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A statistical study of synoptic systems causing significant rainfall over Tamil Nadu during southwest monsoon season

B. MANIKIAM* and S. SRIDHARAN

Regional Meteorological Centre, Madras

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सार — दक्षिण-पश्चिमी मानसून की अवधि में विभिन्न सिनॉप्टिक प्रणालियों की उपस्थिति, जिसके कारण तमिलनाडु में हुई, सार्थक वर्षा के पांच वर्षों (1975–1979) के आंकड़ों के सांख्यकीय विश्लेषण का अध्ययन किया गया है। यह देखा गया है कि सिनॉप्टिक प्रणालियों की उपस्थिति सतह द्रोणी (उपरितन पवन चक्रवातीय परिचलन से युक्त अथवा विहीन) और कम दाब वाल क्षेत्र सामान्यता की दृष्टि से मानसून द्रोणी पर निर्भर होते हैं। जब मानसून द्रोणी अपनी सामान्य स्थिति में उत्तर में होती है तब चक्रवातीय परिचलन के साथ सतह द्रोणी के होने और कम दाब वाले क्षेत्र की उपस्थिति की संभावना बढ़ जाती है। चक्रवातीय परिचलन (20 %) से युक्त अथवा विहीन अथवा समुद्री स्तर द्रोणी की तुलना में निम्न दाब क्षेत्र (66 %) के साथ सार्थक वर्षा के होने की संभावना बढ़ जाती है।

ABSTRACT. A statistical analysis of the five-year data (1975-79) has been carried out to study the occurrence of various synoptic systems which cause significant rainfall (scattered/fairly widespread/widespread) over Tamil Nadu during the southwest monsoon season. It is seen that the occurrence of the synoptic systems—surface trough (with or without upper air cyclonic circulation) and low pressure area — is dependent on the position of the monsoon trough with respect to the normal. There is a high probability of occurrence of surface trough with cyclonic circulation and low pressure area when the monsoon trough is to the north of its normal position. Also the probability of occurrence of significant rainfall is higher with low pressure area (66 %) compared to sea level trough with or without cyclonic circulation (20 %).

1. Introduction

Though Tamil Nadu gets most of the annual rainfall during the northeast monsoon season (Oct-Dec), there is a significant contribution from the southwest monsoon season. The hilly regions of the State, namely Nilgiris district, Coimbatore district and western parts of Madurai district get nearly 50 % of the annual rainfall during the southwest monsoon season. The rainfall decreases gradually towards the coast which gets about 25-30 % of annual rainfall during this season. The rainfall during southwest monsoon season is very important for the first crop and also for the hydel projects in the hilly tracts of the State. The synoptic situations which occur in the northeast monsoon season have been fairly well studied while there has been no detailed study of the rain-giving systems which affect Tamil Nadu during the southwest monsoon season. An attempt has been made in this paper to classify the synoptic situations which yield significant rainfall over Tamil Nadu during southwest monsoon season.

2. Data utilised

The study is based on the data for the period of 5 years from 1975 to 1979. The working charts of Area Cyclone Warning Centre, Madras have been utilised for obtaining synoptic situations. There are about 60 rainfall stations in Tamil Nadu (belonging to India Met. Dep. and State Government Departments) from which data are received telegraphically at Area Cyclone Warning Centre, Madras. These data have been utilised for working out the spatial distributions of rainfall.

3. Synoptic situations

The strength of the low level westerlies over Peninsular India varies considerably from day to day during the southwest monsoon depending upon various factors. The westerlies are strong when the monsoon trough shifts southwards or when a low pressure system forms over head Bay and travels westnorthwestwards (Rao 1976). They weaken considerably when the monsoon trough shifts northward of its normal position. When the monsoon westerlies are strong over the Peninsula, no significant synoptic situations occur and weather remains mainly dry over Tamil Nadu. When the monsoon westerlies are weak, significant synoptic systems can be seen to occur at the surface or in the lower tropospheric levels (shallow) over southwest Bay off Cape Comorin-Sri Lanka coast (Ramamurthy 1969). The synoptic systems which occur are shallow surface trough, surface trough extending upwards into

*Presently at ISRO HQs, Bangalore

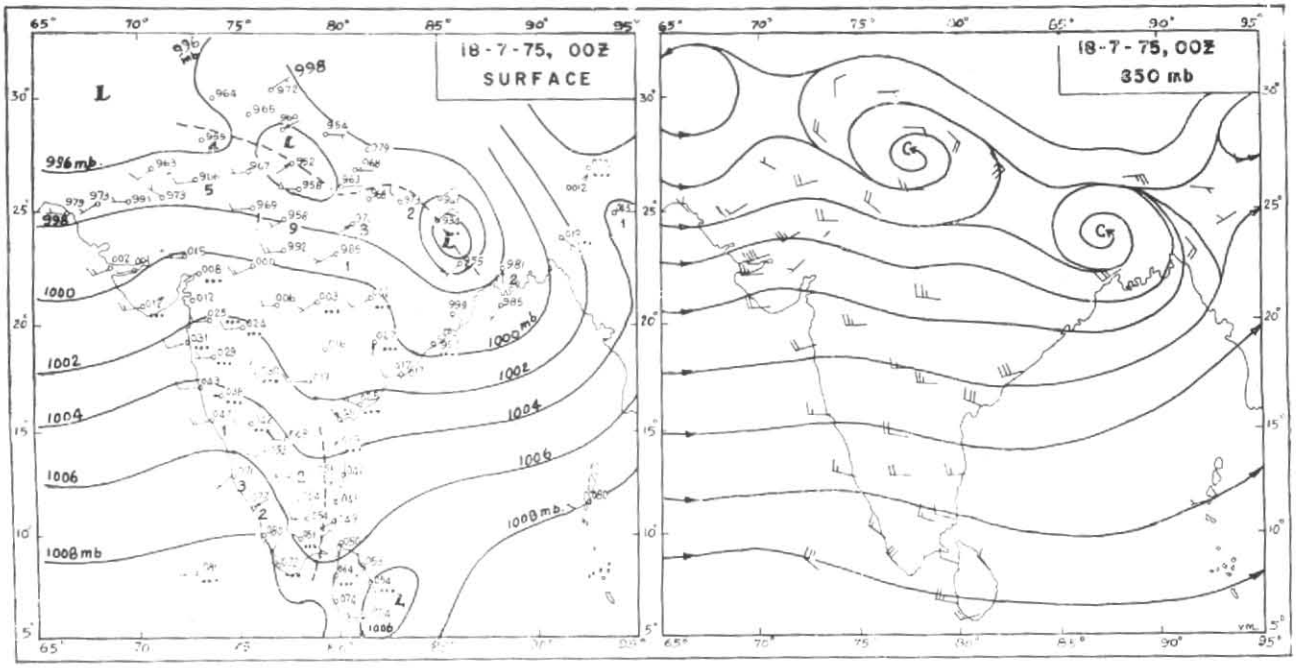

Fig. 1. Surface trough over Tamil Nadu

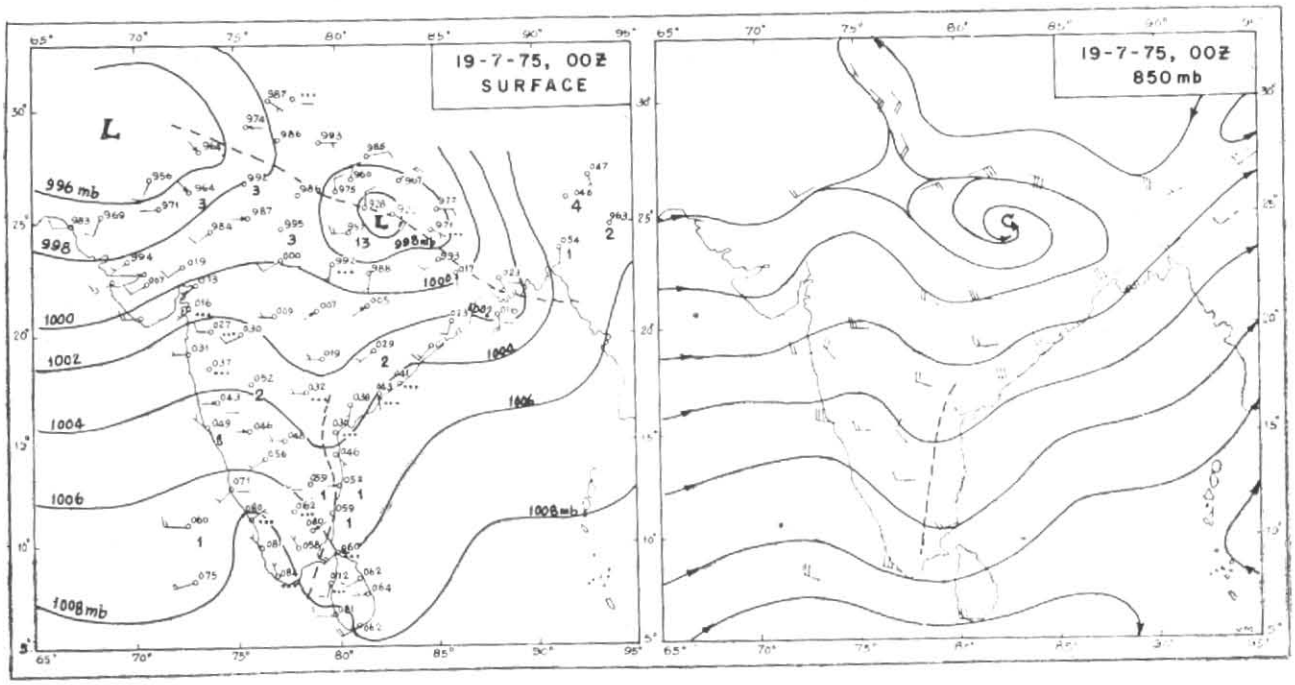

Fig. 2. Trough extending up to 850 mb

the lower tropospheric levels and low pressure area at the surface with circulation in the lower levels. Typical pressure and wind patterns associated with these synoptic systems are presented in Figs. 1-3. For the purpose of the study, significant rainfall has been taken as those when Tamil Nadu received rainfall as scattered and widespread/fairly widespread. The frequency of occurrence of the above synoptic systems in relation to the mean sea level position of the monsoon trough over northern India and the resultant rainfall over Tamil Nadu has been analysed.

4. Analysis and results

The daily working charts of Area Cyclone Warning Centre, Madras for the southwest monsoon period for the years 1975-'79 have been utilised to identify the synoptic situations and associated rainfall.

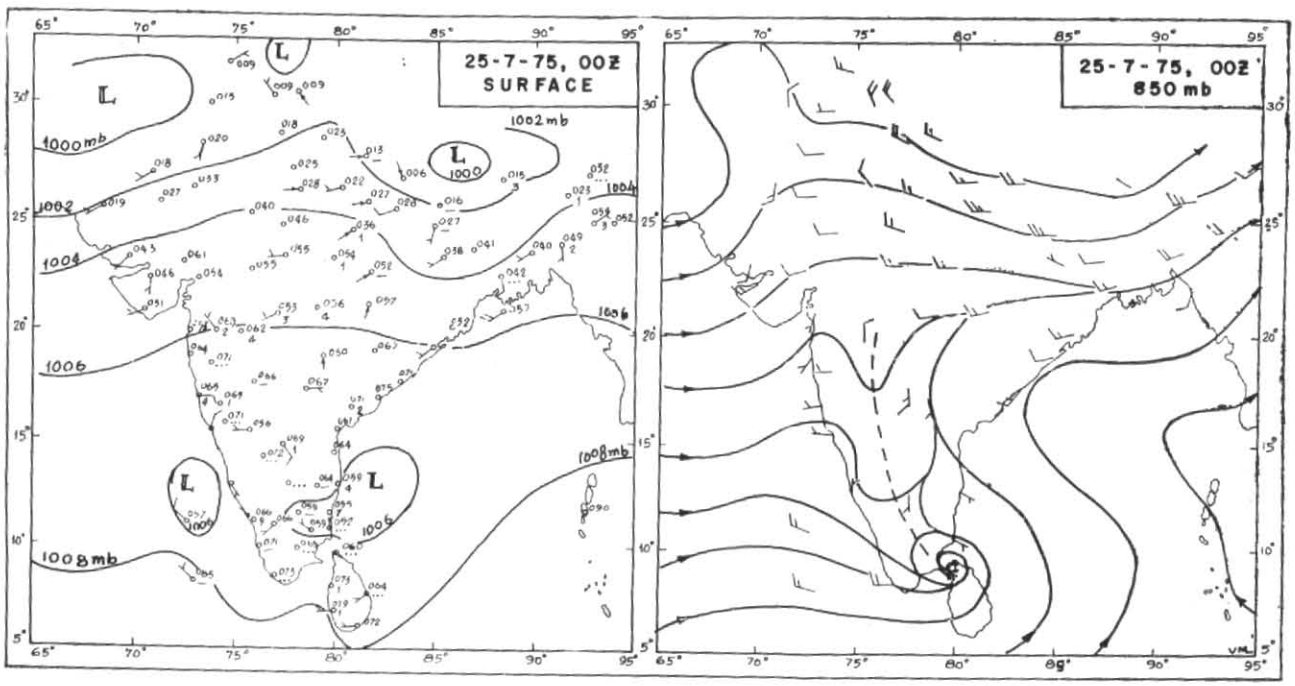

Fig. 3. Low pressure area with trough aloft

TABLE 1

Percentage of occurrence of synoptic situations

Mean sea level position of monsoon trough	Percentage of occurrence			
	Sea level trough	Sea level trough with upper air trough/ circulation	Low pressure area	Without system
North of normal	36	33	10	21
Normal	52	16	1	31
South of normal	46	12	2	40
Total No. of occasions	273	126	27	185

TABLE 2

Statistics of spatial distribution of rainfall

	Average number of days with rainfall			Average No. of days with no rainfall
	W/FW	Sc	Iso	
Jun	0	4	17	9
Jul	2	4	16	9
Aug	2	8	13	8
Sep	3	9	13	5

The normal position of the monsoon trough at the surface is taken as a line joining Calcutta to New Delhi or within 2 degrees of latitude on either side. When it shifts north of this limit it is classified as north of its normal and south of these limits as south of its normal position. When the axis of the monsoon trough tilts in such a way that it is north of the normal position in some places and to the south in some other places the average position of the trough position between 75°E and 85°E has been taken to classify the position of the monsoon trough.

Table 1 gives the percentage frequency of occurrence of the different types of synoptic situations against different mean sea level positions of the monsoon trough over northern India. It can be seen from the table that synoptic situations like low pressure areas and surface troughs with associated upper air trough or cyclonic circulations occur predominantly when the monsoon trough is north of normal position (43%), whereas on 83-86% of the days when the monsoon trough is in its normal position or south of normal position either there is no system or only a shallow surface trough is seen.

Table 2 shows the frequency of occurrence of the different rainfall distributions in the months of June to September over Tamil Nadu. It can be seen from the table that there are about 21 to 23 days with rainfall in June, July and August and about 25 days in September. But on majority of the rainy days, the rainfall is isolated (65%) with scattered rainfall accounting for 26% of rainy days. Widespread/fairly widespread rainfall is rare, occurring only on 2 to 3 days in each of the months, except June in which month no fairly widespread rainfall was noticed during the 5 years under study.

TABLE 3

Significant rainfall and associated synoptic situations

Rainfall	Synoptic situations			
	Sea level trough	Sea level trough with upper air trough/ cycir.	Low pressure area	Without system
Widespread/fairly widespread	5	19	9	—
Scattered	50	52	9	12
% occurrence of significant rain	20	57	66	7

Table 3 gives the frequency occurrence of significant rainfall (scattered and widespread/fairly widespread) with respect to the various synoptic situations. It can be seen that the sea level trough with upper air trough/ circulation contributed to the maximum number of significant rainy days followed by sea level trough. The potential of the different synoptic situations to produce significant rainfall is given as a percentage in Table 3. The % refers to the number of occasions which yielded significant rainfall with respect to total number of occasions. It can be seen that the low pressure areas have higher probability (66%) of causing scattered and FW/W rainfall while sea level trough has lower probability (20%). The number of occasions with significant rainfall caused by no synoptic situations is negligible (7%).

5. Conclusions

This study has brought out the relative importance of different synoptic situations in causing significant rainfall over Tamil Nadu during the southwest monsoon season. The 5-year data analysis indicates that the low pressure areas though occurring on a less number of occasions, have greater potential of causing scattered and widespread/fairly widespread rainfall than the surface trough with upper air cyclonic circulation though the latter system occur on large number of occasions. Also the sea level trough with upper air cyclonic circulation and low pressure area occur mostly when the monsoon trough is to the north of its normal position.

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