

Unusual formation and movement of a deep depression over Rajasthan during the monsoon season

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(Received 11 October 1973)

ABSTRACT. An unusual formation and intensification of a monsoon depression over Rajasthan is discussed. The upper air advection of positive vorticity in association with troughs in easterlies and westerlies over a pre-existing sea level system is found to be responsible for deepening. The uncommon southerly/south-easterly movement of the system is also explained.

1. Introduction

In this paper a very unusual formation and movement of a monsoon depression have been discussed. The study was undertaken as this depression caused widespread rains leading to floods over south Rajasthan.

The important feature is that it caused fairly widespread to widespread rains over west Rajasthan for a continuous period of 6 days which is unusual, the reason being that the system lay either as a depression or a deep one over west Rajasthan during the whole period (15-18 August 1973). As normally depressions, even when they affect west Rajasthan, move away westnorth-westwards and merge with the seasonal low, the occurrence of widespread rainfall with some very heavy falls for such a long duration is rather unknown. It is the stationary nature of this depression and the unusual southeastward movement which was responsible for such a phenomenon leading to widespread floods in south Rajasthan. In fact Jaisalmer had an all time record rainfall of 20.4 cm on 16 August, which is higher than its annual normal. Other noteworthy rainfall amounts were : Barmer 23 cm on 18th; Jalore 17 cm on 19th and 11 cm on 15 th. Further, it is of interest to note that the cumulative rainfall for the period 14-19 August 1973 for most of the stations in southwest Rajasthan is more than their annual normal. Table 1 gives the actual rainfall, normal for the period, percentage excess and the annual rainfall in respect of stations in southwest Rajasthan.

According to press reports heavy rains and strong winds lashed all parts of arid Jaisalmer and Barmer districts continuously for more than 60 hours during this period. Such rainfall was unprecedented in living memory. There were

widespread floods marooning hundreds of villages for days together in south Rajasthan. All tanks, ponds, lakes, wells, dams and reservoirs were full to the brim and many overflowing. Several old people in the age group of 80-100 years remarked that they had neither heard nor experienced such a heavy rainfall in their life-time. The great Indian Thar desert which covers about 50 per cent of total area of Rajasthan had been completely transformed into a green carpet as a result of this heavy rainfall. Even though the floods caused immense suffering to the local population, people of Rajasthan as a whole were jubilant because of the excellent prospects of bumper crops which will fully meet their requirements for next 2-3 years.

2. Synoptic situation

On the evening of 12 August 1973, an upper air cyclonic circulation between 1.5 and 4.5 km a.s.l. developed over central parts of Uttar Pradesh. On 13th morning it intensified into a well marked low with circulation upto 500 mb over southwest Uttar Pradesh with central region about 100 km southwest of Agra. It moved in a westerly direction till 14th, then westnorthwestwards and concentrated into a depression which lay on 15th morning about 100 km northwest of Phalodi. It then moved southwards and lay as a depression with its centre about 100 km southeast of Jaisalmer till 17th morning when it further intensified into a deep depression.

From this day onwards it started moving east-southeastwards and lay on the 18th morning about 50 km west of Jodhpur. It further moved east-southeastwards and on the same evening, its centre was located about 50 km south of Jodhpur. Thereafter, it rapidly weakened and lay as a low over

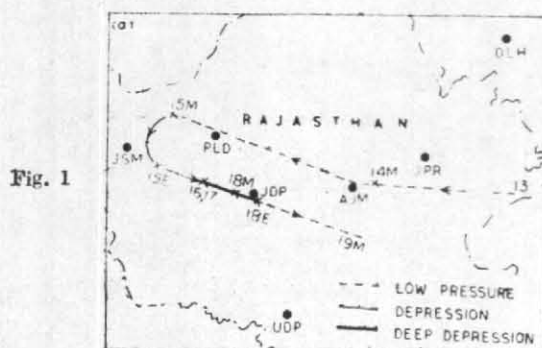


Fig. 1

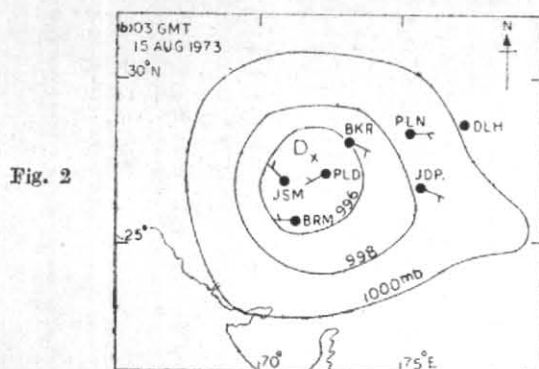


Fig. 2

Fig. 1. Track of depression between 13 and 19 August 1973

Fig. 2. 03 GMT sea level chart of 15 August 1973

TABLE 1

Rainfall in southwest Rajasthan during 14-19 August 1973

Station	Rainfall (mm)			Percentage of excess	Annual normal (cm)
	Total	Normal	Excess		
Barmer	328.9	32.5	296.4	912	31
Jaisalmer	267.9	7.3	260.6	370	20
Jalore	443.7	21.5	422.2	1964	36
Jodhpur	218.9	20.8	198.1	952	37
Nagpur	82.0	21.8	60.2	276	25

southeast Rajasthan and finally merged with the seasonal trough on 20th. The track of the depression is given in Fig. 1.

3. Discussion

The interesting feature about this depression is that it concentrated over Rajasthan where normally depressions tend to weaken and fill up. Its further concentration into a deep depression also occurred over west Rajasthan. This is a very rare phenomenon. An examination of the last 25 years records indicated that there was only

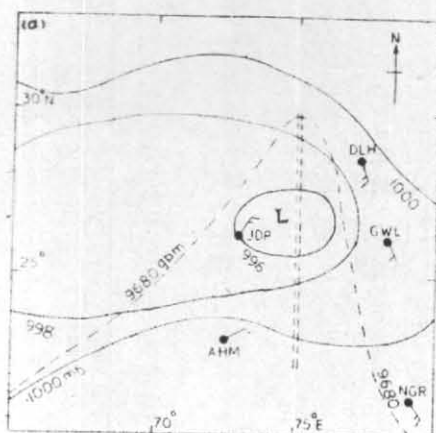


Fig. 3

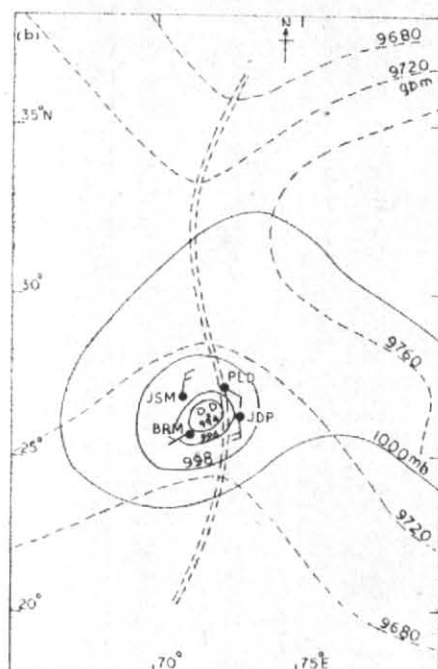


Fig. 4

Fig. 3. 03 GMT sea level isobars of 14 Aug 1973 with 300 mb contours (dotted lines) at 00 GMT. Plotted winds and trough (double dotted lines) are at 300 mb.

Fig. 4. 03 GMT sea level isobars of 17 Aug 1973 with 300 mb contours (dotted lines) at 12 GMT of 16 Aug. Plotted winds are at surface and trough at 300 mb.

one instance of a deep depression over west Rajasthan in 1961 which had its origin over the Bay and moved westnorthwestwards without weakening. But there was no case where such intensification took place over west Rajasthan.

The concentration of the low pressure area into a depression on 15th can be clearly seen from the 03 GMT sea level chart (Fig. 2). There were closed isobars on the sea level chart and the pressure departure was -6 to -7 mb. The associated cyclonic circulation was seen extending upto

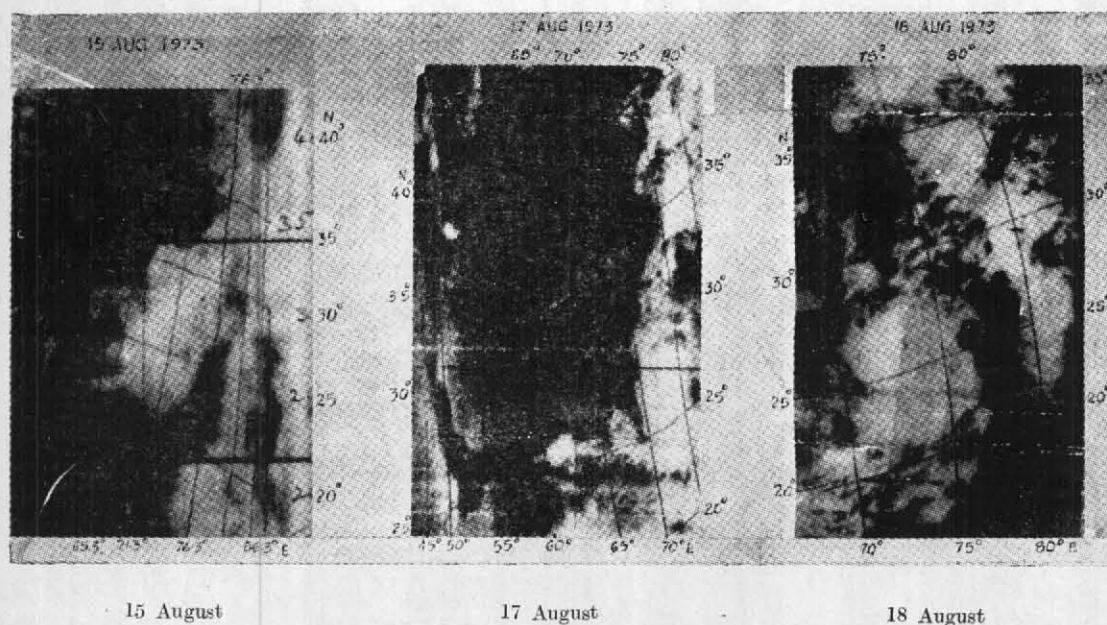


Fig. 5. Satellite pictures

5.8 km. In order to examine the reasons for this concentration over land, the upper air features have been studied. A well marked trough in the easterlies at 300 mb lay on 14th along Long. 75°E between 23°N and 30°N (Fig. 3). (The easterly trough was not present earlier). In the same figure, the sea level pattern of 14th is also depicted. It can be seen from Fig. 3 that the easterly trough was superimposed over a sea level system, namely, a well marked low pressure area. The low level convergence due to this well marked low coupled with the pre-existing pronounced instability and moisture content in the area, as evinced from the Jodhpur $T-\phi$ gram of 14th at 00 GMT (not presented) were responsible for the intensification of the sea level system into a depression.

Even though the depression moved as much west as 100 km northwest of Phalodi, its further westward movement was arrested due to the presence of a westerly wave trough at 300 mb along 72°E , north of 30°N on 16th. This is in agreement with the findings of Pisharoty and Desai (1956) that depressions lose their westward component of motion when they come under the influence of an upper westerly trough. The easterly trough which was along 75°E on 14th moved westwards and also lay along 72°E on 16th. Thus the easterly and the westerly troughs were in phase roughly along 72°E and the depression was also centred on 72°E (Fig. 4). The combined effect of these two troughs was responsible for the further intensification of the depression to a deep one. That the depression intensified into a deep one is evidenced by the 3 closed isobars

on 03 GMT sea level chart of 17th. Also the surface and the lower level winds of Jodhpur strengthened from 12 GMT of 16th to 00 GMT of 17th.

The satellite pictures of 15th, 17th and 18th (Fig. 5) corroborate to the intensification of the low into a depression on 15 August and the depression into a deep one on 17th and 18th.

Koteswaram and George (1958) referred to cases of cyclonic development and formation of depressions in association with easterly troughs at higher levels. They also envisaged intensification of depressions under influence of in-phase superposition of wave troughs. In the present case also, while the deepening of the low pressure area into a depression was due to an upper easterly trough, the further deepening into a deep depression was the result of the interaction between the westerly and easterly wave troughs being in juxtaposition along 72°E . Such interaction has also been reported by Sen Gupta (1971) in connection with the formation of a depression near Patna.

From Figs. 2 and 4 it is clear that the depression moved south. Its further movement southwards is clear from the vertical time-section of Jodhpur (Fig. 6). It can be seen that the surface as well as the upper winds upto 3.1 km backed from southwesterly to northerly through southerlies.

The intensification of the system over Rajasthan can well be explained by the positive vorticity advection in association with troughs (easterly

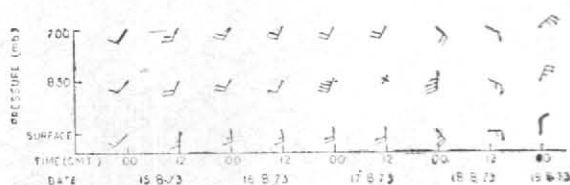


Fig 6
Vertical time-section of Jodhapur

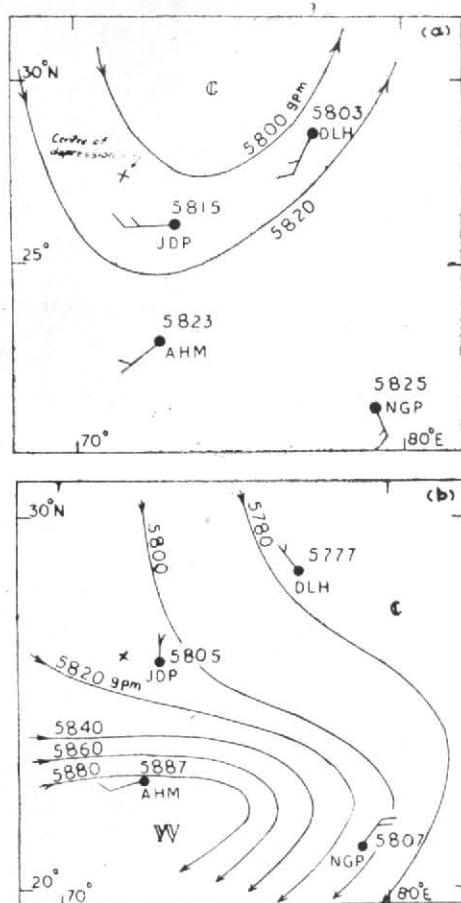


Fig. 7

1000-5000 mb thickness charts at 12 GMT of (a) 15 August 1973 and (b) 17 August 1973—Centre of depression

and westerly) at 300 mb. Further, the intensification is in association with troughs at 300 mb only as there were no well marked troughs at 200 mb. Desai and Rao (1954) have mentioned that any level between 500 and 200 mb can be used for both the intensification and direction of movement of tropical cyclones. In the present case, the 300 mb flow pattern was mainly responsible for the intensification.

According to Sutcliff's development technique "depressions and anticyclones are steered by the thickness lines which pass over their centres" (Gordon 1962). Petterssen (1956) says "to some considerable extent the movement of mid-latitude cyclones and anticyclones are guided in the direction of the thermal winds in the middle troposphere, and it has been customary to say that these pressure configurations are steered by the thermal wind aloft".

Accordingly, in order to explain the unusual southerly/southeasterly movement of the depression after 15th, the 1000-500 mb thickness charts have been prepared and analysed using the thermal winds. Fig. 7 representing the thickness patterns along with thermal winds of 15th and 17th at 1200 GMT explain broadly the southerly/southeasterly movement of the depression in accordance with the above premises as illustrated by George (1953) earlier.

4. Conclusion

From the study it is seen that cyclogenesis over land is possible under favourable upper air support in the form of advection of positive vorticity superimposed on a surface system. Similar mechanism was found responsible by Petterssen (1955) for the cyclogenesis in extra-tropical regions. The movement of the depression southward/southeastwards was broadly along the thickness lines which is found to be true for the mid-latitude cyclones.

Acknowledgement

The authors wish to thank Shri Shiv Dayal for the preparation of diagrams and Shri Satish Kumar Sabharwal for typing the manuscript.

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