

Westward moving sea level low pressure systems in the south Bay of Bengal during southwest monsoon

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ABSTRACT. The movement of low pressure systems from the east, across south Bay of Bengal and south Indian Peninsula, during July and August, when the southwest monsoon has established itself over India, has been studied for a 20-year period from 1946 to 1965. Only well marked systems, which could be delineated on the sea level synoptic chart, are reported in the present paper. The characteristics of these systems and its relation with other systems, breaks in southwest monsoon etc are discussed.

The effect of migratory lows on rainfall has been studied for Madras State, Kerala and coastal Mysore. While Madras gets good rain with scattered heavy to very heavy falls, the rainfall over the West Coast, particularly in the northern parts, is comparatively less marked.

1. Introduction

During the southwest monsoon, low pressure waves move from the east to the north or central Bay of Bengal. Some of them even concentrate into depressions or cyclonic storms. Once the monsoon has fully established itself, no depressions form south of 15°N until it is time for the withdrawal of the monsoon, but during July 1964, a migratory low could be traced from the Gulf of Siam to southwest Bay of Bengal between 22 and 26 July. It was well-marked when it lay over southwest Bay on the 26th. Later, it gradually recurved northeastwards over the Peninsula and, after weakening, became unimportant over coastal Andhra Pradesh on the 31st.

Apart from the fact that the movement of such a system at low latitudes during July was rather unusual, the low was responsible for fairly wide-spread rainfall, with a few heavy and very heavy falls along its track, particularly in Madras State, which does not normally get much rain in July. The movement of this low was also associated with a break in the monsoon between the 27th and 31st.

A similar synoptic case also occurred in August 1965. The break in monsoon rains lasted nearly three weeks, leading to serious failure of crops over large parts of the country, even though the low caused very heavy rainfall in south Peninsular India.

Synoptic cases of the similar nature have also occurred in the past. They are often associated with very heavy rain in Madras State, leading at times to minor floods. As this type of heavy rainfall is unusual for the season, the present study was undertaken to find out the conditions under which it occurs. As a first step, only those systems which could be detected on the sea level chart were examined.

2. Data utilized

This study covers the months of July and August, typical monsoon months, during the 20-year period from 1946 to 1965. The associated rainfall over Madras State has been analysed in detail. Some features of the rainfall over the southern half of the West Coast (Kerala and coastal Mysore) have been also studied for the earlier years upto 1956 for which State raingauge data were available.

Data published in the *Indian Daily Weather Reports* have been generally utilized. Daily rainfall figures of State raingauge stations and district averages have been taken from published volumes containing the daily rainfall of India for the years prior to 1964. Data for 1964 and 1965 for Madras State were obtained from State Government officials. The data for Kanyakumari district for the years prior to 1955, when the district did not exist as a separate entity, have been calculated separately.

TABLE 1
Sea level low pressure systems in the south Bay of Bengal during July and August 1946-1965

Duration of system		Duration of break monsoon	Rainfall				No. of places reporting 12 cm or more rain	Other synoptic features
Year	Period		Period (in days)	Per cent of monthly total				
				Madras	West Coast			
1948	30 Jul to 7 Aug	1 to 6 Aug	1 to 4 Aug (4)	44	16	1	—	
1950	18 to 26 Aug	16 to 24 Aug	20 to 23 Aug (4)	50	8	3	—	
1952	9 to 12 Jul	9 to 12 Jul	10 to 12 Jul (3)	49	5	4	—	
1954	22 to 27 Jul	22 to 28 Jul	24 to 25 Jul (2)	42	5	1	Low along 6°S	
1955	12 to 17 Aug	14 to 16 Aug	—	—	—	—	Depression along 6° S	
1958	2 to 12 Aug	9 to 12 Aug	—	—	—	9	This was depression (vide Fig. 1)	
1960	14 to 24 Jul	16 to 22 Jul	18 to 20 Jul (3)	44	—	4	—	
1964	22 to 31 Jul	27 to 31 Jul	24 to 29 Jul (6)	80	—	2	Westerly waves across Iran to Tibet	
1965	4 to 18 Aug	5 to 20 Aug	—	—	—	—	W'ly waves across Persian Gulf to Tibet. Vortex at 11°S, 82°E	

3. Detailed case histories

The history of all low pressure systems during the 20-year period mentioned above was prepared and tabulated. The main features have been summarised in Table 1. Sometimes a series of low pressure systems are observed as in 1965. Floods in July due to the effect of rainfall over Madras are practically unheard of; but in 1964 floods were reported in the Palar river and the railway line between Madras and Bangalore was breached to a length of about 130 m at about 100 km from Bangalore. These low pressure systems sometimes give exceptionally heavy rain. One such case was reported by Balasubramanian (1965).

Of all the systems studied, the strongest one was in 1958, and surface chart of 1130 IST of 9 August 1958 is reproduced in Fig. 1 as an illustration.

4. Results and Discussion

4.1. *Characteristics of these systems*—This study brings out the important fact that the movement of low pressure systems at low latitudes during the southwest monsoon season is more frequent than was hitherto realised. As many as 9 instances occurred during the 20-year period. We could discern no bias in the monthly distribution of these systems. They seemed to occur equally frequently in July and in August. This aspect is further discussed in Section 4.7.

4.2. *Direction of movement*—The direction of movement of these systems was generally westwards or northwestwards. In some cases, they

recurred north or northeastwards. Out of 9 cases presented here, 6 systems moved west to northwest throughout, 2 moved northwards and the remaining one recurred northeastwards after moving west or northwestwards initially. Approximate tracks of the six low pressure systems are shown in Fig. 2.

4.3. *Intensity*—While a number of these systems intensified into well-marked low pressure areas, only one of them (in 1958) probably reached the depression stage. These migratory lows, therefore, appear to be in the nature of weak perturbations on the mean circulation pattern at low latitudes.

4.4. *Relation with breaks in southwest monsoon*—In all the cases studied, the passage of these low latitude systems was associated with a general break in the monsoon. In the majority of cases, the appearance of a low in the south Bay of Bengal preceded a decrease in the intensity of the monsoon. The break persisted over a large part of the country as long as the low was active. The monsoon revived either in the wake of a low or after the low became less marked. The time lag between the appearance of the low and the onset of break conditions was about a day in most cases. In one case (in 1964), the break occurred about 4 days after the appearance of the low. In the remaining cases, either the break preceded the appearance of the low (as in 1958 and 1965) or the appearance of the low coincided with the onset of break as in 1950. In 1955 and 1958 and, to

some extent in 1965, break conditions did not persist throughout the life history of these low latitude systems.

4.5. *Relation with systems in the southern hemisphere*—It was observed that in 3 instances (1954, 1955 and 1965), a well-defined low pressure system (depression or cyclonic storm) was moving westwards just south of the equator, when a low pressure system was moving across south Bay. The two appeared to move simultaneously in pairs. It is likely that the influence of systems of the southern hemisphere is significant, as discussed in section 4.7.

4.6. *Relation with movement of westerly waves in sub-tropical latitudes*—An examination of the extended northern hemispherical charts and inferences for July 1964 and August 1965 showed that during the passage of a easterly wave across south Bay and south Peninsula, a series of westerly waves could also be located over the Persian Gulf, Iran, Russian Turkistan, Tibet and the extreme northern parts of India. Available data indicate that in July 1954 and August 1958 when lows were moving westwards along low latitudes, a few westerly waves moved across the extreme north of the country. A possible relation between the two systems is discussed below.

4.7. *Inter-relationship among the synoptic features*—Normally in July and August, the axis of the seasonal trough of low pressure lies over the Gangetic plains at the lower levels, with easterlies to the north and strong westerlies or southwesterlies to the south. Over the Peninsula, these westerlies extend upto 6.0 km. It is however, well known that the axis of the seasonal trough shows north-south oscillation. Often it is located at the foot of the Himalayas, resulting in a break in the monsoon. Sometimes, it shifts as far south as 20°N. Low pressure waves from the east (often intensifying into a depression or a cyclone) also move in a westerly direction along this belt. Under strong monsoon conditions, with the axis situated in its normal position or to the south of it, westerlies over the Peninsula and over south and central Bay are very pronounced. It is probable that, in such a strong wind field, cyclonic circulations may not develop at all or, even if they develop, their movement westwards is likely to be retarded by a deep layer of strong westerlies. However, under weak monsoon conditions, the strength of the westerly flow over the Peninsula and south and central Bay decreases, and westward moving low pressure circulations may appear at low latitudes. A

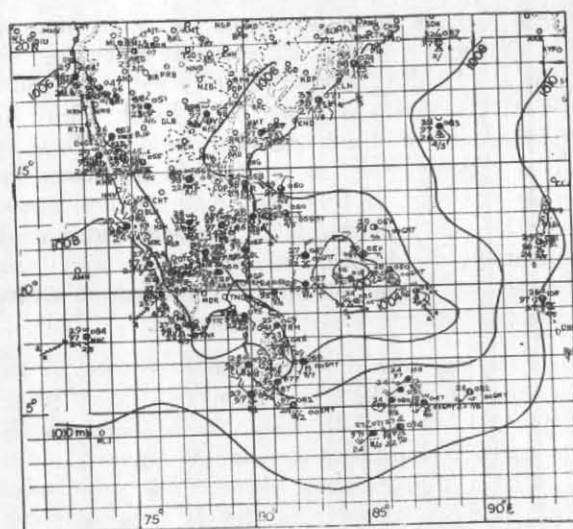


Fig. 1. Surface chart at 1130 IST on 9 August 1958 showing a well-marked low over southwest Bay

A few ships observations of 0530 IST are also shown

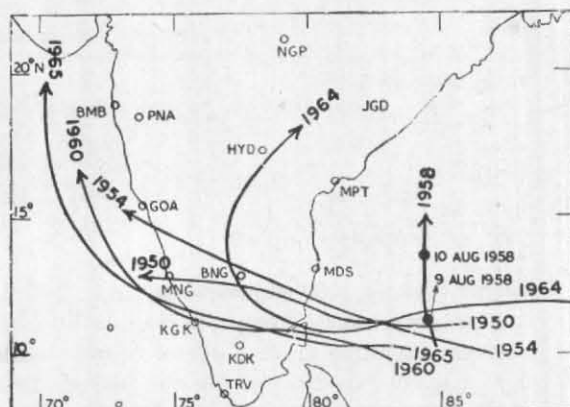


Fig. 2. Tracks of six low pressure systems over south Bay during July and August 1946-1965

particularly favourable situation is when there is decrease in the activity of the monsoon because, on such occasion, the axis of the monsoon trough tends to shift to the foot of the Himalayas and westerlies over the Indian Peninsula are weak.

Once a low pressure system develops over the Indian region, the low latitude circulation appears to help the onset of break conditions. Koteswaram (1950) suggests the following mechanism. The pressure gradient over south Peninsula in normal monsoon conditions is directed from lower to higher latitudes, in the lower troposphere. The approach of a low at low latitudes reverses the pressure gradient, cutting off the flow from the southern hemisphere. Consequently a break in the monsoon results.

It follows, therefore, that the movement of a low latitude system should be generally associated

with a break in the monsoon. This was noticed in all the 9 synoptic situations presented in this paper. It also follows that conditions are more favourable for the onset of a break after the appearance of a low pressure system. The fact that in some cases the break came after considerable time lag, or that the break did not persist for long is understandable, because under weak monsoon conditions, incipient lows may also develop at higher latitudes. These help to retard the onset of a break in the monsoon.

A strong low pressure system moving in the southern hemisphere may have the effect of reducing the flow of air from the southern to the northern hemisphere across the equator. This weakens the westerly current over the south Bay and south Peninsula, thereby creating conditions favourable for the movement of a easterly low across the south Bay. Similarly, the movement of westerly waves along subtropical latitudes may influence the northward shift of the monsoon trough, thereby inducing the onset of break and creating conditions favourable for the movement of low latitude disturbances.

Compared to July, the normal pressure gradient over the Peninsula is weaker in August. One would, therefore, expect a larger number of low pressure systems in August than in July. The present study, however, does not support this view.

5. Rainfall associated with migratory lows

5.1. *Madras State*—Except in one case, when the system began to move northwestwards while still far out in the Bay of Bengal, all of them caused considerable rainfall in Madras State. Rainfall of the order of 10 to 15 cm occurred at many stations, leading at times to local minor floods (as in 1964). From a study of actual rainfall and the district averages, it was found that in many districts, rainfall during a short period covering the passage of these low pressure systems (usually 2 to 4 days) often exceeded the entire month's normal rainfall. Sometimes, rainfall during this short period was found to be as high as 200 to 300 per cent of the month's normal. These figures are impressive when we take into account the fact that the number of raingauge stations (for which normals are available)

in most of these districts exceeds 15, and is often as high as 34.

5.2. *West Coast of India*—Though this study is primarily concerned with the rainfall in Madras State, a comparison was made with similar district averages for the West Coast districts (covering Kerala and coastal Mysore) for the same period. The object was to see whether the approach of these low pressure systems strengthened the monsoon along the West Coast. State raingauge data of West Coast districts were available for the years prior to 1956, but the data show that the rainfall in these districts during the period was in general equal or less than the expected percentage of the monthly normal. The percentage was particularly small in those districts situated to the north of the track of migratory lows. As may be expected, the monsoon strengthened along the West Coast on a number of occasions, as soon as the low pressure system moved into the Arabian Sea.

5.3. *Distribution of heavy rainfall*—As these systems cause heavy to very heavy rain in Madras State, where heavy rainfall is not expected in July and August, the problem of forecasting their occurrence is of some importance. For this purpose attempts were made to locate the sector in which the heavy rainfall occurred. The cases of 1950 and 1960 were tried. But consistent results could not be obtained due to certain inherent limitations in the cases considered. The low pressure areas were moving in low latitudes where the width of the Peninsula is approximately equal to the distance travelled by the disturbance itself in a day. Since rainfall data are available only from land stations in the Peninsula, it was not possible to get sufficient distribution of rainfall observations in all the sectors, so as to arrive at definite conclusions. Also, since the lows weakened considerably on crossing the Peninsula, rainfall observed on successive days, could not be combined to give a consistent picture.

6. Acknowledgement

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