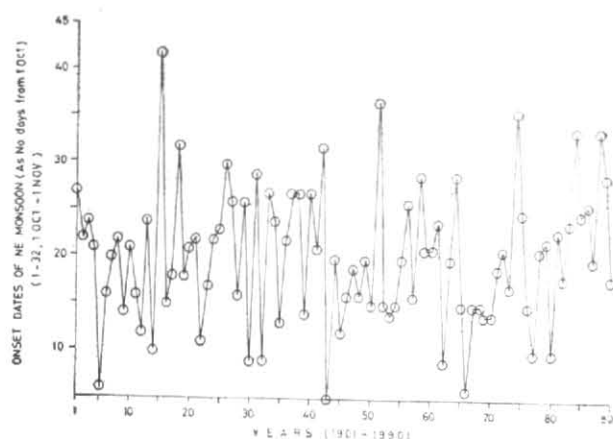


Fig. 3. Northeast monsoon onset dates over coastal Tamil Nadu, 1901-90

As already pointed out the easterly onset over Tamil Nadu and monsoon withdrawal should be compatible with each other. If monsoon withdrawal (over coastal Andhra) occurs prior to easterly onset over Tamil Nadu there is no discrepancy, but if withdrawal is announced after easterly onset it might lead to conflicting situations in certain years. For example withdrawal is given as 22 October, but easterly onset is on 10 October. Now if a good spell of rain occurs over coastal Tamil Nadu between 15 & 20 October, whether this spell should be taken as associated with northeast monsoon onset is the obvious question. On such occasions perhaps it would be appropriate to study the rainfall of Andhra and also the circulation features and examine the possibility of preponing the date of withdrawal. If no significant rainfall has occurred over Tamil Nadu between 10 & 22 October perhaps no such revision is called for. Taking these aspects into consideration, the withdrawal dates of southwest monsoon which succeeded easterly onset over Tamil Nadu were examined and new dates fixed if the situation warranted. The number of such occasions was ten only. Table 3 provides the withdrawal dates; revised dates are also indicated.

3.4. Northeast monsoon onset dates as declared by IMD

Scrutiny of IDWR/WWR of each year for the period 1901-90 revealed that the first year in which IMD declared northeast monsoon onset was in 1923, the IDWR of 15 October mentioning that 'northeast monsoon has set in over Tamil Nadu'. Subsequently onset was declared in 1924, 27, 29, 31, 34, 36, 38, 39, 40, 41, 48, 50, 51, 54, 55 & 56. Thereafter uptill 1976 no mention of onset could be found. Since 1977 the onset has been mentioned in IDWR/WWR except for 1982. The IMD declared onset dates are presented in Table 3.

3.5. Determination of northeast monsoon onset dates

Once the dates of easterly onset over Tamil Nadu and southwest monsoon withdrawal from coastal Andhra are determined, the daily rainfall data of stations

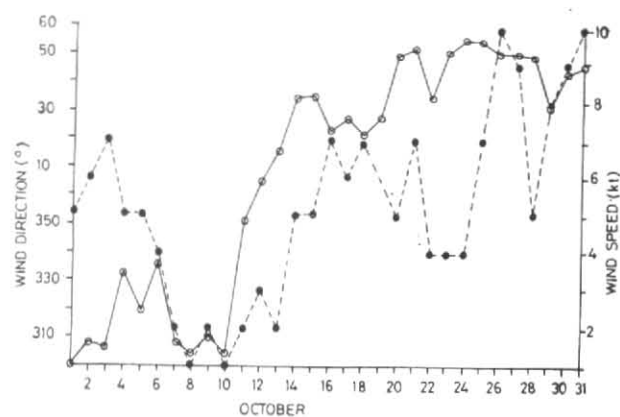


Fig. 4. Daily normal 1.5 km a.s.l. wind over Madras during 1-31 October based on data of 1956-86 (—) Direction, (---) speed

of coastal Tamil Nadu could be examined and the northeast monsoon onset date fixed in accordance with rules R_1 to R_5 of Sec 2.1. In case the date happened to be prior to 10 October the surface charts and upper wind data were thoroughly examined to decide as to whether the onset of easterlies was temporary or permanent. Rule R_5 was applied in respect of four years, viz., 1954, '83, '84 and '86 as the dates arrived at by application of R_1 to R_4 were associated with generally one day rainfall. In these years the next date of fairly widespread rainfall proved to be the most suitable date.

The onset dates of northeast monsoon thus arrived at for the 90-year period of 1901-90 are presented in Table 3.

4. Statistical properties of northeast monsoon onset dates over Tamil Nadu

Fig. 3 presents the onset dates for 1901-90. The frequency distribution is depicted in the form of histogram in Fig. 2. The mean onset date is 20.2 days from 1 October, i.e. 20 October which is also the median. The first and third quartiles are 14.5 and 25.2 days respectively from 1 October. The standard deviation is 7.3 days. The earliest onset date occurred in the year 1943 on 5 October whereas the most delayed onset occurred in 1915 on 11 November. On 7 years northeast monsoon ushered in the month of November and on 6 years it struck the Tamil Nadu coast before 10 October, the cut off date suggested in rule (iv) of Sec 1.4. These statistical parameters along with the decadal means are presented in Table 2.

5. Relation amongst onset dates of easterlies — onset dates of northeast monsoon — rainfall over Tamil Nadu

The onset date of persistent easterlies over coastal Tamil Nadu given in Table 3, has a mean of 13.7 days (from 1 October) with a standard deviation of 7.4 days. Normal date of easterly onset over Madras can thus be taken as 14 October, 6 days ahead of the normal onset date of northeast monsoon. The correlation coefficient between dates of easterly onset and monsoon onset during 1901-90 was 0.75; significant at 0.1% level. This fairly high correlation suggests that a medium range outlook on date of northeast monsoon onset (y) can be had from date of easterly onset (x). The

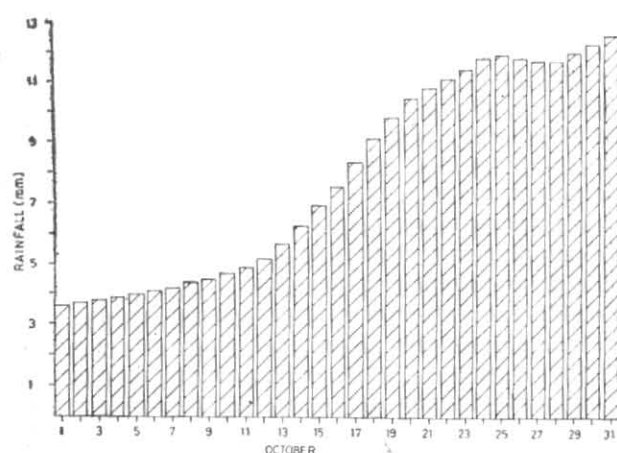


Fig. 5. Normal daily rainfall of coastal Tamil Nadu for 1-31 October based on data of 1901-1986

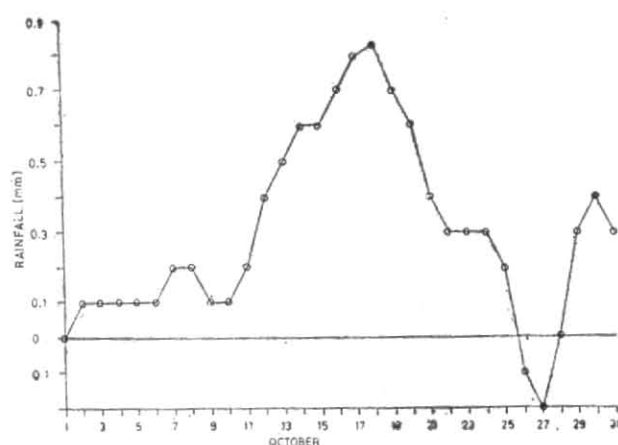


Fig. 6. Difference filter of normal rainfall of coastal Tamil Nadu for 1-31 October

regression equation of y on x is : $y=0.74x + 10.1$ with a standard error of 4.8 days, x and y both counted as number of days from 1 October. For the period 1956 to 1986 for which the date of easterly onset could be accurately determined, the correlation coefficient was 0.76 showing that the coefficient based on 90-year data is quite reliable. The lag between the two dates varied from 0 to 30 days, year to year. From the daily 1.5 km asl wind data of Madras for 1-31 October for 1956 to 86 the daily normal wind values were computed and are presented in Fig. 4. It is seen that the reversal of normal winds from westerlies to easterlies occurs on 12 October. The mean of dates of easterly onset (from Table 2) during 1956 to 86 is 11.8 days (from 1 October) consistent with Fig. 4.

The onset dates of northeast monsoon exhibited a negative correlation with the rainfall of Tamil Nadu during October to December. The correlation coefficient based on the 90-year data was -0.32 significant at 1% level. However, the variance explained, which is 10.2% is too small for the relation to be of any real use in foreshadowing northeast monsoon rainfall. It is also interesting to note that during 1981 to '90 when the mean onset date was 25 October (Table 2), which is 5 days later than normal, the rainfall of Tamil Nadu was 13% deficient from the long period normal.

6. Normal daily rainfall of coastal Tamil Nadu in relation to the northeast monsoon onset

6.1. Normal daily rainfall

The daily mean rainfall of the six stations of coastal Tamil Nadu considered in the study, for each day of 1 September-31 December was computed from the available data. Subsequently, the seven day moving average was computed as in IMD (1962) and the daily normal thus obtained was further smoothed by a weighted moving average with weights (1, 4, 6, 4, 1) (Brooks and Carruthers 1953). Thus six rainfall series were realised for 1 September-31 December save for the first and last 5 days. The normal daily rainfall of coastal Tamil Nadu was computed from the above six series by weighted averaging, the weights here being the number of years with data for each station (Table 1).

TABLE 2(a)

Statistical properties of dates of onset of northeast monsoon over coastal Tamil Nadu : 1901-90

| | |
|--------------------|------------------|
| Normal (Mean) | 20 October |
| Standard deviation | 7.3 days |
| First quartile | 15 October |
| Median | 20 October |
| Third quartile | 25 October |
| Earliest onset | 5 October 1943 |
| Most delayed onset | 11 November 1915 |

TABLE 2(b)

Onset dates — Decadal means

| Decade | Mean |
|---------|------------|
| 1901-10 | 19 October |
| 11-20 | 21 " |
| 21-30 | 20 " |
| 31-40 | 22 " |
| 41-50 | 18 " |
| 51-60 | 21 " |
| 61-70 | 16 " |
| 71-80 | 20 " |
| 81-90 | 25 " |

The normal daily rainfall thus computed is exhibited in Fig. 5 for the period 1-31 October. The difference filter of the normal daily rainfall (*i.e.*, daily rainfall change) is presented in Fig. 6 from which we see that peak corresponds to 18 October, which is the date of sharp rise (or point of inflexion) in the normal daily rainfall of Fig. 5.

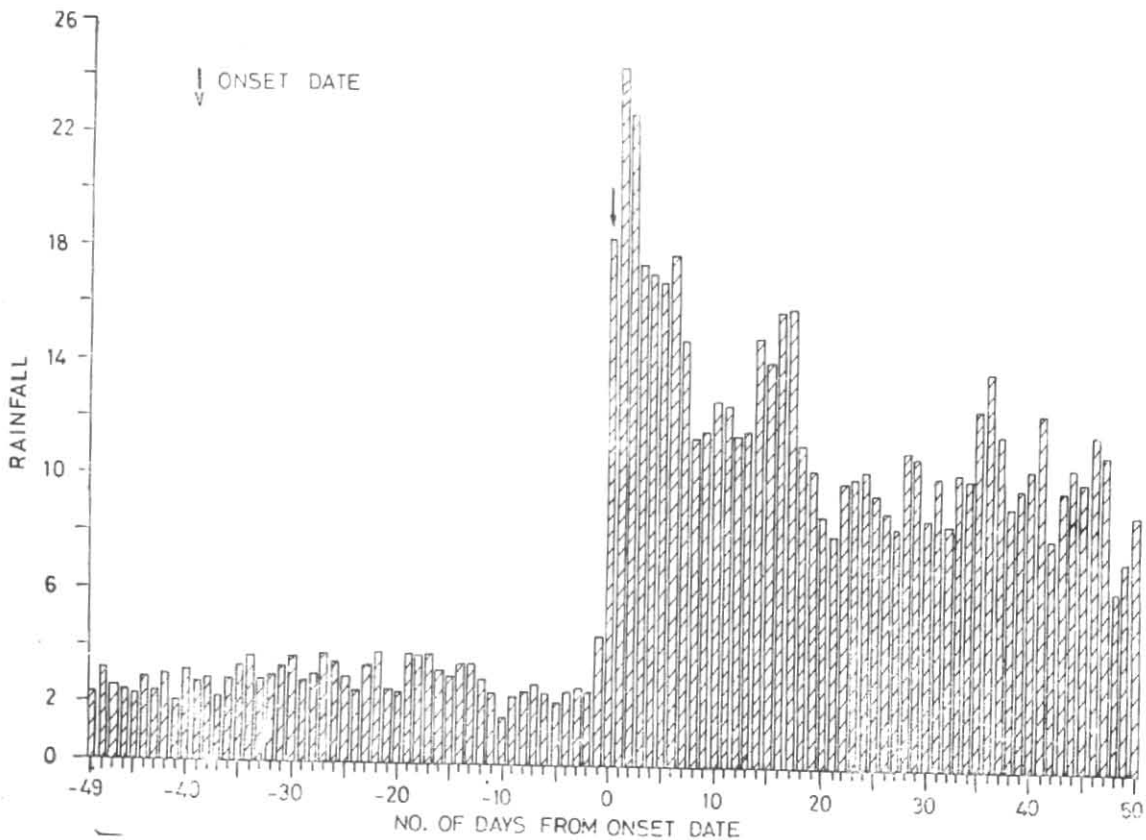


Fig. 7. Mean daily rainfall (mm) over coastal Tamil Nadu with reference to northeast onset monsoon dates (1901-86) superposed epoch analysis

Thus the normal dates of northeast monsoon onset determined by, (i) averaging year-to-year onset dates, and (ii) locating the date corresponding to sharp rise in the daily normal graph manifest a difference of two days. This should not be considered as contradictory as the underlying principle behind the methods are different. The date arrived at, by (i) above, *viz.*, 20 October is preferable one from the statistical point of view.

6.2. Superposed epoch analysis

Though Figs. 5 and 6 do testify to the increase of rainfall associated with northeast monsoon onset, the real nature of increase of rainfall which is associated with onset (and occurs year-after-year) gets considerably masked as the onset dates show a wide dispersion from year-to-year whereas the averaging of rainfall to obtain the normal values is done for calendar days. To bring out the true nature of increase we have computed mean daily rainfall over coastal Tamil Nadu with reference to the onset dates. This type of analysis is known as superposed epoch analysis (Panofsky and Brier 1968), which has been done by Ananthkrishnan and Soman (1988). Accordingly for each year the onset date is taken as 0th day and the dates prior to and after the onset dates are taken as, -3, -2, -1, 0, 1, 2, 3, . . . days with reference to the onset date. The mean rainfall corresponding to . . . -3, -2, -1, 0, 1, 2, 3, . . . days are then computed by averaging over the years. Such mean rainfall was computed for the six stations separately and hence for coastal Tamil Nadu by weighted averaging as done in Sec. 6.1. The mean daily rainfall thus obtained is presented in Fig. 7.

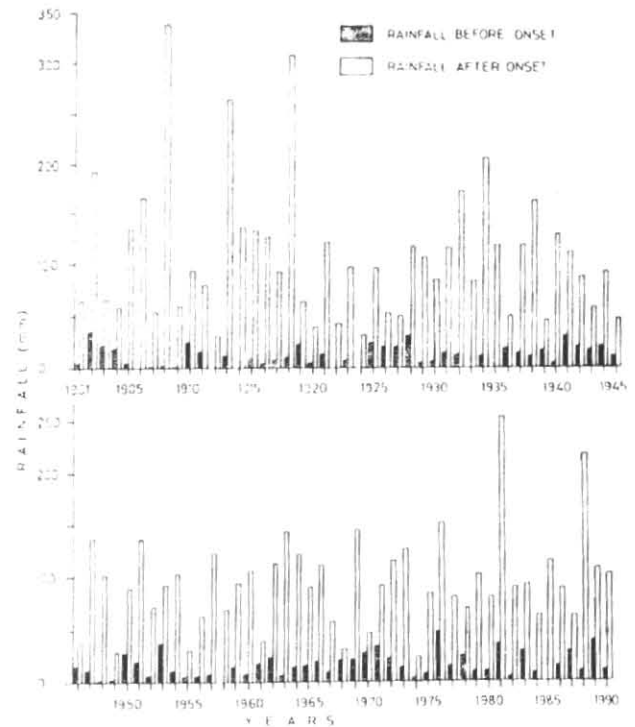


Fig. 8. Increase of pentad rainfall associated with northeast monsoon onset over coastal Tamil Nadu, year to year variation during 1901-90

ONSET DATES OF NORTHEAST MONSOON

TABLE 3

Northeast monsoon onset dates over coastal Tamil Nadu : 1901-90

| Year | A | B | C | D | Year | A | B | C | D | Year | A | B | C | D |
|------|----|----|----|-----|------|------|------|-----|-----|------|-------------|----|-----|---------|
| 1901 | | 24 | | 27 | 1931 | | 27 | 29 | 29 | 1961 | 22 (20) | 20 | | 24 9 |
| 02 | | 20 | | 22 | 32 | | 5 | | 9 | 62 | 10 | 1 | | |
| 03 | | 22 | | 24 | 33 | | 26 | | 27 | 63 | 18 (13) | 13 | | 20 |
| 04 | | 15 | | 21 | 34 | | 17 | 20 | 24 | 64 | 16 (12) | 12 | | 29 |
| 05 | | 4 | | 6 | 35 | | 9 | | 13 | 65 | 13 (4) | 4 | | 15 |
| 06 | | 12 | | 16 | 36 | | S 23 | *21 | 22 | 66 | 9 (S 28) | 2 | | 6 |
| 07 | | 19 | | 20 | 37 | | 17 | | 27 | 67 | 15 | 4 | | 15 |
| 08 | | 11 | | 22 | 38 | | 20 | 26 | 27 | 68 | 15 | 12 | | 15 |
| 09 | | 10 | | 14 | 39 | 11 | 11 | *N1 | 14 | 69 | 5 | 11 | | 14 |
| 10 | | 15 | | 21 | 40 | | 23 | 28 | 27 | 70 | 12 | 10 | | 14 |
| 11 | | 14 | | 16 | 41 | | 17 | 22 | 21 | 71 | 12 | 17 | | 19 |
| 12 | | 11 | | 12 | 42 | | 22 | | N1 | 72 | 14 | 9 | | 21 |
| 13 | | 18 | | 24 | 43 | | 2 | | 5 | 73 | 16 | 14 | | 17 |
| 14 | | 2 | | 10 | 44 | | 19 | | 20 | 74 | 31 | 28 | | N 5 |
| 15 | | 25 | | N11 | 45 | | 7 | | 12 | 75 | 27 (21) | 25 | | 25 |
| 16 | | 12 | | 15 | 46 | S 25 | 8 | | 16 | 76 | 12 | 1 | | 15 |
| 17 | | 13 | | 18 | 47 | 6 | 15 | | 19 | 77 | 12 (9) | 5 | 14 | 10 |
| 18 | | 23 | | N1 | 48 | 3 | 4 | 16 | 16 | 78 | 23 (18) | 20 | 23 | 21 |
| 19 | | 14 | | 18 | 49 | | 15 | | 20 | 79 | 18 | 6 | 22 | 22 |
| 20 | | 17 | | 21 | 50 | 2 | 12 | 16 | 15 | 80 | 8 | 3 | 11 | 10 |
| 21 | | 18 | | 22 | 51 | | 19 | 27 | N 6 | 81 | 15 | 6 | 23 | 23 |
| 22 | | 11 | | 11 | 52 | 1 | 1 | | 15 | 82 | 11 | 2 | | 18 |
| 23 | 14 | 15 | 15 | 17 | 53 | 9 | 6 | | 14 | 83 | 19 | 17 | 24 | 24 |
| 24 | | 20 | 22 | 22 | 54 | 11 | 11 | 11 | 15 | 84 | 1 | 24 | 5 | N 3 |
| 25 | | 19 | | 23 | 55 | 6 | 13 | 6 | 20 | 85 | 24 | 19 | 25 | 25 |
| 26 | | 26 | | 30 | 56 | 18 | 10 | 25 | 26 | 86 | 21 (11) | 11 | 27 | 26 |
| 27 | | 21 | 22 | 26 | 57 | 9 | 9 | | 16 | 87 | 24 (20) | 19 | 30 | 20 |
| 28 | | 13 | | 16 | 58 | 26 | 25 | | 29 | 88 | 12 | 21 | N 2 | N 3 |
| 29 | | 21 | 25 | 26 | 59 | 17 | 14 | | 21 | 89 | 13 | 20 | 27 | 29 |
| 30 | | 7 | | 9 | 60 | 17 | 13 | | 21 | 90 | 17 | 17 | 19 | 18 |

S — September, N — November, If nothing is mentioned the month is October.

A — Withdrawal date of southwest monsoon from coastal Andhra Pradesh as declared by IMD. If the date is revised in the study, revised date is given in the bracket.

B — Date of onset of easterlies over Tamil Nadu.

C — Date of onset of northeast monsoon over Tamil Nadu as declared by IMD.

D — Date of onset of northeast monsoon over coastal Tamil Nadu as determined in the study.
Blank means date was not available/declared.

* week ending.

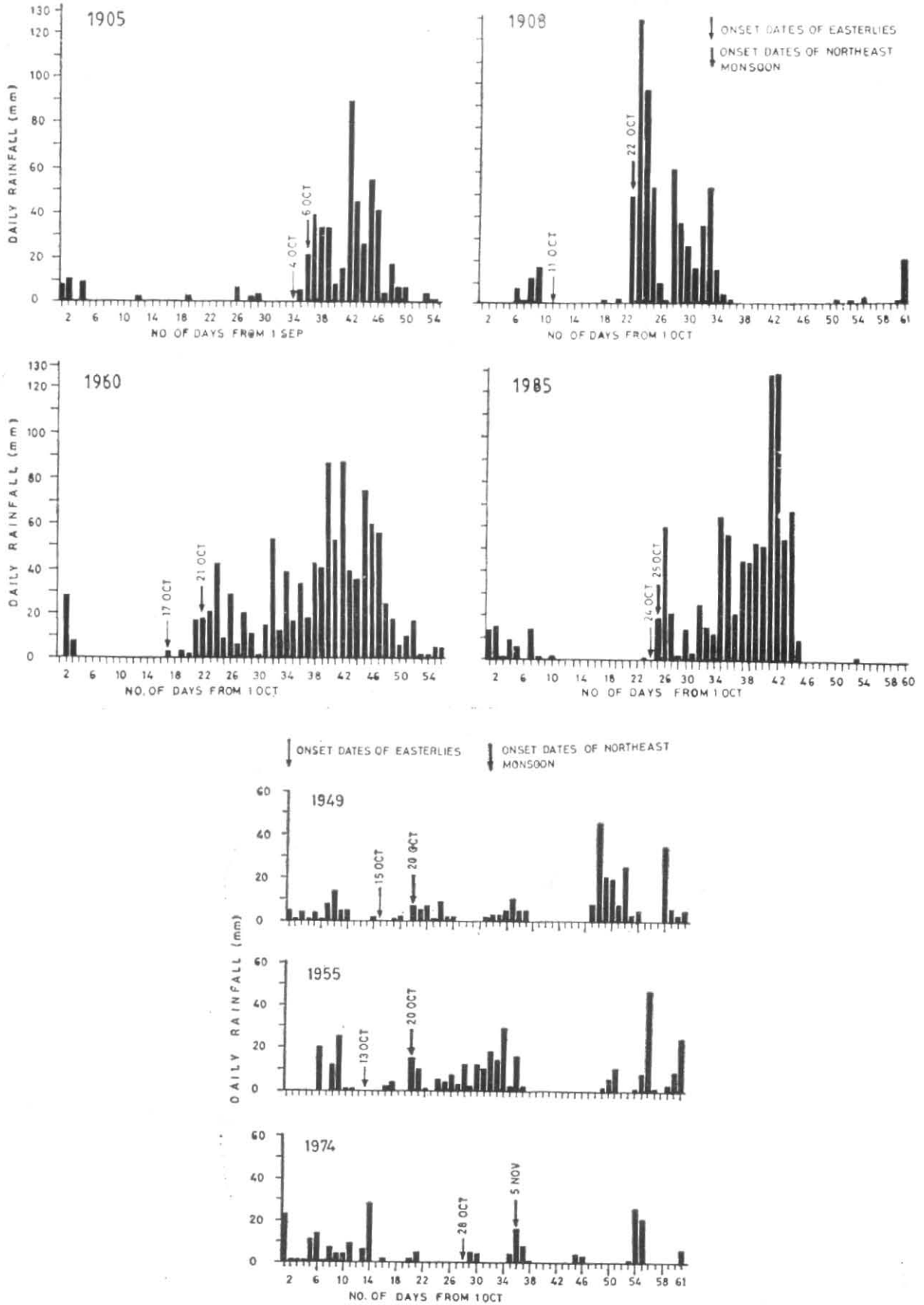


Fig. 9. Pictorial presentation of northeast monsoon onset over coastal Tamil Nadu for selected years depicting spectacular onset (1905, '08, '60 & '85) and subdued onset (1949, '55 and '74) ↓ onset dates of easterlies. ↓ onset dates of northeast monsoon

The spectacular and abrupt increase of rainfall in association with onset is clearly brought out by Fig. 7. The rainfall per day which varies between 2 & 4 mm before onset rises sharply to 17-25 mm. The rainfall during a pentad before onset worked out to 15 mm whereas during the pentad after onset it is 101 mm, an increase of nearly 7 times. The mean rainfall remains 6-7 mm per day above the pre-onset mean even after 50 days of onset.

7. Increase of rainfall associated with northeast monsoon onset—year-to-year variation

7.1. The rainfall over coastal Tamil Nadu during the pentad before the onset date and the subsequent pentad beginning with the onset date was computed for every year of 1901-90. The data is presented in Fig. 8. The rainfall of pre-onset pentad varies between 0 & 48 mm and that of onset-pentad varies between 29 & 338 mm. The increase of rainfall from one pentad to the other varied between 9 & 335 mm.

7.2. Description of onset of northeast monsoon for certain years

The temporal variation of rainfall over coastal Tamil Nadu has been depicted in Fig. 9 for some years when the onset was spectacular and for some years when it was subdued. The date of onset of easterlies and of northeast monsoon have also been indicated. In 1905, the onset was on 6 October a fortnight earlier than the normal date. From 1 September to 5 October there was only sporadic rain. Good rainfall commenced on 6 October, with the spell continuing up to 20 October. As the rainfall is continuous from 6 October it is obvious that the selection of 6 October as onset date is quite justified and application of rule (iv) of section 1.3 would not be realistic. In 1908 the easterlies set in on 11 October and there was practically no rain from 11 to 21 October. Heavy rain commenced on 22 October and the spell continued up to 4 November. In 1960, from 1 to 20 October, there was very little rain. Easterlies established on 17 October, persistent and heavy rain commenced on 21 October, the spell lasting for a month up to 21 November. The year 1985 witnessed yet another spectacular northeast monsoon onset. During 8-24 October there was hardly any rain. Easterlies set on 24 October. Rainfall commenced on 25 October and interspersed with heavy spells continued up to 14 November.

The years 1949, '55 and '74 provide examples when the onset phase was subdued and the increase of rainfall associated with the onset was comparatively less, though rules R_1 to R_5 of Sec. 2.1 were completely satisfied.

7.3. Onset associated with migratory low pressure system

Reference to IMD Storm Track Atlas (1979) and the annual storm tracks for the subsequent years revealed that only in six years (i.e., on 6.7% of the years) 1916, '43, '63, '75, '76 and '82, the onset of northeast

monsoon over coastal Tamil Nadu was associated with depressions/cyclonic storms that moved closer to or crossed the Tamil Nadu coast. Thus we conclude that by-and-large northeast monsoon onset is not associated with a moving vortex.

7.4. Length of onset spell

According to the criteria adopted, fairly widespread rain must occur over coastal Tamil Nadu on the day of onset. Examination of data revealed that fairly widespread rain occurred over coastal Tamil Nadu on 82% of years the first day after onset, 66%, 64% and 59% on the second, third and fourth days respectively, after the onset. If we define a continuous rain spell as consisting of days of fairly widespread rain, the length of the onset spell varied between 1 and 19 days, with a mean value of 4.3 days.

8. Scope for further study

The feasibility of determination of northeast monsoon onset dates over interior Tamil Nadu, coastal Andhra Pradesh, Kerala and withdrawal dates also for all these sub-divisions in addition to coastal Tamil Nadu are some of the related topics which offer scope for further study.

9. Summary

The results of the study are summarized here under :

(i) The northeast monsoon onset dates over coastal Tamil Nadu for the 90-year period 1901-90 have been objectively determined. The normal onset date is 20 October, the standard deviation is 7.3 days and the range is 5 October-11 November.

(ii) The onset date of easterlies over coastal Tamil Nadu was also determined for 1901-90. Its normal date is 14 October, viz., 6 days prior to the normal onset date of northeast monsoon. The dates of onset of easterlies & northeast monsoon were positively correlated, the coefficient being 0.75, thus yielding a regression equation to foreshadow monsoon onset.

(iii) The onset dates of northeast monsoon exhibited a significant but not very high, negative correlation with the October-December rainfall of Tamil Nadu.

(iv) The normal daily rainfall of coastal Tamil Nadu was computed and the construction of difference filter revealed that the date of sharp rise is 18 October by-and-large agreeing with the normal onset date.

(v) The mean rainfall computed from superposed epoch analysis revealed the abrupt increase of rainfall associated with the onset. The rainfall increases to nearly 7 times in the post-onset pentad from the pre-onset pentad value.

(vi) The onset is by-and-large, not associated with migratory low pressure systems.

(vii) The average length of a rain spell associated with onset is 4 to 5 days.

(viii) Some instances of spectacular/subdued onset have been highlighted.

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