Indian J. Met. Geophys. (1974), 25, 2, 239-2244

551.577.2 : 551.585.3(543)

A study of hourly rainfall distribution around monsoon depression centre in central India

K. S. VENKATARAMAN, A. CHOWDHURY and A. K. BANERJEE

Regional Meteorological Centre, Nagpur

(*Received 20 April 1972*)

ABSTRACT. Average distribution of rainfall around the centre of monsoon depression in separate intervals of six hours in central India is presented and discussed in this paper.

It is observed that the area around the first 100 km of the depression centre is generally free from intense rainfall activities. Heavy rainfall belt is mostly confined to the left forward quadrants of the depression field. Rainfall is almost widespread in these quadrants in the third and fourth six-hour intervals, reckoned with 03 GMT. Hourly intensities of rainfall greater than 50 mm/hr are, however, more frequent during the first 6-hr interval.

1. Introduction

About 80 to 90 per cent of the annual rainfall in central parts of India occur during the summer monsoon. Out of this, a major portion occurs in association with monsoon depressions. For issue of timely warnings for heavy rainfall associated with the monsoon depressions and other short range forecasts, the necessity of knowing the climatological character of rainfall distribution around these systems is felt. From the results of previous studies on the subject, it is known that copious rain with heavy to very heavy falls in a 24-hr period has greater tendency to occur in the southwest quadrant of the depression field than in any other quadrant. Pisharoty and Asnani (1957) with the help of composite charts corroborated the above findings and also suggested a method of forecasting heavy rainfall areas in the depression field in an objective manner. Utilising more extensive data, Bedekar and Banerjee (1969) confirmed the above results. They also prepared a nomogram which can be used directly with the W_3 surface chart to forecast the possible regions of heavy rainfall around the depression centre for a 24-hr period.

With the establishment of various flood forecasting centres in the country and other river-valley projects, there has been an increasing demand for forecasts of rainfall and its intensity for shorter periods. To cater to such requirements a knowledge of the climatological character of the distribution of hourly rainfall around depression centres and other rain producing systems is necessary. With this view, the network of self recording raingauges have been augmented in the country in recent years. The existing network of raingauge stations in Madhya Pradesh and Vidarbha is shown in Fig. 1.

2. Physical features

The region under study consists of the State of Madhya Pradesh and Vidarbha (Maharashtra) which is generally plain area with elevations less than 300 m a.s.l. The hill ranges of Vindhya and Satpura run east to west across the region and in the hilly tracks the individual peaks are between 1000 to 1500 m a. s. l. The two main river systems in the region are *Narmada* and *Tapti*, both flowing east-west into the Arabian Sea.

3. Data collection

In 1967 there were 17 self recording (S.R.) raingauge stations in the region under study. These increased to 23 in 1968, 28 in 1969 and 36 in 1970, as shown in Fig. 1. For the purpose of the present study, monsoon depressions which followed the normal west to northwesterly tracks across the region during 1967 to 1970 were selected. Data for 33 depression days pertaining to 11 such depressions were tabulated. In general, the central pressure defect of the selected depressions was between 4 and 8 mb.

Fig. 1

Locations of self-recording raingauge stations in M.P. & Vidarbha as in 1970

4. Analysis of data

The following analytical procedure was adopted for tabulating the data :

The position of the depression at 03 GMT (0830 IST) from the day it started affecting the region were determined from the corresponding surface charts. The direction (in degrees) and distance (in km) of each of the S.R. raingauge stations (shown in Fig. 1) with respect to the depression centre were then found out. The heavy rainfall values in the 24-hr period succeeding 03 GMT were noted from the hyetograms of the stations. The above procedure was repeated for a number of days till the depression recurved or moved out of the region or became unimportant. The depression field around the centre was divided into 12 sectors of 30° each from the north and 8 equal distance-ranges of 100 km each from the centre, except for the first distance range from the centre which was sub-divided into two, each of 50 km width.

Knowing the positions of S.R. raingauge stations with respect to the depression centre at 03 GMT the annular zones in which they fell were determined. The hourly rainfall data of a station for a period of 24-hr commencing from 03 GMT were considered as pertaining to that annular zone in which it was situated at the above hour with reference to the depression centre. In this way hourly rainfall figures in respect of each annular zone in the depression field were extracted for 33 depression days from the hyetograms of the raingauge stations and parameters of six hourly rainfall averages, highest hourly fall in six-hour intervals etc for each zone were suitably plotted on polar diagrams for study.

5. Discussions

(a) *Six hourly rainfall averages*

The distribution of rainfall averages for the four 6-hr intervals in different zones around the depression centre, the zero hour being reckoned with 03 GMT are presented in Fig. 2. As may be seen from these figures, heavier amounts of rain invariably occur in the left forward sectors of the depression. Further in the first 6-hr interval (Fig. 2 a) the 10 mm isopleth lies between 240° to 300° and covers a range of 100 to 500 km from the depression centre. Within the 10 mm isopleth, in the sector 240° to 270° and range 200 to 300 km, the 20 mm isopleth is located. Rainfall in the first 100 km of the depression centre is generally less than 10 mm in the first 6-hr period.

In the next 6-hr interval (Fig. 2 b) the 10 mm considerably expands and now lies between 210° to 300° and the distance range of 100 to 700 km from the centre. There is a corresponding increase in the area occupied by 20 mm isopleth. The next two higher isopleths, namely, 30 and 40 mm are observed within 20 mm isopleth, the latter isopleth virtually replacing the 20 mm isopleth in the first six-hour interval.

Isolated 10 mm isopleth cells are observed towards south and northwest of depression centre but far removed from it. As in the first 6-hr interval, the rainfall within 100 km around the centre is less than 10 mm.

During the third 6-hour interval (13 to 18 hr the 10, 20, 30 and 40 mm isopleths, occupy wider areas (Fig. 2 c), the expansion of each of these isopleths occurring west of the centre of depression. Thus, the 10 mm isopleth streches from south-southwest to northwest of the centre and extends right upto 800 km whereas the 20 mm isopleth moves upto 700 km. Further, within the 20 mm isopleth, the next higher isopleths of 30 and 40 mm appear in the ranges 100 to 600 km and 200 to 500 km respectively. For the first time, a 50 mm isopleth is seen during this interval, lying between 240° to 270° in the distance range of 200 to 4 00 km. It is interesting to note that isopleths higher than 10 mm, are approximately symmetrical about 270° azimuth.

Scattered isopleths of 10 mm continue to appear in other sectors away from the centre.

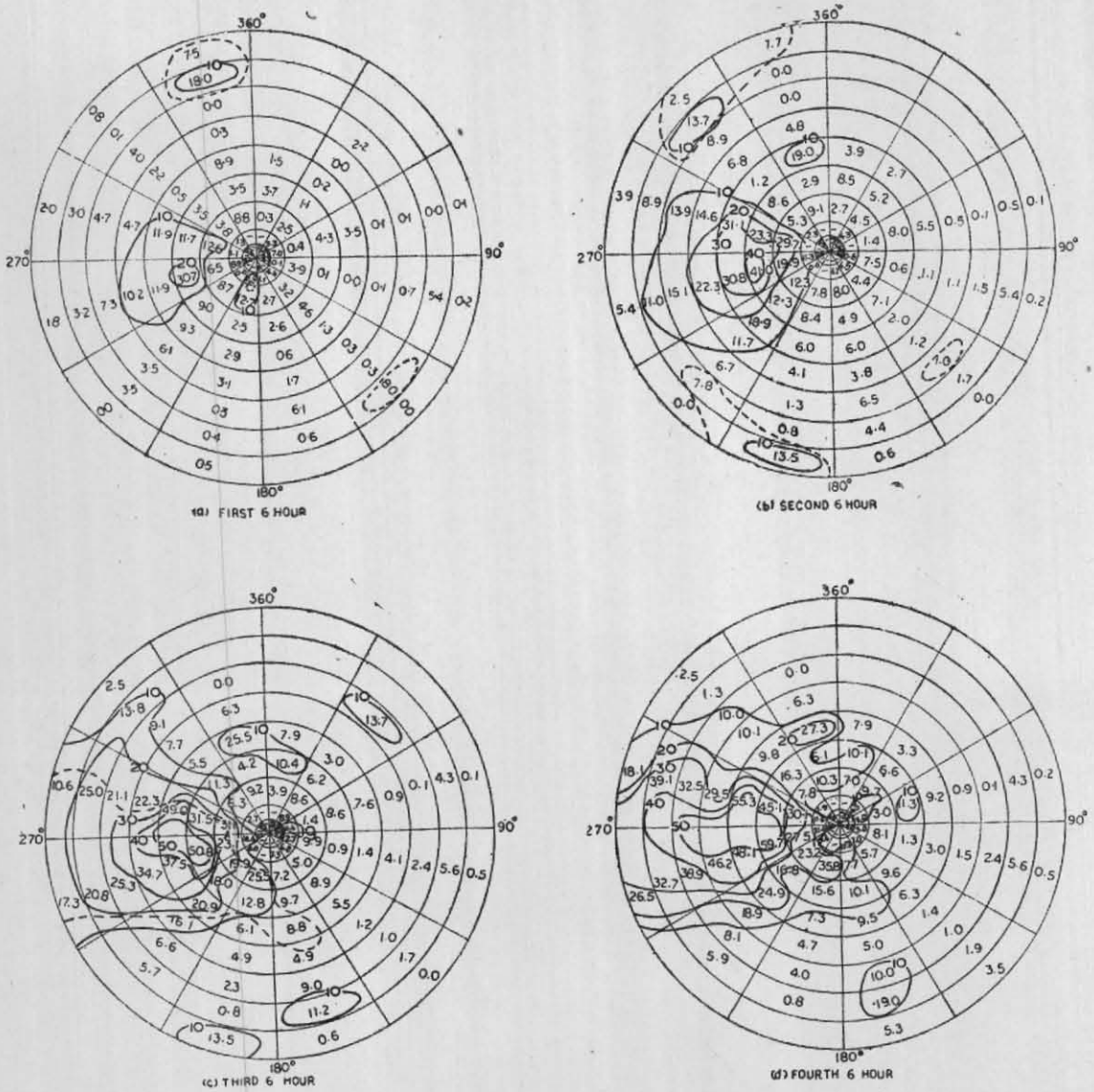

Fig. 2

Distribution of average rainfall (mm) in different zones around the depression in 6-hr intervals
The dotted line covers the area where rainfall was 30% of the total rainfall in 24 hr

The rainfall activity during the last 6-hr interval (19 to 24 hr) appears to be at its peak. The 10 mm isopleth now spreads from 150° to 30° through 270° (Fig. 2 d). The other isopleths of the preceding interval, also show areal expansion towards west. The 20 and 30 mm isopleths now, each extends upto 800 km and enclose 40 to 50 mm isopleths. The latter isopleths lie between 240 and 300° and respectively spread over 200 to 700 km and 200 to 600 km distance ranges. Moveover, the symmetrical alignment of the isopleths, as seen in the 13 to 18-hr interval, is also seen in the last interval. Scattered isopleths of 10 mm continue to be observed during this interval.

During the last two 6-hr intervals, as in the case of first two intervals, the rainfall is generally less than 10 mm within 100 km around the centre.

(b) *Highest hourly rainfall*

The distribution of highest hourly rainfall in the four 6-hr intervals is presented in Fig. 3.

In the first 6-hr interval, it may be seen that the isopleths of highest hourly rainfall having values between 20 to 80 mm are heavily packed within 240° and 300° and distance ranging from 100 to 700 km from the centre (Fig. 3 a). An exceptionally high rainfall amount of 89 mm/hr is seen in the

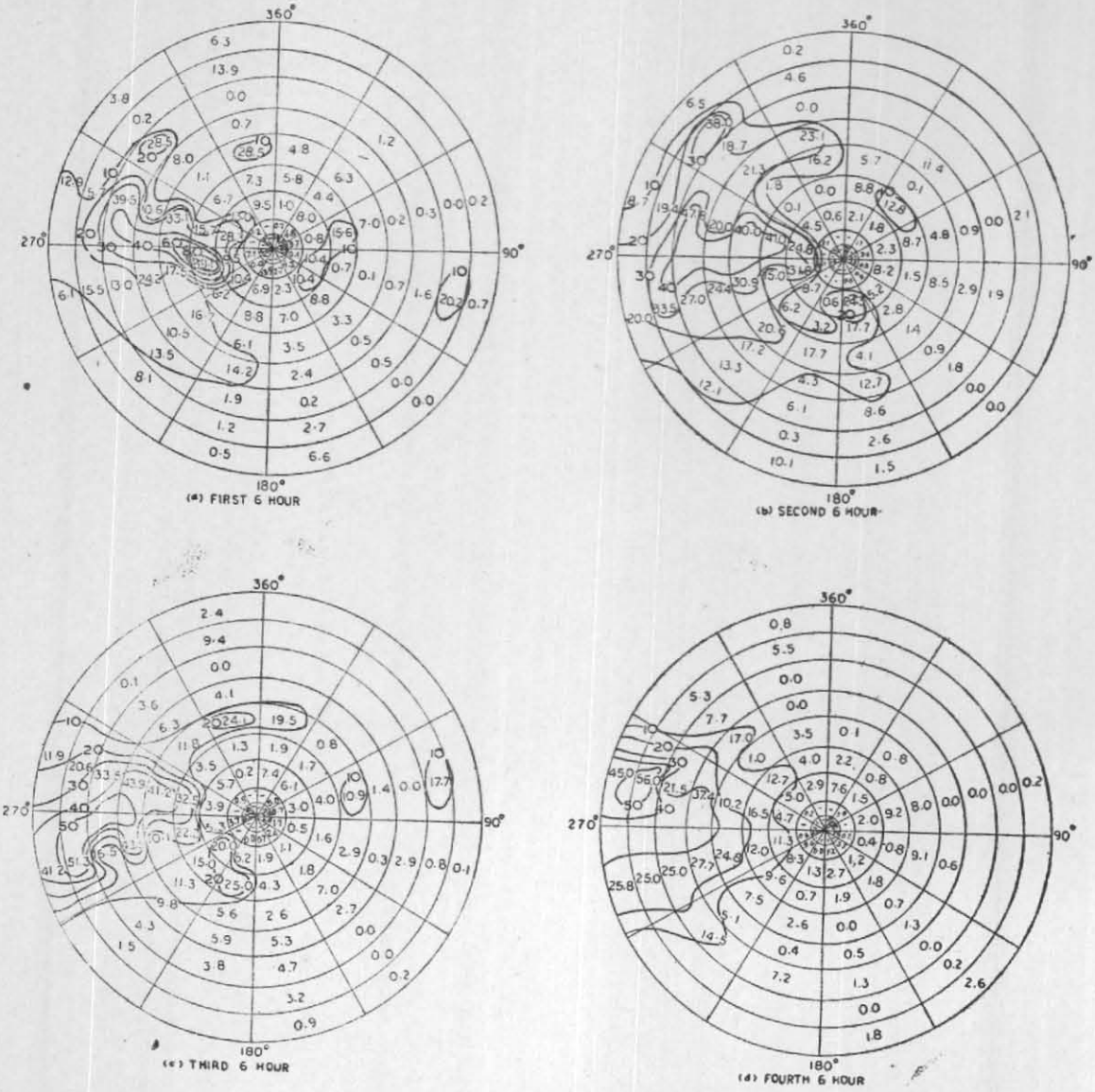

Fig. 3

Distribution of highest hourly rainfall (mm) around the depression in 6-hr intervals

annular zone lying between 240° to 270° and 200 to 300 km distance range.

During the subsequent interval (Fig. 3 b) the isopleths expands considerably. However, the highest isopleth now is of 40 mm occupying the 240-300°/200-600 km space. The heaviest hourly intensity of 48 mm occurs in the annular zone 270 to 300° and 500 to 600 km from the centre.

In the third 6-hr interval (13 to 18 hr) the isopleths show tending to shift westwards away from the centre (Fig. 3 c). Further, in general, the isopleths from 20 to 50 mm are all concentrated within 240° to 300° and 200 to 800 km distance range. The highest intensity is of 51 mm/hr in the 240-270° and 600-700 km annular zone.

The isopleths in the last interval (Fig. 3 d) though occupy smaller areas compared to the preceding intervals, appear to be more organised. The steep gradient observed in the first 3 intervals appears to be broken. However, the movement of isopleths towards west is quite noteworthy in this last 6-hr interval. The highest rainfall intensity is 50 mm/hr occurring within 270-300°/600 to 700 km from the centre of depression.

(c) *Percentage of total rainfall in 24 hours*

The percentage of 24-hr rainfall in each of the 6-hr period has been worked out. For the sake of clarity only the configuration of 30 per cent isoline has been shown in Fig. 2 (a, b and c). The conspicuous absence of this line during the first two intervals is striking. It can also be seen that the area covered by the 30 per cent isoline appears prominently during the third six-hour interval (Fig. 2 c) and by the fourth interval (figure not shown), it was observed to cover the whole area in

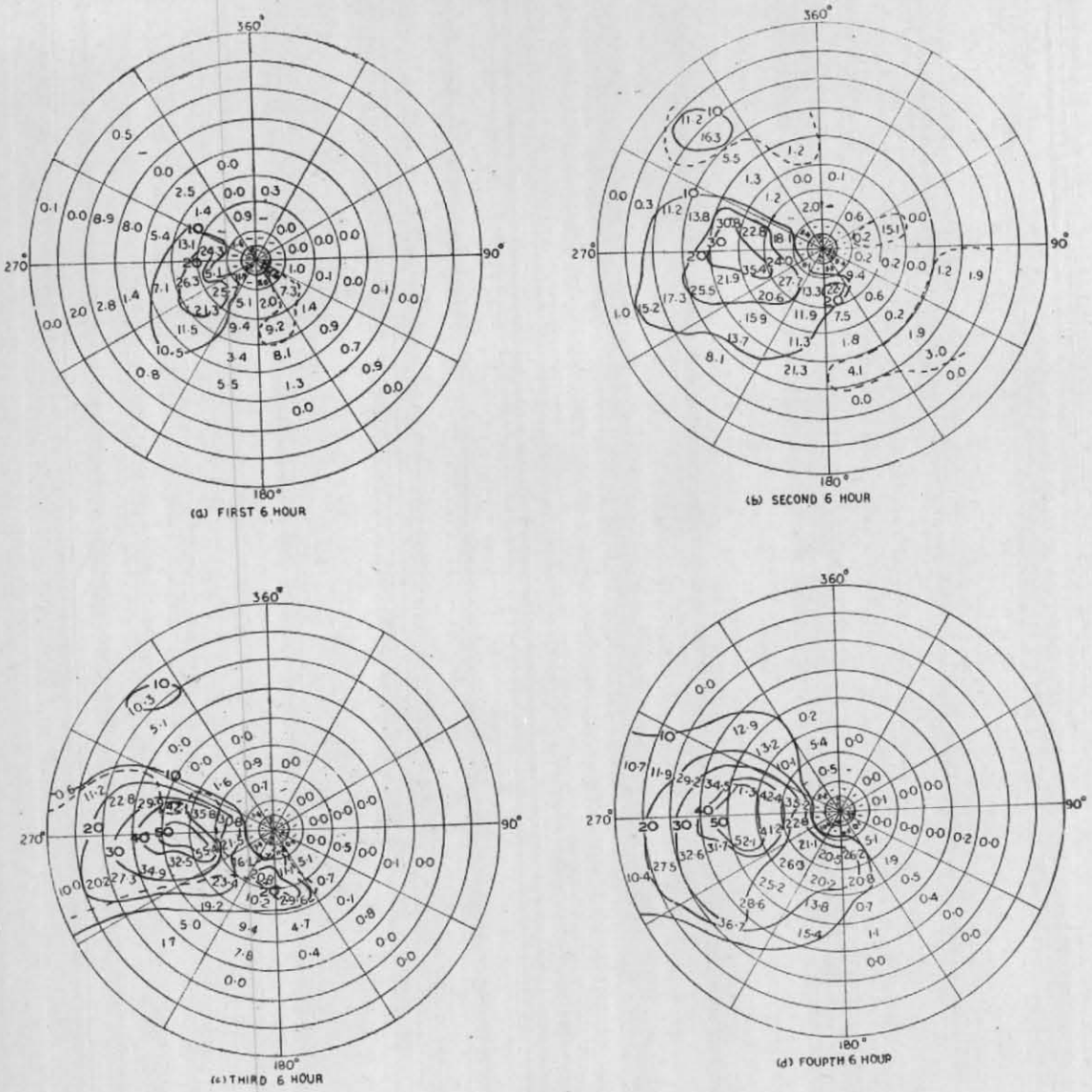

Fig. 4

Distribution of average rainfall (mm) in 6-hr intervals. The dotted lines cover the area where rainfall was 30% of the total rainfall in 24 hr

the depression field. This also corroborates the findings stated earlier that rainfall of higher amount extends over the fields of depression between 13 to 24 hr period.

6. Illustrative example

A depression which formed in the head Bay on 12 August 1972 moved westnorthwest across the region. The data from 14 to 18 August 1972, when it was affecting the area under study was compiled and analysed. This case has been discussed and depicted in brief below.

(a) *Six hourly average and percentage of 24-hr rainfall*

During the first six hours, the highest isopleth of 20 mm cover annular space in 210-270° at distance ranging from 200-300 km from the centre (Fig 4a). In the next three 6-hr interval (Figs. 4 b to 4 d), the highest isopleths are of 30, 50 and 50 mm all lying in the 240-300° azimuthal zone, at distances ranging from 200-400 km in the case of second and third intervals and 300-500 km during the concluding 6-hr interval.

The percentage of 24-hr rainfall, indicated in Fig. 4(a, b and c) shows that the 30 per cent or more falls occur in western sectors by the third interval (Fig. 4 c). During the fourth interval (figure not shown) generally the whole area in the field of depression gets 30 per cent or more of the 24-hr rainfall.

(b) *Highest hourly rainfall*

Fig. 5 depicts the highest hourly rainfall observed in the case study during the four 6-hr interval.

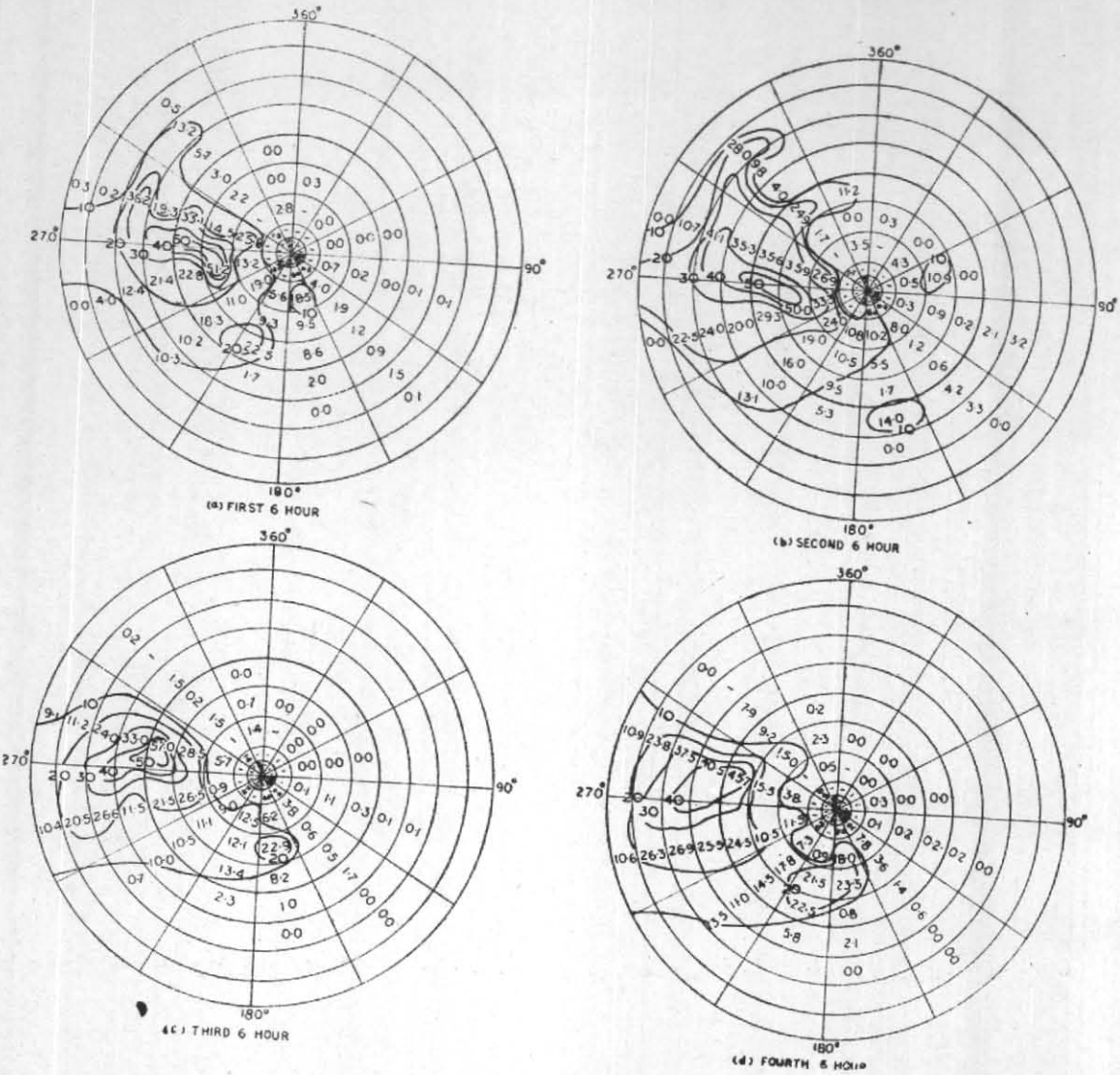

Fig. 5

Distribution of highest hourly rainfall (mm) in 6-hr intervals

In the first two intervals the highest isopleth is of 50 mm/hr each lying within the zone 240-300° and between 200-400 km from centre while in remaining two intervals the highest isopleths are of 50 and 40 mm respectively but have shifted slightly westwards and both lie in 270-300° annular space within the distance range of 300 to 400 km from the centre.

7. Conclusions

(*i*) An area around 100 km from the depression centre is generally free from intense rainfall activity.

(*ii*) The heavy rainfall belt is invariably confined to the left forward sector of the depression.

(*iii*) In the break up of 24-hr rainfall, greater percentage of rainfall occurs in the fourth 6-hr interval (19 to 24 hr). Higher amounts of rainfall (>10 mm) also extend over wider areas in this interval.

(*iv*) Higher hourly rainfall tend to progressively shift westwards from first to the fourth 6-hr interval.

Acknowledgements

The authors are thankful to Sharvashree A. D. Kelkar, S. M. Pardhi and P. D. Vaidya for collecting data and typing.

REFERENCES

Bedekar, V. C. and Banerjee, A. K. 1969 *Indian J. Met. Geophys.*, 20, 1, pp. 23 29.

Pisharoty, P. R. and Asnani, G. C. 1957 *Ibid*, 8, 1, p. 15.