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On some aspects of southwest monsoon rainfall over Tamilnadu

S. K. SUBRAMANIAN and V. N. THANKAPPAN
Regional Meteorological Centre, Madras
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सार — तमिलनाडु के प्रमुख जल स्रोतों में जल संचयन के दृष्टिकोण से दक्षिण-पश्चिम मानसून की वर्षा उत्तर-पूर्वी मानसून की वर्षा की भांति अत्यन्त महत्वपूर्ण है। उत्तर-पूर्वी मानसून वर्षा, वार्षिक वर्षा के आधे के बराबर होते हुए भी अपनी दीर्घ अन्तर-वार्षिक परिवर्तिता के कारण पर्याप्त रूप में स्थायी नहीं है। जबकि दूसरी तरफ दक्षिण-पश्चिमी मानसून वर्षा अधिक स्थायी है। तमिलनाडु और उसके आस-पास खाड़ी के ऊपर उत्तर-दक्षिण में बनने वाले कम दबाव के क्षेत्र के उपरितन वायु चक्रवातीय परिसंचरण निम्न क्षोभ मंडलीय स्तरों के कम दबाव के क्षेत्र के साथ मिलने से दक्षिण-पश्चिम मानसून ऋतु की उल्लेखनीय तीन चौथाई वर्षा होती है। दक्षिण-पश्चिमी मानसून तथा उत्तर-पूर्वी मानसून ऋतु के दौरान होने वाली वर्षा −0.18 के नाममात्र के सह संबंध के साथ एक-दूसरे से भिन्न पाई गई है। इससे इस बात का पता चलता है कि उत्तर-पूर्वी मानसून वर्षा के पैटर्न के पूर्वानुमान के लिए दक्षिण-पश्चिमी मानसून की वर्षा अधिक उपयोगी सिद्ध नहीं होगी।

ABSTRACT. The rainfall during southwest monsoon season over Tamilnadu is quite significant from the point of view of water storage in major reservoirs as northeast monsoon rainfall, which is about half of the annual rainfall, is not stable enough due to its large interannual variability. The southwest monsoon rainfall, on the other hand, is more stable. The north-south oriented trough over Tamilnadu and adjoining Bay togetherwith upper air cyclonic circulation/trough in lower tropospheric levels account for three fourths of significant rainfall occurrence during southwest monsoon season. Rainfall during southwest monsoon and northeast monsoon seasons was found to be independent with a small negative correlation of −0.18. This shows that the southwest monsoon rainfall may not be of much use to predict the pattern of northeast monsoon rainfall over Tamilnadu.

Key words — Rainfall, Monsoon, Correlation coefficients, Variability, Synoptic situations, Troposphere, Frequency.

1. Introduction

Among all meteorological sub-divisions in India, Tamilnadu has the unique feature that the rainfall received during southwest monsoon (June-September) is less than the rainfall received during northeast monsoon season (October-December). Though the latter is the principal rain giving season, rainfall received during southwest monsoon season contributes substantially towards annual rainfall. Considering the long term (90-year period) average, Tamilnadu receives annually about 100 cm rainfall of which 34 cm (34%) falls in the southwest monsoon season and 48 cm (47%) during the northeast monsoon season. There is every possibility that in the same year the deficiency in southwest monsoon rainfall may be wiped out by an excess rainfall dur ing northeast monsoon and vice-versa. But years of rainfall deficiency in both the seasons cause great concern to the administrators. Poor rainfall during southwest monsoon season will deplete the storage position in all major lakes in the state and unless and until this deficiency is made up by good rainfall activity during northeast monsoon season, the shortage will be very acute in some areas. On the other hand if the southwest monsoon rainfall is either normal or above normal the situation is relatively comfortable. This does not, however, mean that the northeast monsoon rainfall is not at all necessary for agricultural operations when once the rainfall activity during southwest monsoon season is quite good.

Manikiam and Sridharan (1988), in their study based on a 5-year period (1975-1979), have examined various synoptic systems that cause significant rainfall over Tamilnadu during southwest monsoon. They have found that the low pressure areas, though occurring on a less number of occasions, have greater potential of causing scattered and fairly widespread/widespread rainfall than the surface trough with upper air cyclonic circulation, though the latter system occurs on large number of occasions. Dhar and Rakhecha (1983) have studied the relationship between southwest monsoon and northeast monsoon rainfall based on the data of 230 stations in Tamilnadu for the 100-year period from 1877 to 1976 and found that the rainfall amounts in the two seasons are dependent and showed negative correlation of −0.38 which is

TABLE 1

Annual and seasonal percentage frequencies of rainfall distribution

Period	Excess	Normal	Deficient	Scanty	No rain
Annual	8	83	9	0	0
Winter (Jan-Feb)	26	14	25	35	0
Pre-monsoon (Mar-May)	18	42	40	0	0
SW monsoon (Jun-Sep)	14	65	21	0	0
NE monsoon (Oct-Dec)	22	54	23	1	0

TABLE 2

Seasonal (southwest monsoon) and monthly percentage frequency of rainfall distribution

Period	Excess	Normal	Deficient	Scanty	Normal
SW monsoon (June-September)	14	65	21	0	0
June	16	40	43	1	0
July	21	45	33	1	0
August	26	36	33	5	0
September	25	44	25	6	0

significant and that the rainfall activity during southwest monsoon season can be used to forecast the northeast monsoon rainfall over Tamilnadu. However, Williams *et al.* (1982) using the data of 12 observatory stations have found that the correlation coefficient between southwest and northeast monsoon rainfall in the same year for north and south Tamilnadu is −0.15 and −0.12 respectively, both being statistically insignificant.

A detailed analysis of the southwest monsoon rainfall series of Tamilnadu covering the 90-year period (1901-1990) was taken up and the results are presented. The different types of synoptic situations that give significant rainfall over Tamilnadu during the southwest monsoon period are also discussed.

2. Data used

The monthly sub-divisional rainfall data prepared by the India Meteorological Department (IMD) for the 90-year period (1901-1990) were used in the analysis.

For studying the synoptic features that caused significant rainfall (by significant rainfall it is meant to cover spatial distribution of scattered, fairly widespread and widespread rainfall) the data covering a period of 15 years from 1976 to 1990 were examined. The working charts at Regional Meteorological Centre, Madras were consulted to find out different types of synoptic situations that caused significant rainfall over the state. The Indian Daily Weather Report published from Pune and the

TABLE 3

Monthly percentage frequency of spatial distribution

Period	Scattered	Fairly wide-spread	Wide-spread	Isolated/ No rain
June	9.3	1.1	0.0	89.6
July	12.5	5.4	0.4	81.7
August	19.3	4.7	0.2	75.8
September	30.2	9.1	2.2	58.5

Regional Daily Weather Report published by Regional Meteorological Centre, Madras have also been consulted for particulars concerning spatial distribution of rainfall.

3. Results and discussion

3.1. *Features of Tamilnadu rainfall*

On an average, out of a total annual rainfall of 1004.8 mm Tamilnadu receives 477.2 mm rainfall during the northeast monsoon season and 341.1 mm during the southwest monsoon. The figures in respect of pre-monsoon season (March-May) and winter months (January-February) are 138.9 mm and 47.6 mm respectively. The percentage contribution of these four seasons to the annual rainfall, thus, works out to be 47, 34, 14 and 5 respectively. The winter rainfall is highly variable with coefficient of variability equal to 98% followed by the pre-monsoon season with 32%. Though the total rainfall during northeast monsoon is more than that during southwest monsoon, the latter has less variability (19%) than the former (27%) as mentioned by Dhar and Rakhecha (1983). The coefficient of variability for the annual rainfall works out to be 14%. This shows that the southwest monsoon rainfall over Tamilnadu is relatively stable as compared to the rainfall of other seasons.

Of the normal southwest monsoon rainfall of 341.1 mm, 110.6 mm (32%) rainfall is realised in September, 95.7 mm (28%) in August, 77.6 mm (23%) in July and the remaining 57.2 mm (17%) in June. July rainfall shows maximum variability of 44% followed by August (36%), September (35%) and June (34%).

3.2. *Pattern of rainfall distribution over Tamilnadu*

The annual and seasonal percentage frequencies of rainfall distribution (Excess, normal, deficient, scanty, no rain) is given in Table 1.

The percentage frequencies of excess and deficient rainfall for the annual as well as for the northeast monsoon season were nearly balanced on either side of normal rainfall, whereas for the southwest monsoon season it showed a tilt towards deficiency.

Examining the pattern of rainfall distribution during southwest monsoon period month-by-month (Table 2), it is seen that all the four months showed a tendency towards deficiency, the maximum being noticed in the month of June.

3.3. *Frequency of occurrence of significant rainfall over Tamilnadu during southwest monsoon period*

The monthwise percentage frequency of occurrence of significant rainfall over Tamilnadu during southwest monsoon period is given in Table 3. It may be seen that the frequency of occurrence of significant rainfall was maximum (42%) in September and minimum (10%) in June. One possible reason for this is that the frequency of occurrence and duration of "break" monsoon conditions is relatively high during September. In June, there had been no instances of widespread rainfall over Tamilnadu in these 15 years.

3.4. *Significant rainfall and associated synoptic situations*

Tamilnadu experiences significant rainfall during southwest monsoon period under any one or more of favourable synoptic situations of the following categories :

(A) A cyclonic disturbance over southwest and adjoining west central Bay with associated upper air circulation extending upto the middle and upper

TABLE 4

Monthly and seasonal (southwest monsoon) percentage frequencies of synoptic situation

Period	Categories					
	A	B	C	D	E	F
June	6.8	28.4	27.0	20.3	8.1	9.4
July	1.4	44.0	40.4	4.3	7.1	2.8
August	3.7	30.9	44.1	6.4	12.8	2.1
September	12.8	38.5	32.8	5.1	7.1	3.7
SW monsoon (June-September)	7.4	36.5	36.8	6.9	8.7	3.7

TABLE 5

Contingency table of rainfall distribution during southwest and northeast monsoon seasons

Southwest monsoon	Northeast monsoon			
	Excess	Normal	Deficient	Scanty
Excess	1	6	6	0
Normal	11	35	12	1
Deficient	6	8	4	0
Scanty	0	0	0	0

troposphere. This type of synoptic situation occurs during "break" monsoon conditions.

(B) Upper air cyclonic circulation/trough over Tamilnadu and southwest and adjoining west central Bay in lower tropospheric levels.

(C) North-south oriented trough on sea level over Tamilnadu or over southwest Bay.

(D) East-west trough line over the peninsula south of latitude 15°N in lower and middle troposphere.

(E) Low pressure area/depression in northwest and adjoining west central Bay with a trough extending to southwest Bay.

(F) On a few occasions, the significant rainfall was not associated with any of the above synoptic situations and such cases have been classified as falling under category F.

The monthwise percentage frequencies of occurrence of significant rainfall under different synoptic situations for the southwest monsoon period are given in Table 4. The noteworthy features seen are as shown below:

(*i*) The occurrence of significant rainfall under the influence of an east-west trough line, category D, (about 20%) was generally noticed only in June. This type of situation was normally associated with the onset phase of the southwest monsoon. The frequencies in respect of other months were small (4-6%).

(*ii*) The upper air cyclonic circulation/trough in lower and middle troposphere together with the north-south oriented trough on sea level chart over Tamilnadu or

adjoining southwest/west central Bay, categories B and C, had an 85% chance of realisation of significant rainfall in July and about 70-75% in August and September. In June, it was only 55%. This is understandable because such synoptic situations prevail on days of weak monsoon conditions when the westerlies in the lower/middle troposphere are not so strong.

(*iii*) The formation of a cyclonic disturbance over southwest and adjoining west-central Bay with associated upper air cyclonic circulation, category A, accounted for significant rainfall of about 13% in September, about 7% in June and about 4% in August. This type of situation normally occurs during the onset phase of the southwest monsoon during June or under break monsoon conditions. The chance of getting significant rainfall in July under such synoptic situation was only 1%.

(*iv*) The low pressure area and depression forming in north Bay and adjoining west-central Bay with a trough extending to southwest Bay, category E, sometimes caused significant rainfall over Tamilnadu. The percentage frequency for such a situation was maximum (about 13%) in August. For the other months they were of the order of about 7-8%.

(*v*) For the southwest monsoon period as a whole, the synoptic situations under categories B and C together accounted for about 73% for the occurrence of significant rainfall over Tamilnadu.

3.5. *Relationship between southwest monsoon rainfall and northeast monsoon rainfall*

It is found that the correlation coefficient between the southwest monsoon and northeast monsoon rainfall over Tamilnadu is −0.18 which is significant only at 5% level but not 1% level. This is comparatively lower than the value of −0.38 obtained by Dhar and Rakhecha (1983). This may be due to difference in the period of coverage of the two data sets.

The possible relationship between the southwest and northeast monsoon rainfall was also found using 'Chi-Square' test. Contingency table was prepared on the rainfall distribution of the two series and given in Table 5. The 'Chi-Square' test revealed that the two classifications are independent, thereby showing that the southwest monsoon rainfall is not so helpful in the prediction of the following northeast monsoon rains as discussed by Dhar and Rakhecha (1983).

4. Conclusions

(*i*) The southwest monsoon and annual rainfall over Tamilnadu are relatively steady as compared to rainfall in other seasons. The coefficient of variability for southwest monsoon season is less than that for northeast monsoon season though the rainfall during the latter season is higher.

(*ii*) During southwest monsoon period, July rainfall shows greater variability compared to the other 3 months.

(*iii*) The rainfall distribution during southwest monsoon season is skewed towards deficiency.

(*iv*) The frequency of occurrence of significant rainfall over Tamilnadu is maximum in September and minimum in June.

(*v*) The north-south oriented trough on sea level chart over Tamilnadu or adjoining southwest/west central Bay together with upper air cyclonic circulation/trough over southwest Bay and neighbourhood in lower and middle troposphere accounted for about 73% for the occurrence of significant rainfall over Tamilnadu during southwest monsoon season.

(*vi*) The southwest and northeast monsoon rainfall series are independent. As such southwest monsoon rainfall cannot be used to predict the pattern of northeast monsoon rainfall over Tamilnadu.

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