

A monsoon storm as studied on 5-day mean charts

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1. Introduction

In this note, 5-day mean surface and 700-mb charts and the corresponding 5-day precipitation amounts have been studied for a period in the monsoon season when an active cyclonic storm developed at the head of the Bay of Bengal and moved across the country. The results of this study may be found useful in connection with the preparation of medium range forecasts for precipitation likely to be caused by similar storms.

The storm in question followed a long track. It crossed the coast near Puri on the morning of 22 August 1957 and finally broke up over the Kashmir Himalayas on 26 August 1957. Under its influence, heavy to very heavy rain occurred in the central parts of the country, the West Coast, coastal Andhra Pradesh, Gujarat, Rajasthan, the Punjab (I) and Jammu and Kashmir. According to press reports the Kashmir Valley from Anantnag to Sepore—a 75 mile stretch was completely under water excepting the small areas comprising the city of Srinagar and some neighbouring villages. The Godavari near Bhadrachalam and the Nerbada near Indore were in high spate, dislocating rail and road traffic in those areas. The river Ravi was also in spate threatening the city of Amritsar.

Another interesting feature about the same time was that two more disturbances were present—one in the Pacific Ocean and the other in the South China Sea. The

above three disturbances developed in sea areas within a latitude belt of ten degrees. The Bay disturbance formed with its centre about 300 km to the east of Puri on 20 August 1957 and intensified into a cyclonic storm by the next day. The other two disturbances formed on 14 August near Lat. 12°N and Long. 135°E, and Lat. 12°N and Long. 117°E respectively. The first one, of these two, eventually intensified into a typhoon. It attained the maximum intensity on 19th when the estimated central pressure was as low as 890 mb while the pressure represented by the outermost closed isobar was 1000 mb. The China Sea disturbance had the lowest central pressure of about 980 mb on 18th and 19th. The pressure on the outermost closed isobar on these two days was 1000 mb. In contrast, the Bay disturbance under study was much less severe, its maximum depth (between the outermost closed isobar and the centre) being only about 12 mb on the 20th morning.

The Bay disturbance initially moved northwestwards and later recurved towards northnortheast (Fig. 1). It dissipated over the Kashmir Himalayas on the 26th. The Pacific disturbance initially moved northnorthwestwards and later took a northeasterly course. The China Sea one did not show much movement but it would appear from its short track, that it first moved northwestwards and then north-northeastwards. The information in respect of the disturbances in the Pacific Ocean and the China Sea has been collected from

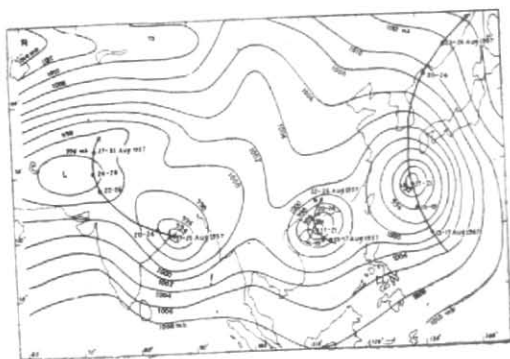


Fig. 1. Mean surface pressure pattern for 17-21 August 1957

● Position of the storm on mean charts

the daily charts published by the Vietnam Meteorological Service, Saigon. The 5-day mean patterns associated with the above two disturbances have also been to some extent studied along with those of the Bay disturbance to find out if any interesting features were present, which could be useful for forecasting purposes.

2. Preparation of the mean charts

In the U.S.A., medium range forecasts (for the next 5 days) for rainfall and temperatures are being issued with the help of 5-day mean charts. The American methods are primarily based on two distinctly different steps, namely, the (i) construction of mean prognostic charts from the actual mean charts and (ii) interpretation of the mean prognostic charts in terms of weather. If any close contemporaneous relationship is observed between the 5-day mean pressure patterns and the corresponding 5-day rainfall patterns, this relationship could be used by a forecaster in predicting the precipitation distribution when the future pressure pattern is once prognosticated by him.

For the preparation of a 5-day mean surface chart, pressure values at the central and corner points of different 5-degree latitude-longitude squares were determined by interpolation from the daily working charts for the 5-day period in question. The average pressure was then worked out for each of the above fixed

points and plotted there. As both the morning (03 GMT) and evening (12 GMT) observations have been used, the pressure at each point on a mean chart is thus the average of ten pressure values. The mean 700-mb charts have also been prepared in the same way by making use of the daily working 700-mb charts. The mean charts have been extended upto Long. 145°E to the east and upto Lat. 50°N to the north so as to cover the areas across which the typhoon moved. The mean pressure and contour data for areas outside the Indian sub-continent have been gathered from the mean northern hemisphere charts prepared by the Weather Bureau, U.S.A. As the data from American charts have been utilised, it has been necessary to select the same 5-day periods as used by the Weather Bureau. The Weather Bureau prepares extended range forecasts thrice a week and, therefore, there is an overlapping period of two or three days in their two successive mean charts.

3. Discussion of the mean charts

Mean charts have been prepared for the period 17-21, 20-24, 22-26 and 24-28 August during which heavy to very heavy rainfall occurred in various parts of the country. Of these charts, only the first and the last sets which are more interesting are presented here.

It is seen from the daily charts that all the three disturbances attained their maximum intensity during the period 17th-21st. The mean surface and 700-mb charts relating to this period are shown in Figs. 1 and 2 respectively. On the mean surface chart the three disturbances were located near Lat. 20°N, Long. 87°E; Lat. 20°N, Long. 112°E and Lat. 27°N, Long. 129°E respectively and appeared much less marked as compared to their intensity on daily charts. When averaging is applied to daily pressure values, the patterns usually tend to become more flat. The disturbances weakened further as they moved on and their positions on the subsequent mean

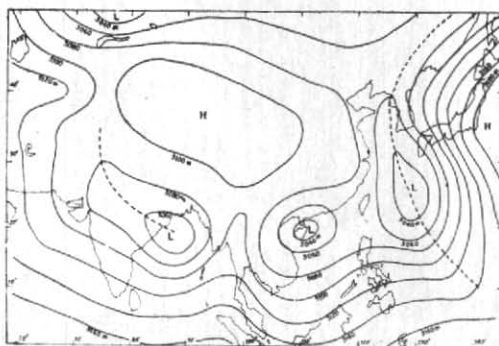


Fig. 2. 700-mb level mean contour pattern for 17-21 August 1957

--- Trough line

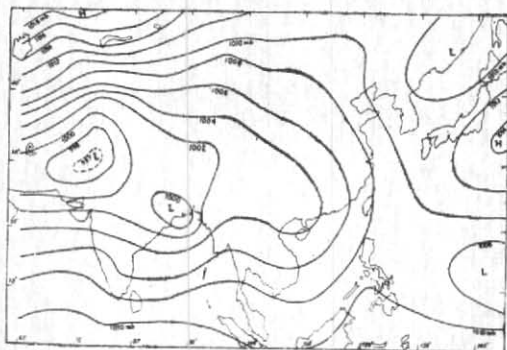


Fig. 3. Surface mean pressure pattern for 24-28 August 1957

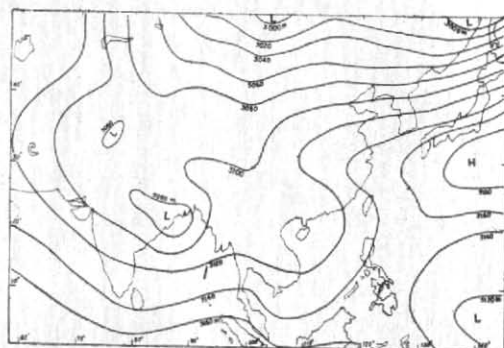


Fig. 4. 700-mb level mean contour pattern for 24-28 August 1957

surface charts are shown in Fig. 1 by solid dots. At 700-mb level (Fig. 2), the typhoon and the Bay storm lay more or less as extended lows and their trough lines roughly coincided with their tracks on the surface (Fig. 1). There was, however, no such extended pressure field at this level over the third disturbance and it died out without much movement. It would thus appear from the above disturbances that the trough line at higher levels gives some indication about the future movement of a storm.

The mean charts for the period 24th-28th when unusually heavy rainfall was reported from Kashmir are shown in Figs. 3 and 4. It will be seen that the China Sea disturbance had already filled up by this time and the other two also were dying out. The Bay disturbance lay over the south Punjab (P) at the surface and over Kashmir

at 700-mb level. The typhoon in the Pacific was moving away northeastwards across the Manchurian coast as a low pressure area. During the same 5-day period, unsettled conditions again appeared at the head of the Bay of Bengal and its neighbourhood and this feature was also reflected in the mean charts by the appearance of a low pressure area over and near that region. These unsettled conditions did not, however, concentrate into a storm or depression. The heavy rainfall in Kashmir apparently occurred under the combined influence of the Bay disturbance which lay over that area and the western disturbance which moved eastwards over Kazakhstan (Figs. 2 and 4).

It is also seen from the mean charts prepared for this study that the patterns (both surface and 700mb) associated with the

three disturbances exhibited good continuity—a feature which is very important in so far as the problem of prognostication of a future pattern from a given pattern is concerned.

From this study and also from another similar study (p. 239 of this issue) undertaken by the authors, it would however, appear that the mean 700-mb charts give better indications about the occurrence of rainfall and the movement of important pressure systems than the mean surface charts. For instance, the two moving storms under study followed tracks which almost coincided with the trough lines at 700-mb level (Fig. 2). During the period when Kashmir recorded exceptionally heavy rain, the Bay disturbance was located exactly over that area and a western disturbance was also moving eastwards through the extreme north (Fig. 4). On the mean surface chart for the same period, the Bay disturbance merged with the seasonal low and lay over the south Punjab (P). No western disturbance was present in this chart over the northern parts of the country. So it is rather difficult to explain the heavy rain in Kashmir on the basis of the mean surface charts. The mean 700-mb charts have therefore been selected below for some more detailed study in relation to the precipitation distribution.

4. Relationship between 5-day mean circulation at 700-mb level and 5-day precipitation

In his study for development of a technique for forecasting 5-day precipitation over the Tennessee valley, Klein (1949) used several parameters as measures of convergence on the mean charts at 10,000 ft level. Of these parameters, the following three have been tested in the present study in relation to precipitation: (i) curvature of contour lines, (ii) change in the curvature of contour lines and (iii) horizontal wind shear. The areas of convergence located on the mean 700-mb charts by using (i) and (ii) did not show any satisfactory agreement with the 5-day precipitation distribution. The third parameter has given some better

results. The horizontal wind shear patterns associated with the Bay storm, as obtained from the mean 700-mb charts, are presented in the note and compared with the 5-day rainfall patterns. Similar study in respect of the other two disturbances could not be carried out due to lack of the necessary rainfall data.

The horizontal wind shear at a given point O has been quantitatively determined from the mean 700-mb chart in the following way. The geostrophic wind values (V_F and V_E) at two points F and E lying at a distance of 1 degree latitude to the left and right respectively of the given point O (facing down stream) were first computed by using the *Smithsonian Meteorological Tables*. V_E was then subtracted from V_F and the difference divided by the distance between E and F. The above expression for wind shear, viz.,

$$\frac{V_F - V_E}{EF}$$

gives a positive value when the shear is anticyclonic and a negative value when the shear is cyclonic. Shear values have thus been computed for a number of points over the country, plotted and their isolines drawn. For the computation of wind shear, separate charts were used, in which the mean contour lines were drawn at an interval of 10 metres.

5. Discussion of the 5-day rainfall charts with reference to the wind shear charts and the storm track

The rainfall and wind shear charts for the various 5-day intervals during the heavy wet spell period 17th—28th are shown in Figs. 5(a) to 8(a) and Figs. 5(b) to 8(b) respectively. The track of the Bay storm as noticed on the mean charts is also shown in each rainfall diagram by a thick arrow.

Fig. 5 (a) shows that the heaviest rainfall over the plains during the period 0830 IST of 17th to 0830 IST of 22nd occurred in south east Madhya Pradesh which is located to the south or southwest of the storm track. It is also seen that the heavy falls were recorded in or near the places having high cyclonic wind shear—Fig. 5(b). The areas with anticyclonic wind shear were, on the other hand, generally

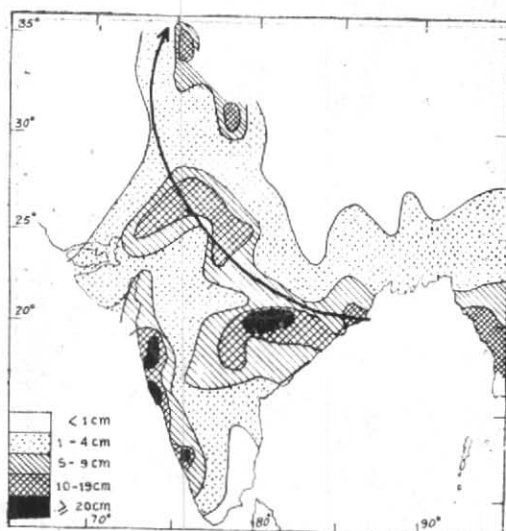


Fig. 5(a). Rainfall for 5 days from 0330 IST of 17 August 1957

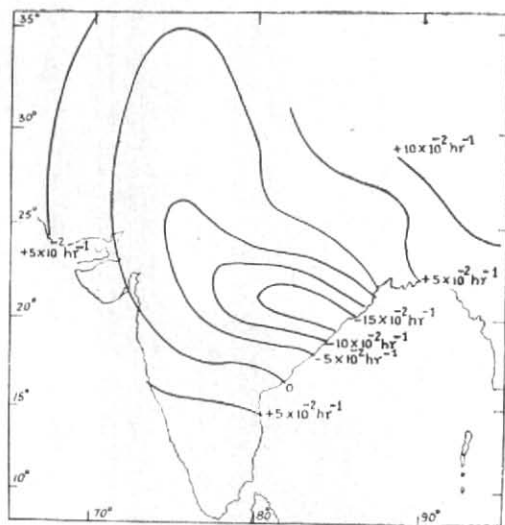


Fig. 5(b). 700-mb level horizontal wind shear pattern for 17-21 August 1957

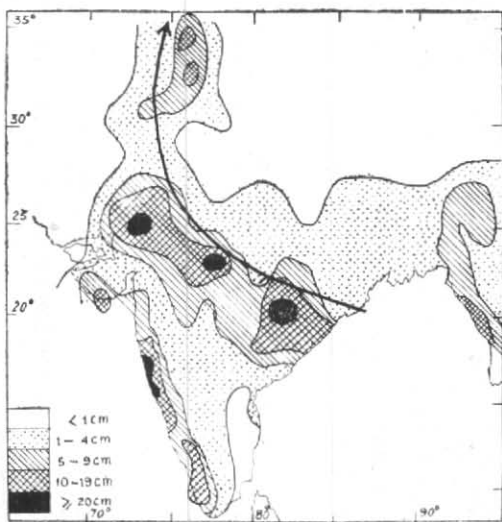


Fig. 6(a). Rainfall for 5 days from 0830 IST of 20 August 1957

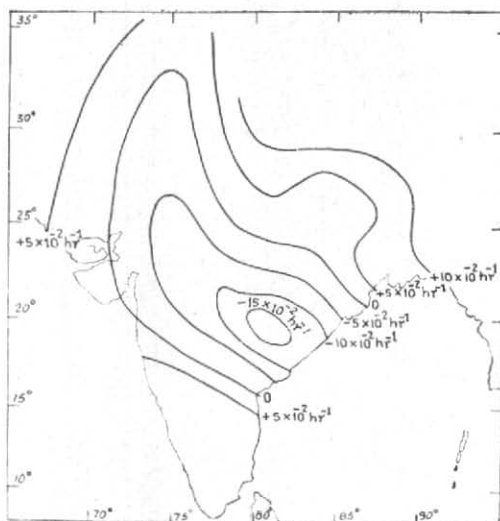


Fig. 6(b). 700-mb level horizontal wind shear pattern for 20-24 August 1957

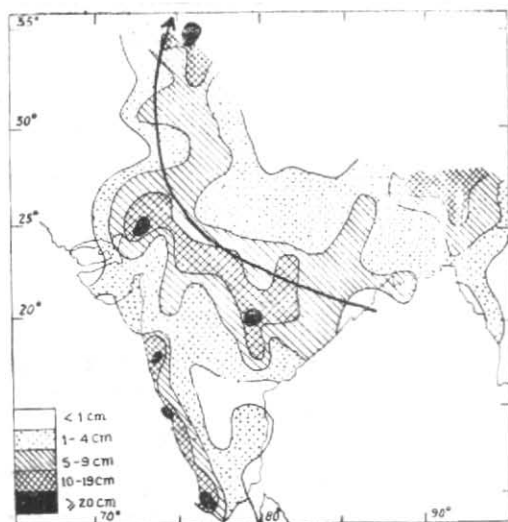


Fig. 7(a). Rainfall for 5 days from 0830 IST of 22 August 1957

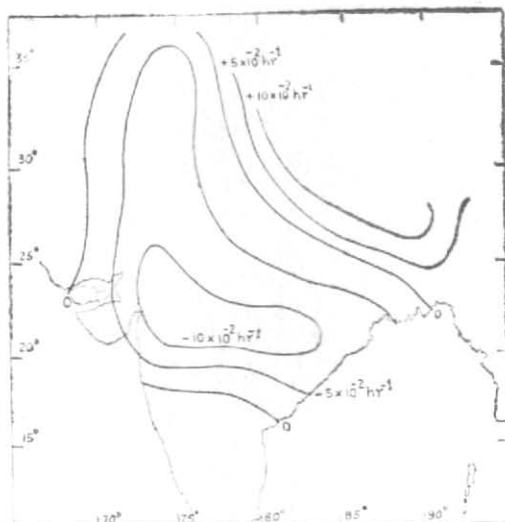


Fig. 7(b). 700-mb level horizontal wind shear pattern for 22-26 August 1957

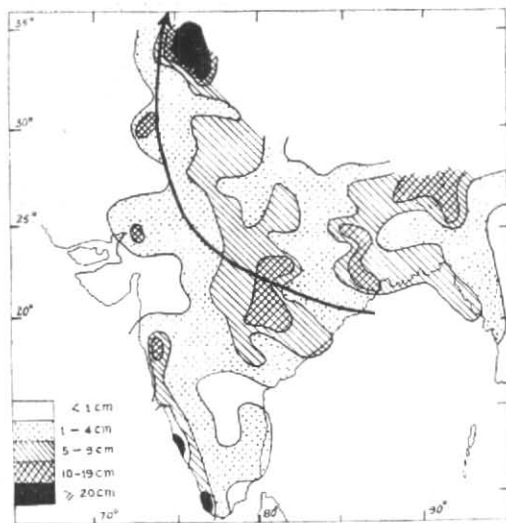


Fig. 8(a). Rainfall for 5 days from 0830 IST of 24 August 1957

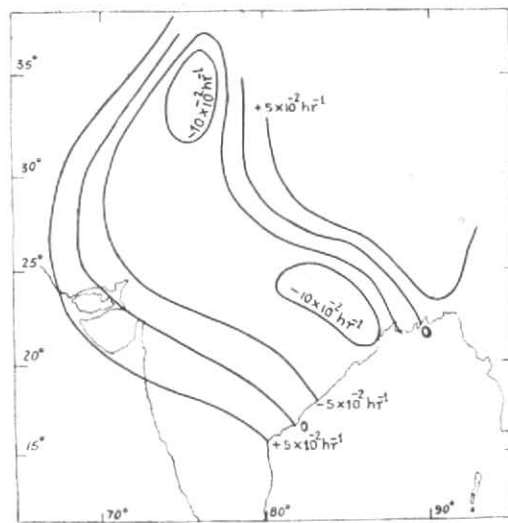


Fig. 8(b). 700-mb level horizontal wind shear pattern for 24-28 August 1957

marked with little or no rainfall. Similar features are also noticed in the charts for the periods 20th—24th and 22nd—26th. The heavy rainfall in Assam and along the West Coast in the above charts was, of course, chiefly due to orography.

During the period 24th—28th, the disturbance weakened considerably and lay over north Punjab (P) and its neighbourhood. The rainfall decreased appreciably over the country except in Jammu and Kashmir. Due to the low pressure area over the head of the Bay extending upto northeast Madhya Pradesh, the general rainfall distribution over the country shifted somewhat northwards. In this case, the heavy rainfall in southeast Madhya Pradesh occurred without high cyclonic wind shear. Otherwise, there was in general a fair agreement between the wind shear and the rainfall distribution. During the above period, there was a marked increase in the values of cyclonic wind shear over

Kashmir and heavy to very heavy rain was recorded there.

The workers in the U.S.A. have observed that the heaviest 5-day precipitation commonly occurs along the mean storm path which prevailed during the 5-day period. From the present study it is seen that when the storm was moving across the coast and the central parts of the country, the heaviest 5-day precipitation occurred somewhat to the south or southwest of the track. However, when it was moving through the extreme north of the country, the heaviest fall occurred on the eastern side of the track. The heavy rain was generally recorded in or near the regions having high cyclonic wind shear.

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