A NORMAL PERIOD OF LARGE-SCALE BREAK IN THE SOUTHWEST MONSOON OVER INDIA*

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Introduction

DURING the southwest monsoon months, June to September, there are occasional large-scale interruptions in the monsoon rains over India, which are referred to as "Breaks in the monsoon". In such situations, there is a pronounced decrease in the rainfall over the major part of the country and a pronounced *increase*** in the rainfall along and near the Himalayas especially the Eastern Himalayas. There is also a significant *increase* in the rainfall over the extreme southeast of Peninsular India[1-5]. The breaks in the monsoon occur mainly in July and August, the occasions in August being somewhat more frequent than in July[5]. About 65% of the breaks in August occur between 7th and 17th[5].

According to Ananthakrishnan[6,7] who has studied the pentad *normal rainfall* over the country, there is a distinct minimum of rainfall, around pentad 46 (14th–18th August) at several stations over North and Central India.

No studies have however so far been made to find out whether we can specify a normal period of break in the monsoon over the country in the same way as normal dates of advance or retreat of the monsoon have been specified. Nor do we know as to what is the *normal* perturbation associated with such a normal period of break.

The present paper is a summary of the study of these aspects in respect of the month of August.

Technique of Rainfall Analysis

The technique adopted by the writer, for this purpose, was a very simple one. As it does not seem to have been used in any earlier climatological study, we describe it below in some detail. The monthly normal rainfall at each station is divided by the total number of days in the month and the daily average rainfall for the month thus obtained is shown as a straight line on a graph. We shall call this line as N_m line (*see* Fig. 1). On the same graph, is then plotted the figures of daily *normal* rainfall for each day of the month and the points thus obtained connected up by a smooth curve. We shall refer to these figures as the N_d values for the different days of the month and the curve obtained by connecting them up as the N_d curve. The variation of the N_d curve relative to the N_m line is then studied. The basic principle underlying this technique is that any deviations of the N_d curve relative to the N_m line may be considered as the effect of a perturbation or perturbations (*e.g.*, due to that associated with a break in the monsoon) on rainfall.

The total monthly normal rainfall for the different stations in August were computed from the India Meteorological Department publication entitled "Normals of Daily Accumulated Rainfall". *Only those stations whose normals are based on data of 30 years or more were utilised in this study.* This was done to satisfy the criterion for a "Standard Normal Period", as laid down by the World Meteorological Organisation[8]. The normal rainfall data of 143 stations, well distributed over the country were studied in this way. The graphs for all the 143 stations were drawn on the same scale to make them comparable. The only exceptions to this were the hill stations, Cherrapunji (25° 15′ N, 91° 44′ E) and Mahabaleshwar (17° 56′ N, 73° 43′ E), because of the enormous rainfall at these two stations. It was found that the N_d curve broadly consisted of crests and troughs on either side of the N_m line. As is to be expected, any excess in the value of N_d relative to N_m in one part of the month was compensated by a corresponding defect in its value in the other parts of the month. In general there was one crest and one trough in each N_d curve. There were however stations for which there was more than one crest and/or one trough. In these cases, the predominant trough/crest was referred to as the primary one and the less prominent ones as secondaries. The primary crest/trough was taken as associated with the breaks in the monsoon. This was done on the basis referred to earlier in this article of the well-known distribution of deficiency/excess of

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* This is a summary of a paper presented by the writer in the Symposium on Droughts in the Asiatic Monsoon Area held at the Meteorological Office, Poona, in December, 1972.

** The term "Break in the monsoon" is a misnomer when used with reference to regions where there is an increase of rainfall. As, however, there is a decrease in rainfall, *taking the Indian subcontinent as a whole* and as it is not desirable to use a number of terms with reference to one synoptic situation pertaining to the whole country, the term "Break in the monsoon" as currently used in Indian Meteorological literature is perhaps justified.

rainfall over different parts of the country during actual break situations.

The dates of beginning and end of the normal break in the monsoon at each of the 143 stations were read off from the graphs. The excesses or deficiencies of N_d rainfall relative to N_m at the *peak phase* of the breaks were worked out in the form of percentages.

There were a few stations (5 out of a total number of 143) in which it was not possible to identify a clear crest or a trough which could be associated with a break in the monsoon. The reasons for this are still to be investigated. We shall refer to these few stations as 'Indeterminate' or I stations (*see* Fig. 5).

Results of the Rainfall Analysis

Figures 1, 2, 3 and 4 show the N_m and N_d curves in August at sixteen representative stations in India. Figure 5 shows the percentage departures of excesses and deficiencies at the *peak phase* of the break at each station. It will be noted that the variations of N_d relative to N_m in Figs. 1 to 4 bear remarkable resemblance to the excesses/defects usually found at these stations during actual break-situations. It is also interesting to note that even hill-stations like Cherrapunji, Mukteswar and Mount Abu show the same type of anomalies as their neighbouring stations in the plains[9-10].

Figure 5 also bears very close resemblance to maps of rainfall and other derived parameters during actual break-situations as published by Ramamurthi[5] and also by us[1-3,9]. The dip southwards in Fig. 5 of the isopleths near 88° E is particularly interesting. The reasons for this will be discussed in the more detailed paper.

Floods and Agricultural Food Production in Relation to Rainfall Analysis

It will be seen from Fig. 5 that there is an area of 30 to 40% excess of rainfall over the Brahmaputra valley, sub-Himalayan West Bengal and North Bihar with a maximum of 54% at Darbhanga (20° 10′ N, 85° 54′ E) in the extreme north of Bihar in the peak phase of break in the

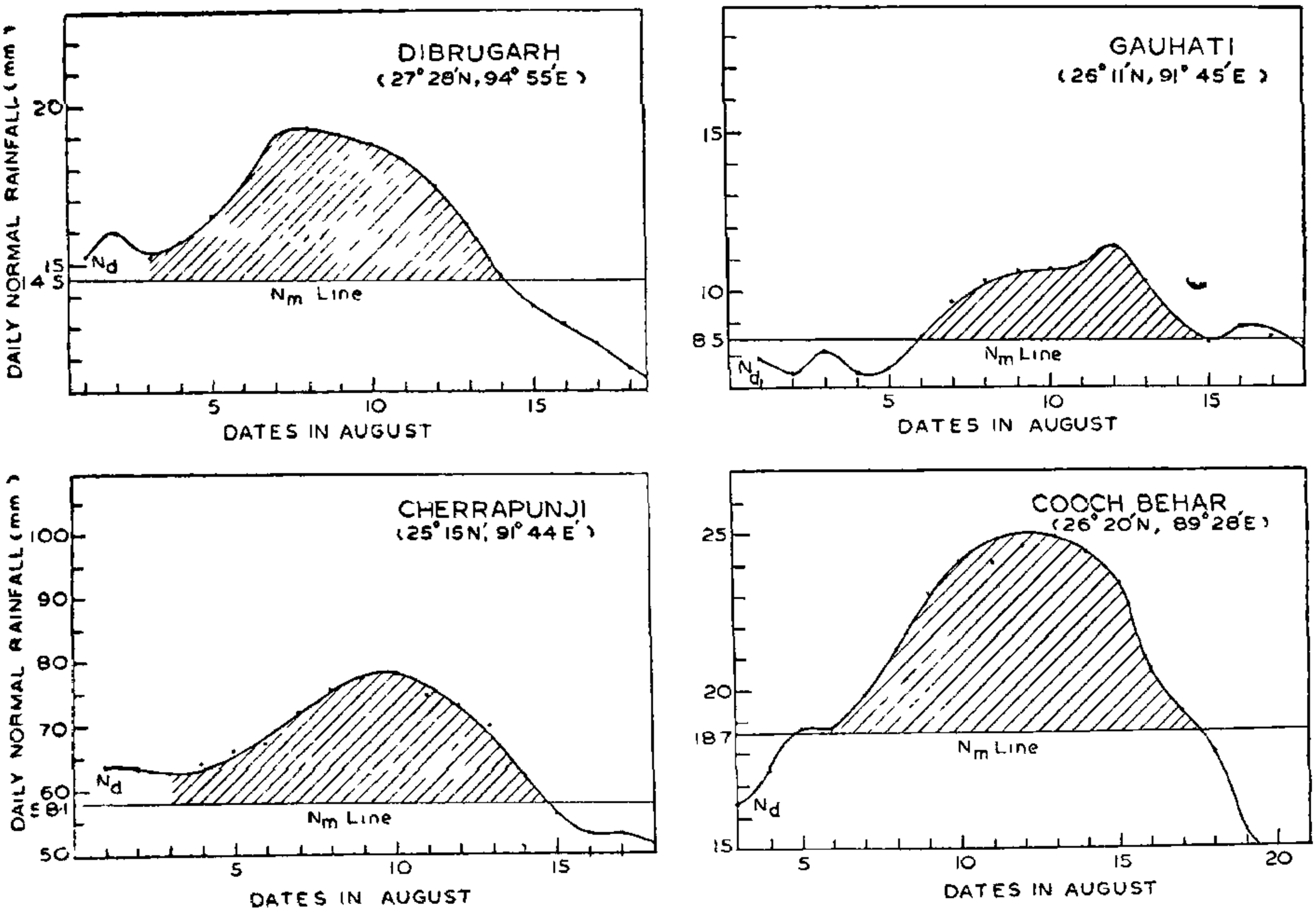

FIG. 1. The smooth curve intersecting the N_m line is the N_d curve. For explanation of N_m and N_d *see* text. The hatched area is the Primary Crest and represents the period of break in the monsoon at each of the stations associated with an excess of rainfall. In the case of Dibrugarh, 3rd August is the beginning of the break, 14th August is the end of the break. The duration of the break is 11 days.

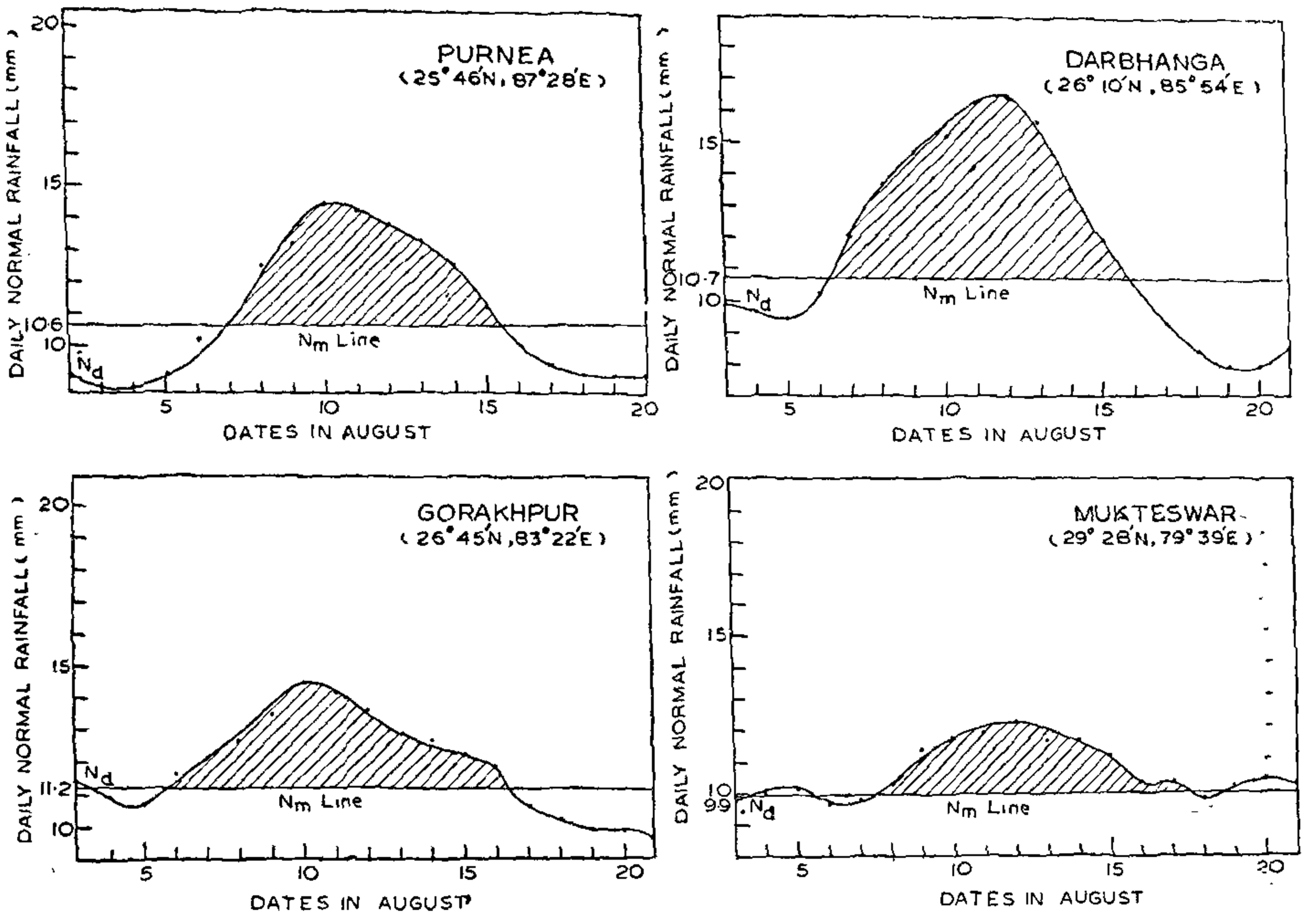

FIG. 2. Explanatory legend same as for Fig. 1.

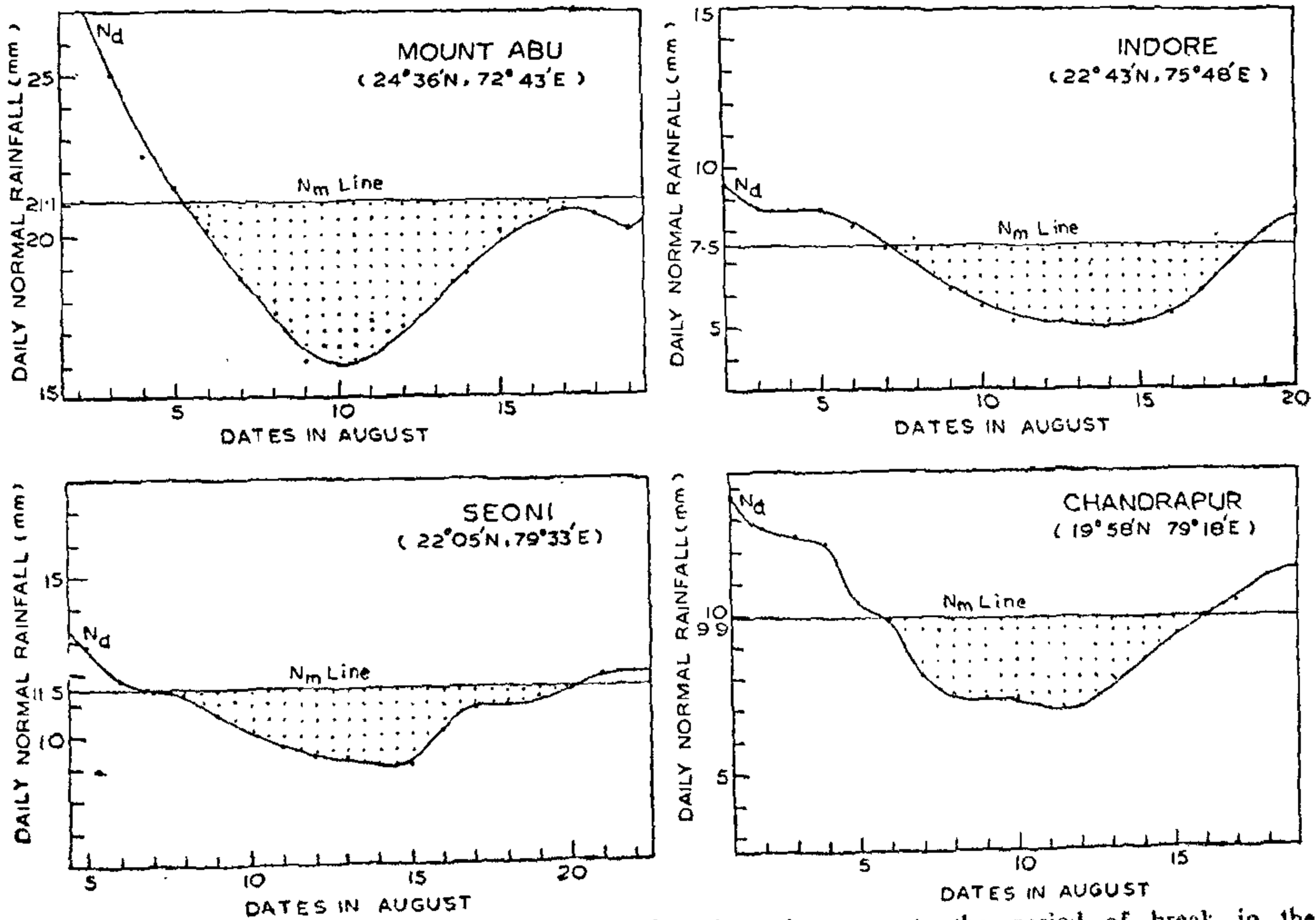

FIG. 3. The stippled area is the Primary Trough and represents the period of break in the monsoon at each of the stations associated with a deficiency in rainfall. In the case of Mount Abu, 6th August is the beginning of the break, 17th August is the end of the break. Duration of the break is 11 days. Other explanations same as for Fig. 1.

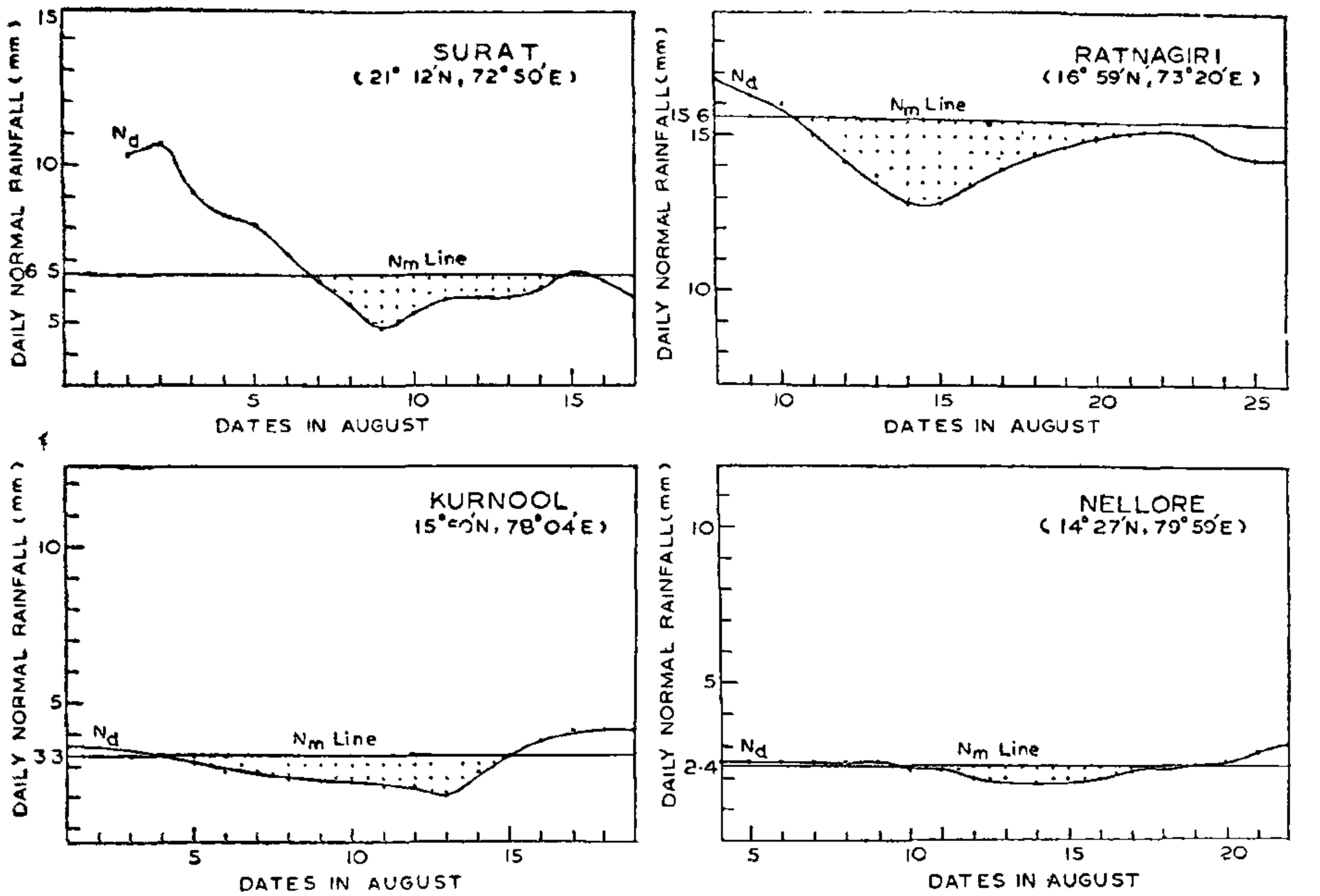

FIG. 4. Explanatory legend same as for Fig. 3.

monsoon. These are areas which, even normally (N_m value). experience large rainfall in the monsoon season. A heavy *excess* of rainfall over this normal during the peak phase of the break would tend to produce floods in the rivers in those areas (other conditions being assumed to be the same)—a conclusion borne out by the fact that floods are an almost annual visitation in those areas. The reader may also note the elongated belt extending from West Rajasthan and Kutch to the interior of Mysore south (through Maharashtra), where there is a 25 to 40% deficiency of rainfall with a 59% defect in Bellary (Lat. 15° 09' N, Long. 76° 51' E) during the peak phase of the break. This area is a Dry Farming area according to Joshi[11]. It also covers a major portion of Area C* of *High Instability* in Agricultural Food Production, according to Sen[12].

We give below a brief summary of our other conclusions.

(*a*) The breaks begin relatively earlier over the Punjab Plains**, Upper and Lower Gangetic Plains** and the Brahmaputra Basin** than over the rest of the country.
It is in those areas that there is a general excess of rainfall of 25% or more during the peak phases of the breaks (*vide* Fig. 5). In the same areas, the breaks also end relatively earlier than elsewhere. The differences in dates in this case are, however, less than in the case of commencement of breaks. The significance of these findings will be discussed in the fuller paper, later.

(*b*) The 'break' commences later and also ends later in the extreme southeast of Peninsular India than elsewhere over the country.

(*c*) Consequent on (*a*) and (*b*) above, there is greater uniformity in the duration of the breaks at different stations in the country. Almost all stations experience breaks which last between 6 and 11 days. Considering

* Area C has been reproduced by us in one of our earlier contributions[3]. Also see footnote on p. 22 of the same contribution.

** We have used the names of the Hydrometeorological sub-zones currently in vogue[13].

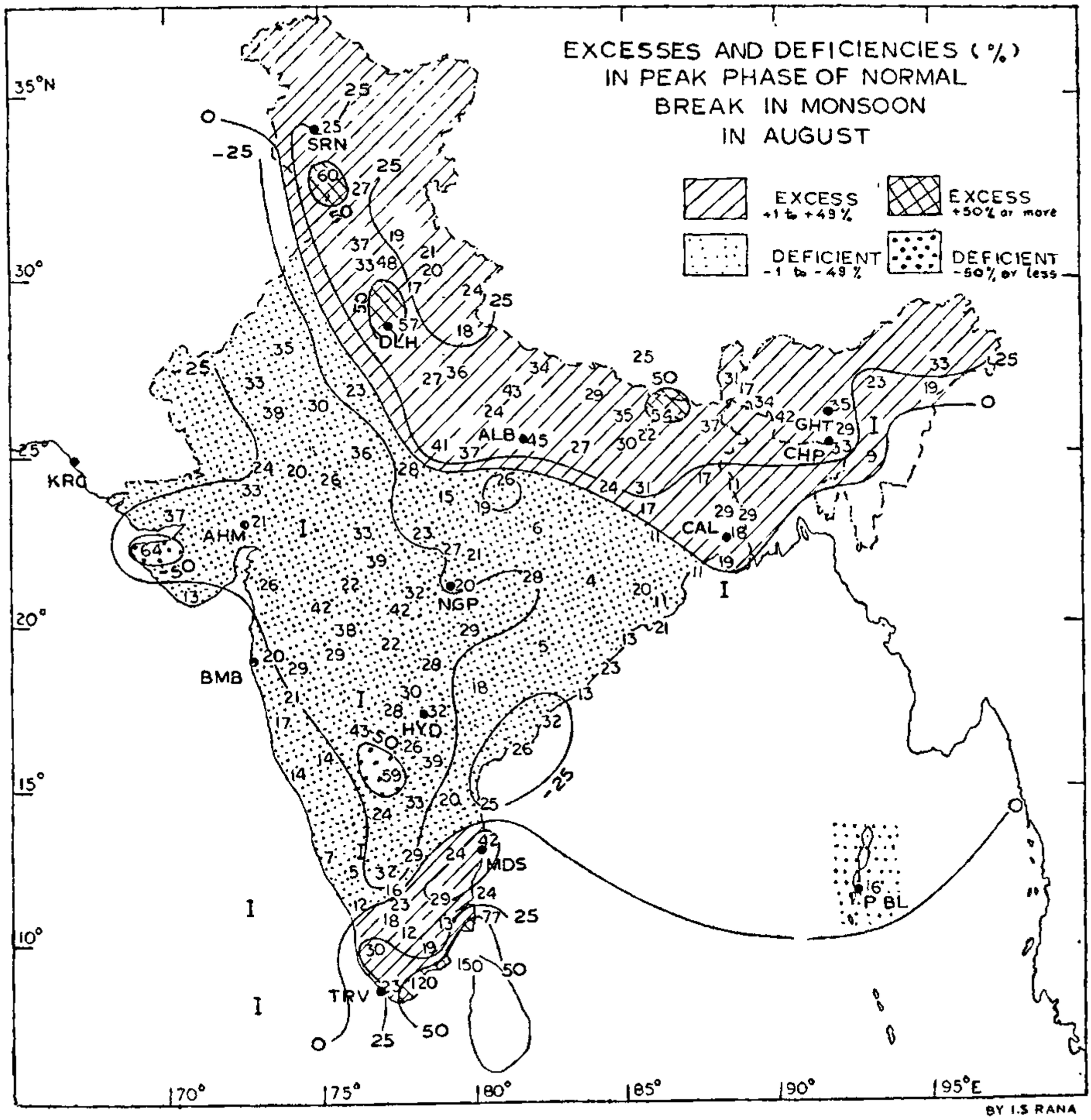

FIG. 5. Letter I plotted at some stations stands for 'Indeterminate' (*see* text).

the Indian sub-continent as a whole, the normal period of break may be taken as 7th to 15th August, *i.e.*, a period of 8 days.

NORMAL PERTURBATION PATTERN

Figure 6 shows the normal perturbation pattern over India during the period 7th to 15th August at the 500 mb level. The winds plotted in the diagram indicate the vector differences between the normal winds during the period 7th to 15th August and during the month of August as a whole. The normal winds for the period 7th to 15th August were worked out by the writer from the daily Rawin and Pilot Balloon data available in the publications of the India Meteorological Department during the period 1949–72 (24-year period). The normal winds for the month of August as a whole were specially obtained from the India Meteorological Department or taken from their publications. The normals for Rawin stations were based on all available data upto 1970 while those for Pibal Winds were based on data upto 1960. Although the data did not cover a 30-year Standard Normal period (as in the case of rainfall), 'the normals' worked out were the best that could be available for this investigation.

By adopting this technique of working out vector differences, we have filtered out the normal *basic flow pattern* during the period 7th to 15th August and thereby brought to light the *residual 'normal perturbation-pattern'* during the same period. It is this residual perturbation pattern which is responsible for the observed excesses and deficiencies in the daily normal rainfall illustrated in Figs. 1 to 5.

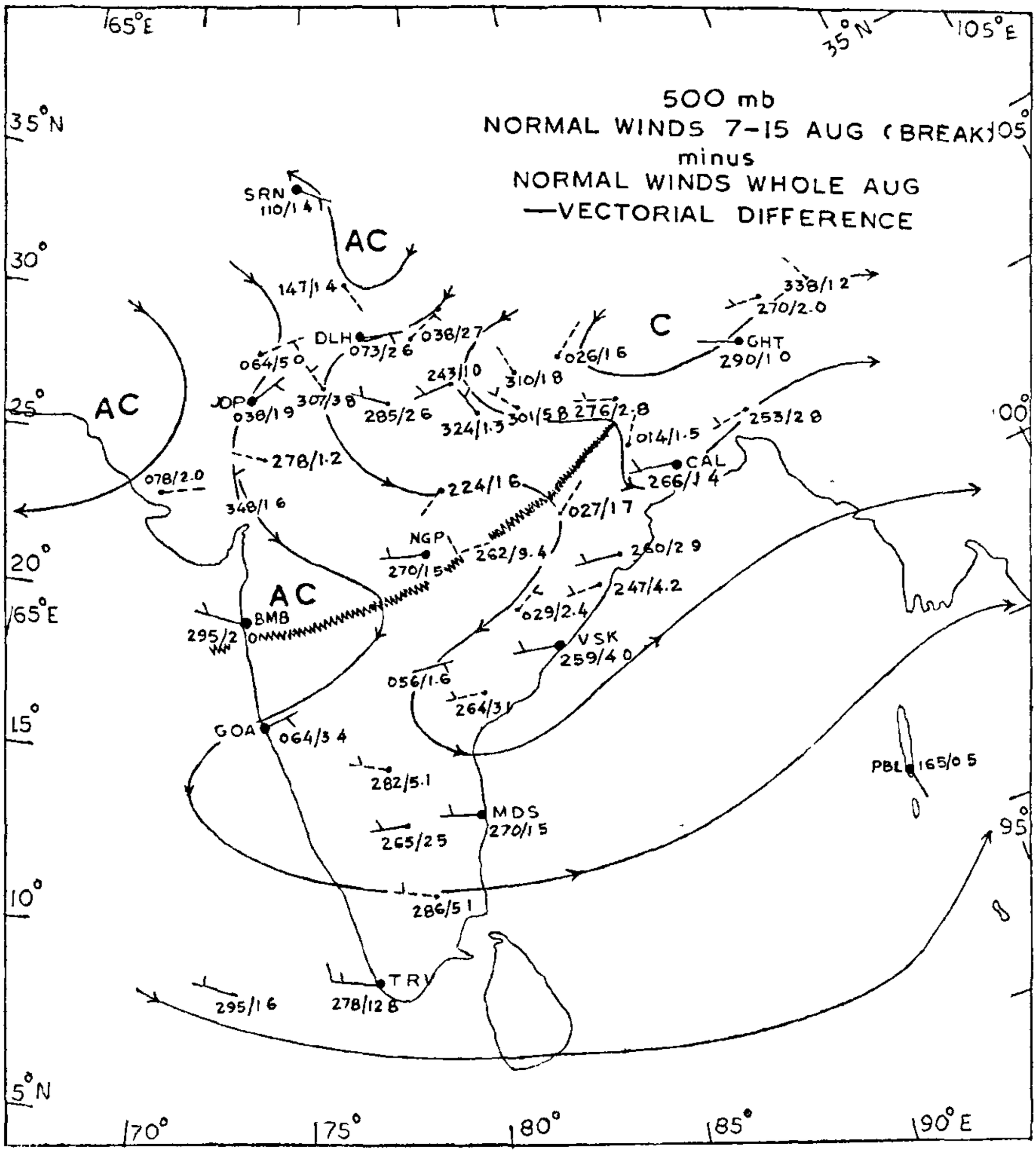

FIG. 6. Normal perturbation pattern during the period 7–15 August. C stands for cyclonic and AC for anticyclonic. The *zig-zag* line represents a ridge line. The direction and speed of the vector winds have been shown against each station besides the usual arrow and barb. The arrows drawn as continutus lines represent Rawin observations. The arrows drawn as dashed lines represent pibal observations. The speed is in knots correct to one decimal place. Note the trough along and near the foot of the Eastern Himalayas and the ridge over the central parts of the country and the northern parts of Peninsular India.

Figure 6 *strikingly brings out the two most important features* of the daily and mean break-synoptic charts published by the writer[1-4,9] and Ramamurthi[5], namely the trough along and near the foot of the Eastern Himalayas and the ridge over the central parts of the country and the northern parts of Peninsular India. Figure 6 is also consistent with the mean perturbation over India at the 500 mb level during weak Arabian Sea monsoon as published by Ramamurthi[14].

The anticyclonic circulation over Kashmir and the adjoining areas in Fig. 6 may also be noted. The significance of this circulation and of other features revealed by this diagram will be discussed in the more detailed paper.

Conclusions

This investigation has brought to light a new parameter in monsoon climatology, namely, a normal break period in the southwest monsoon season. Such a normal period has been found in the case of almost all the individual stations studied as well as over the country as a whole. The normal period in August for India as a whole, may be taken as 7th to 15th August. It is, however, important to bear in mind that the break in any individual year may deviate from the normal both with regard to the date of commencement as well as the date of end of the break in the same way as the actual dates of onset and withdrawal of the monsoon in any individual year may deviate from the normal dates.

Lines for Further Study

Earlier in this article, we had stressed the importance of this investigation from the point of view of Agricultural Food Production in India. What we had stated is however just the beginning of what should be done in this field. There is clearly a need for a more detailed study of this aspect especially with reference to the normal break-periods at individual stations and at groups of stations representing districts. It is also essential to investigate whether there are similar normal periods of break in the other monsoon months especially in July.

Acknowledgements

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