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Onset of Monsoon over India

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ABSTRACT. The large-scale changes in the 5-day mean 700-mb contour pattern associated with the onset of monsoon rains over different parts of the country are located with the help of charts for the period 1957-1962.

The onset of monsoon over India and adjoining seas south of 15°N is associated with the disappearance of the premonsoon 'High' over central parts of the country and the formation of the monsoon trough near 90°E at the 700-mb level. The formation of the monsoon low with the major axis in an east-west direction near about 20°N heralds the establishment of the monsoon over the entire country. Simultaneously the Pacific 'High' shifts northwards.

It is also noticed that the extension of rains over central parts of the country is associated with the disappearance of the anticyclonic curvature in the 700-mb contour pattern over the region. In those years in which the monsoon gradually extends westwards over north India, such an extension is associated with the gradual shift westwards of the monsoon trough.

1. Introduction

Monsoon rains are of paramount importance to agriculture in India and the economy of the country is very closely linked up with them. Advance information about onset, breaks and withdrawal of the monsoon and its activity during any particular period will be very helpful to the farmers. At present weather forecasts valid up to 36 hours duration only are issued by the India Meteorological Department. But for planning agricultural operations, the notice given to the farmers by such forecasts is not adequate. There is, therefore, a need for medium range weather forecasts with periods of validity ranging up to about a week.

The basis of any method of medium range forecasting is the existence of large scale pressure systems which have an influence on weather over the region and whose period of evolution is about a week. The first stage in developing methods of medium range forecasting is, therefore, to discover such large scale pressure systems.

Most of the studies so far made regarding the onset of monsoon over India (Bhullar 1952 and Ramdas *et al.* 1954) and the normal dates of onset of monsoon (India met. Dep. 1943) are all based on rainfall data only. Identifying the monsoon by the rainfall it causes is not satisfactory, especially in regions where the amount of rain caused by the pre-monsoon thunderstorm activity is comparable with the monsoon rainfall. Pant and Vernekar (1963) studied the characteristics of monsoon air and evolved some objective criteria for identifying the onset of monsoon over individual stations. Among the few synoptic studies made of the onset of monsoon, is that of Yin (1949) in which he associated the onset of monsoon during 1946 with (*i*) the movement westwards of a low latitude trough from 90°E to 80°E and (*ii*) the northward displacement of the low latitude westerly jet. But he did not deal in detail with the relation of the changes in large scale circulation with gradual onset of monsoon rain over different parts of India. The purpose of the present paper is to present results of such a detailed study conducted with the help of 5-day mean charts for a period of six years.

2. Data and charts utilised

The following charts were utilised in the study—

(*i*) 5-day mean 700-mb contour charts for the years 1957-1962.

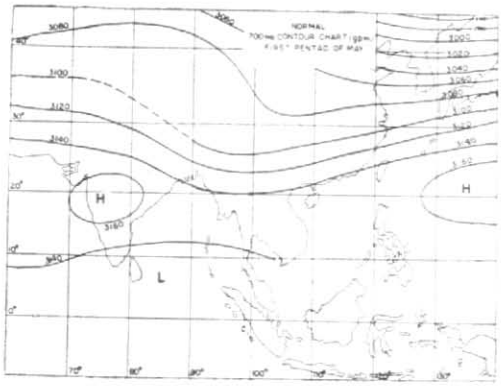

Fig. 1

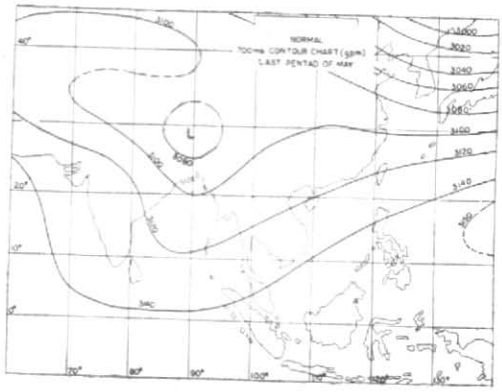

Fig. 2

(*ii*) The normal 700-mb contour pattern for four pentads each representing the four quarters of the months of May and June, based on data for the years 1957-62.

(*iii*) Charts depicting the 5-day total precipitation for the years 1957-62.

Method of preparation of items (*i*) and (*ii*) was described in an earlier paper by the author (Pant 1964). The normal or average charts under item (*ii*) are obtained by averaging the grid point values of the 700-mb contour height on the corresponding 5-day mean charts for each one of the six years (1957-62).

3. Normal changes associated with onset of monsoon

The normal 700-mb contour chart representing the first quarter of May (Fig. 1) shows that there is a prominent high pressure cell over central parts of the country and a weak trough in the westerly between 95°—100°E extending southwards to about 25°N. The Pacific High lies with its axis along about 20°N. During the next quarter of May, the high over central parts of the country weakens and there is only a ridge extending eastwards up to 85°E. The ridge associated with the Pacific High extends westwards upto 95° E. Simultaneously the contours values over north and central Bay of Bengal fall and the equatorial low becomes accentuated. The weak trough in the east shifts slightly westwards and is near 90°E. By the third quarter of May, the ridge over central parts of the country weakens further and recedes westwards. The ridge associated with the Pacific High recedes eastwards indicating the accentuation of the weak trough in the east.

By the last quarter of May (Fig. 2), the monsoon trough with more or less north-south orientation is formed near 90°E. Two significant changes that simultaneously take place are (*i*) disappearance of 3140 gpm contour from the country, indicating the disappearance of the high and (*ii*) dipping down of the 3120 gpm contour as far south as 10°N, indicating the formation of the monsoon trough. At 700 mb there is an indication of a low over southwest Tibet. The Pacific and African high pressure cells move eastwards and westwards respectively.

During June considerable changes take place in the position and intensity of the monsoon trough and the other hemispheric features mentioned above. The monsoon trough, which is usually near 90°E towards the end of May, shifts westwards and simultaneously becomes more intense. 3120 gpm and 3100 gpm contours shift westwards and southwards over the country, the former encompassing the whole country by the end

of June (Fig. 3). Simultaneously, the orientation of the primary axis of the monsoon trough, which was north-south at the beginning of June, becomes east-west by the end of June, the monsoon low having formed with its axis along 22°N. This is the time when monsoon establishes itself over the whole country. Simultaneous with the above mentioned changes in circulation over India and neighbourhood, the spectacular changes in the latitudinal position and strength of the Pacific High take place. The primary axis of the Pacific High shifts northwards from about 15°N at the beginning of June to about 25°N by the end of June (Fig. 3). This shift is best illustrated by the pressures over southern Japan. At the beginning of June, southern Japan is under the influence of the trough off the East Coast of Asia and the height of the 700-mb contour is of the order of 3080 gpm. But by the end of June, the heights over southern Japan show a rise of about 40 gpm having come under the influence of the Pacific ridge. This shift in the position of the high will naturally result in "a general rearrangement of the northern hemispheric long-wave pattern" mentioned by Yin (1949).

It is thus seen that the normal onset of the monsoon over India occurs gradually and is accompanied by spectacular changes in circulation over India as well as over the hemisphere as a whole. It is also clear that the onset of monsoon can objectively be tracked by following some or all the changes in circulation mentioned above. In the light of the above normal changes in circulation accompanying the onset of monsoon, the changes that took place during each one of the years of the period 1957—1962 were examined with particular reference to the effect of these changes in circulation on the extension of the monsoon rainfall over different parts of the country.

4. Changes in the pentad patterns in individual years

An examination of the 5-day mean 700-mb contour charts and the corresponding 5-day total precipitation charts for the individual

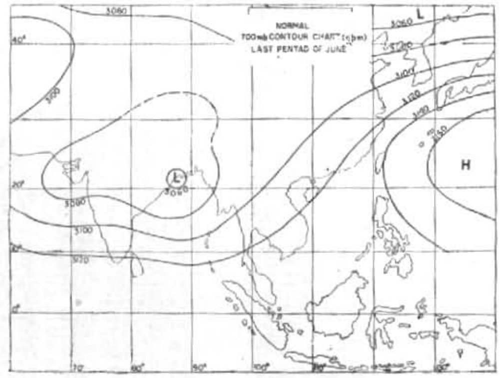

Fig. 3

years has clearly shown that the first disappearance of the high from central parts of the country (as signified by the disappearance of 3140 gpm contour from over the region) and the southward extension of 3120 gpm contour as far south as 10°N, indicating the formation of the monsoon trough, signify the onset of monsoon over India and adjoining seas south of about 15°N. This is confirmed by the charts for all the six years. In Figs. 4 and 5, charts showing the 5-day mean 700-mb contours and the corresponding 5-day total precipitation for two pentads, one prior to and one after the establishment of the monsoon trough are presented. It can be seen clearly that with the establishment of the monsoon trough as described above, monsoon rain started over India in the region south of 15°N, especially along the west coast and in Bay Islands.

At times, as in 1960, rainfall over the south Peninsula increases even prior to the onset of monsoon when a low pressure area is located over that region. But on such occasions, the mean contour pattern does not resemble Fig. 2. The High over the country still persists, though weak. In such cases Bay Islands do not have the normal monsoon rain confirming that the regular monsoon has not yet set in.

As seen from the charts for all the six years, the establishment of the monsoon over the whole country including Punjab,

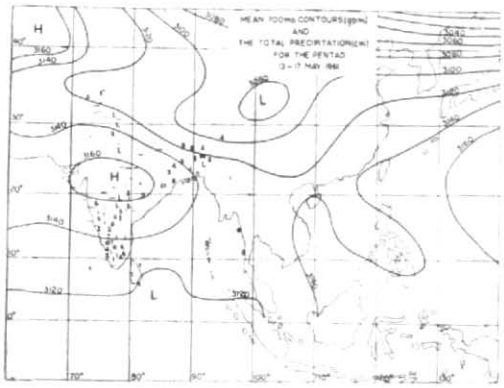

Fig. 4

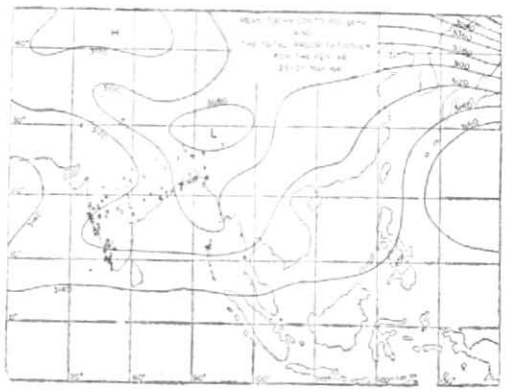

Fig. 5

Jammu and Kashmir and Rajasthan is associated with the formation of the monsoon low with its primary axis in an east-west direction at about 20°N. The monsoon trough, which is initially near about 90°E and has a north-south orientation shifts westwards and finally the monsoon low with its primary axis in an east-west direction is formed near about 20°N. Thus the primary axis of the monsoon trough rotates westwards through roughly a right angle. In Fig. 6 is presented the chart showing the 5-day mean 700-mb contours and the corresponding 5-day total precipitation for the pentad 17-21 June 1961. From this, it is evident that with the establishment of monsoon low, monsoon rain spreads to all parts of the country.

Simultaneous with the establishment of the monsoon low, the high over the Pacific Ocean intensifies and shifts northwards. During the pentad 13-17 June 1961, a trough was extending right through Japan up to 25°N. During the subsequent pentads this trough became less and less prominent with the shift of the Pacific High northwards and it was during this period (17-21 June 1961) that the monsoon established over the country. It was also noticed that, as pointed out by Yin (1949) and the Staff Members of the Academia Sinica (1957), the strength of the upper tropospheric westerlies over north India suddenly decrease with the establishment of the monsoon low.

Another interesting feature noticed is that at times relatively higher pressure (as revealed by the anticyclonic curvature of the contour of 3120 gpm) still persists over central parts of the country even after the onset of monsoon south of 15°N. So long as this feature is there, the monsoon activity does not penetrate over central parts of the country. But when once the anticyclonic curvature disappears and the monsoon trough dominates the circulation over the country, then monsoon rain begins over central parts of India also. In most of the six monsoon seasons studied here, this feature was noticed. In Fig. 7 are shown the 5-day mean 700-mb contours and the corresponding total precipitation for the pentad 4-8 June 1960. A comparison of this with Fig. 8 (14-18 June 1960) clearly shows that monsoon has set in over central parts with the disappearance of the anticyclonic curvature of the 3120 gpm contour over the region.

After the onset of the monsoon over central parts of the country and northeast India, its extension over U. P. and Punjab is usually associated with the shift in the position of the monsoon trough from about 90°E to near about 85°E. This shift occurs gradually in some years and can be traced from one

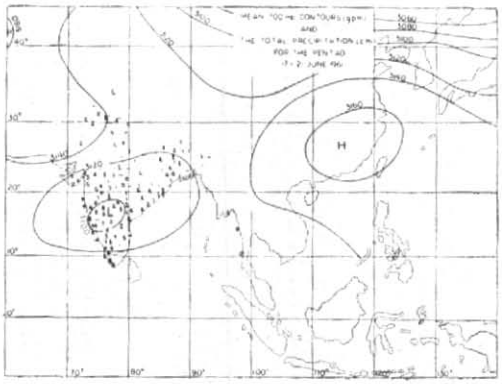

Fig. 6

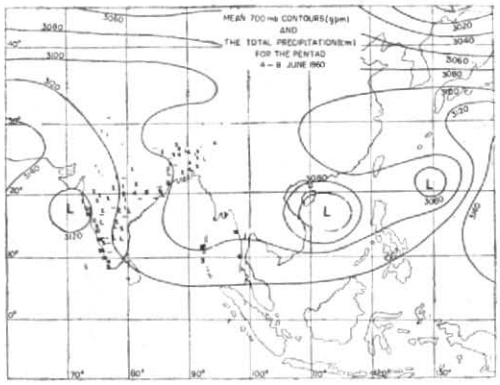

Fig. 7

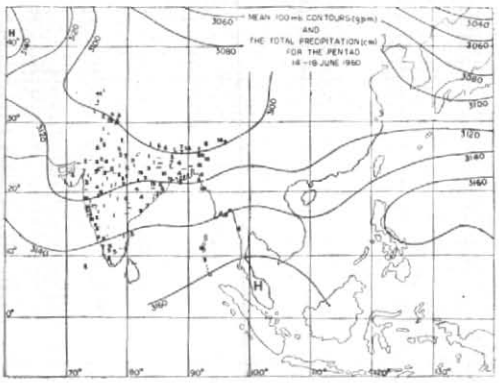

Fig. 8

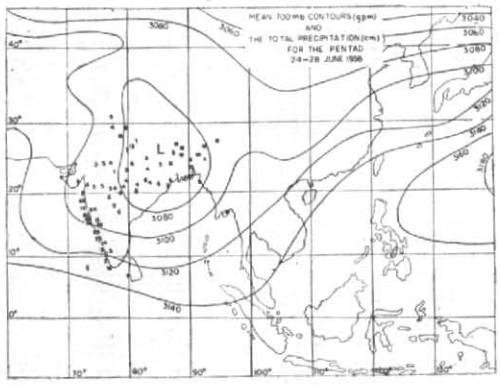

Fig. 9

pentad to the other, whereas in other years it may occur more suddenly. During the period 24-28 June 1958, the monsoon trough at 700-mb level shifted to near 85°E (Fig. 9) and U. P. had the first spell of monsoon rain during this period.

It is also noticed that sometimes the monsoon trough is not sharply defined when it just forms, and then, the rain over Assam and Bengal is not much. But once the trough is better organised and more sharply defined rainfall over Assam and Bengal increases. In 1962, monsoon set in south of 15°N by 22-26 May 1962 (Fig. 10). Heavy monsoon type of rainfall occurred in Assam and Bengal only during 5-9 June 1962 (Fig. 11), when the monsoon trough which still remained near 90°E, became sharply defined.

5. Conclusion

The present study has thus revealed the large scale changes in circulation that take place in association with the onset of monsoon rain over different parts of the country. These would be useful for objectively identifying the onset of monsoon. In order to be able to predict the monsoon rain about a week ahead, methods have to be evolved to prognosticate such features as (*i*) the initial formation of the monsoon trough near 90°E

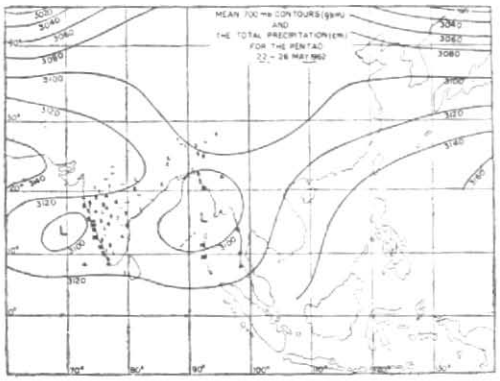

Fig. 10

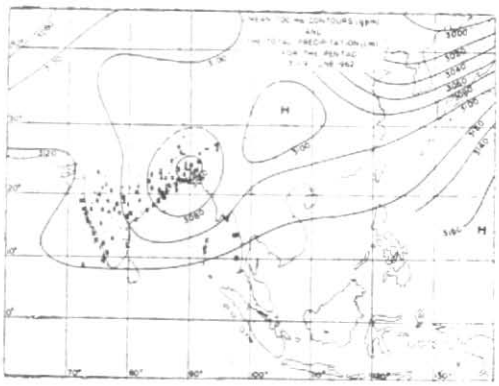

Fig. 11

at 700 mb, (*ii*) its shift westwards up to 80°—85°E and (*iii*) the formation of the monsoon low over central parts of the country, heralding the establishment of monsoon over the whole country. It has also been brought to light that minute changes in the pressure pattern, such as the disappearance of the anticyclonic curvature in a contour, are associated with the progress of the monsoon rain over central parts of the country. Prediction of such changes involves prediction of 700-mb height very accurately. Studies are now in progress to evolve suitable methods of prognostication of the mean pressure pattern.

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