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INDIA METEOROLOGICAL DEPARTMENT

FORECASTING MANUAL

PART IV

18. MONSOONS OF INDIA

ON THE CRITERIA FOR DECLARING THE ONSET OF

THE SOUTHWEST MONSOON OVER KERALA

BY

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On the Criteria for Declaring the Onset of the Southwest Monsoon over Kerala

by

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1. Introduction

1.1 The economy of India is so closely linked with the rainfall during the south-west monsoon months that the onset of the monsoon over the extreme southwestern tip of the peninsula and its northward progress across the country evoke considerable public interest. From about the beginning of May the Forecasting Offices of the Department begin getting inquiries about the monsoon - its expected date of onset and the likely behaviour of the rainfall.

1.2 By long-standing practice in the Department the word "monsoon" conveys two different meanings in two different contexts. In shipping bulletins issued for the Bay of Bengal and the Arabian sea, the word "monsoon" indicates prevailing surface winds. Thus, depending upon the wind strength, the monsoon is described as weak, moderate , strong or vigorous in these bulletins. Over land area, the word "monsoon" indicates rainfall. On the basis of the intensity and distribution of rainfall, the monsoon is described as weak, normal, active, strong or vigorous over an area. The specifications adopted by the Department for defining the strength of the monsoon over the sea and land are given in Table 1.

Table 1 IMD Specifications for describing the strength of the Monsoon

Area	Descriptive term	Specifications
Sea	Weak	Windspeed up to 12 knots (reported or estimated)
	Moderate	13 to 22 knots
	Strong	23 to 32 knots
	Vigorous	33 knots and above
Land	Weak	Rainfall less than half the normal
	Normal	Rainfall between $\frac{1}{2}$ and $1\frac{1}{2}$ times the normal
	Active / Strong	Rainfall $1\frac{1}{2}$ to 4 times the normal (with a minimum rainfall of 5 cms along the west coast and 3 cms elsewhere)
	Vigorous	Rainfall more than 4 times the normal (with minimum rainfall of 8 cms along the west coast and 5 cms elsewhere)

Note : The minimum limit of rain prescribed for "Active/Strong" and "Vigorous" monsoon should be recorded at two neighbouring IMD stations.

1.3 To the public at large, the word monsoon is practically synonymous with rainfall. It is in this sense that the word is made use of in the present report wherein it is proposed to discuss the criteria that are pertinent for declaring the onset of the southwest monsoon over Kerala, an occurrence that repeats year after year in May - June. The problem with which we are concerned here is not one of forecasting the date of onset of the monsoon, which will be discussed elsewhere, but of deciding when the onset has taken place from considerations primarily of the rainfall in the extreme southwestern parts of the peninsula and the neighbouring island stations.

2. Normal Date of Onset of the Southwest Monsoon

2.1 There are two publications of the India Meteorological Department which contain diagrams giving isolines of "normal" dates of onset of the southwest monsoon" over different parts of the country. They are :-

A. Climatic charts of India and Neighbourhood for Meteorologists and Airmen (1943)

B. Climatological charts for Airmen (1943)

Although both these publications were issued in the same year, the diagrams relating

to the onset of the monsoon which are contained in them are not identical. These diagrams are reproduced in Figs 1(a) and (b). According to Fig 1(a) the normal date of onset of the monsoon over south Kerala is about 27 May while according to Fig 1(b) the date is 1 June. The two diagrams also differ significantly in other details.

2.2 The question arises as to how the "normal dates" were arrived at. The procedure followed for this has been indicated under the title "Explanation of Charts" at the beginning of the two climatological atlases. The relevant extract from publication A is reproduced below :-

> "These dates have been derived from five day normals of accumulated rainfall published by the India Meteorological Department. Diagrams were prepared showing the normal rainfall at each reporting station for successive five day periods in the year. The middle date of the five day period showing the characteristic monsoon rise in the rainfall curve was taken as the date of onset of the monsoon."

The same explanatory note is given in publication B, but with the following significant additional sentence :-

> " At stations where the pre-monsoon thunderstorm rains merge into the monsoon rain, and the transition is gradual, other factors have also been taken into consideration. "

2.3 The extract gives the impression that if the 5-day normal rainfall of a station is plotted for successive pentads, a discontinuity in the rainfall curve can be found at the pentad corresponding to the onset of the monsoon. To illustrate the method, the normal pentad rainfall amounts extracted from the IMD publication "Normals of Daily Accumulated Rainfall" (1965) for the months April, May and June for nine stations on the west coast (Trivandrum, Alleppey, Cochin, Kozhikode, Mangalore, Honavar, Marmagao, Ratnagiri and Bombay) and one island station (Minicoy) are depicted in Fig. 2 in the form of histograms. Examination of the figures shows that at Minicoy an increase in the slope of the rainfall curve indicating an increase in rainfall activity occurs in the pentad centred on 13 May. Thereafter, a steady increase in rainfall from one pentad to the next takes place till the pentad centred on 7 June. If we assume that the "characteristic monsoon rise in the rainfall curve" has occurred in the pentad centred on 13 May, this would be the normal date of onset of monsoon at Minicoy. However, this does not agree with the date that is arrived at by interpolation from Fig. 1. The date near 1 June, which Fig 1(b) indicates for the onset of the monsoon at Minicoy lies close to the peak of the rainfall curve of this station.

2.4 The rainfall diagrams for Trivandrum, Alleppey, Cochin and Kozhikode do not enable us to locate uniquely the pentad in which the "characteristic monsoon rise" occurs at these stations. At all these stations there is a progressive increase in rainfall from the second week of May till the second week of June, by which time the monsoon is well-established. The date of transition from the pre-monsoon thunderstorm rainfall activity to the rainfall associated with the south-west monsoon cannot be fixed unambiguously from the normal rainfall diagrams.

2.5 It is, therefore, necessary to inquire what the "other factors" are, that have been considered to fix the date of onset of the monsoon at these stations as these have not been specifically mentioned in the explanatory note in publication B. After searching the old files and records we came across some relevant correspondence on this subject. The discrepancy between the diagrams relating to the onset of the southwest monsoon given in the two publications mentioned in para 2.1 was sought to be clarified in 1948 by a reference made to Rao Bahadur V. Doraiswamy Iyer, who was associated with the preparation of the "Climatological Atlas for Airmen", but had retired from the Department at the close of World War II. The relevant letters are reproduced as items (i) and (ii) of Appendix I. It appears from the letter of Rao Bahadur Doraiswamy Iyer that the date of onset of the monsoon over Kerala was fixed subjectively for each year by three experienced officers of the Department — himself, Mr. S. Basu and Dr. S.R. Savur — from the daily working charts. Presumably the mean of these dates was taken as the normal date of onset of the monsoon over Kerala.

2.6 The reason why the isolines in Fig. 1(b) differ from those in Fig. 1(a) is that the dates of onset of the monsoon derived solely from considerations of the march of the pentad rainfall curves of observatory stations have been modified by taking into account "other factors". These factors have not been clearly specified. They represent, by and large, the accumulated experience of a meteorologist conversant with the weather and climate of India and neighbourhood. Some degree of subjectivity is inevitable in such a case, and this aspect has to be borne in mind while considering the normal charts of date of onset of the monsoon in publication B.

2.7 The inquiry of Prof. Fisher and the reply sent to him — vide items (iii) and (iv) of Appendix I — bring out the difficulty of fixing the date of onset of

NORMAL DATES OF ONSET OF SOUTHWEST MONSOON

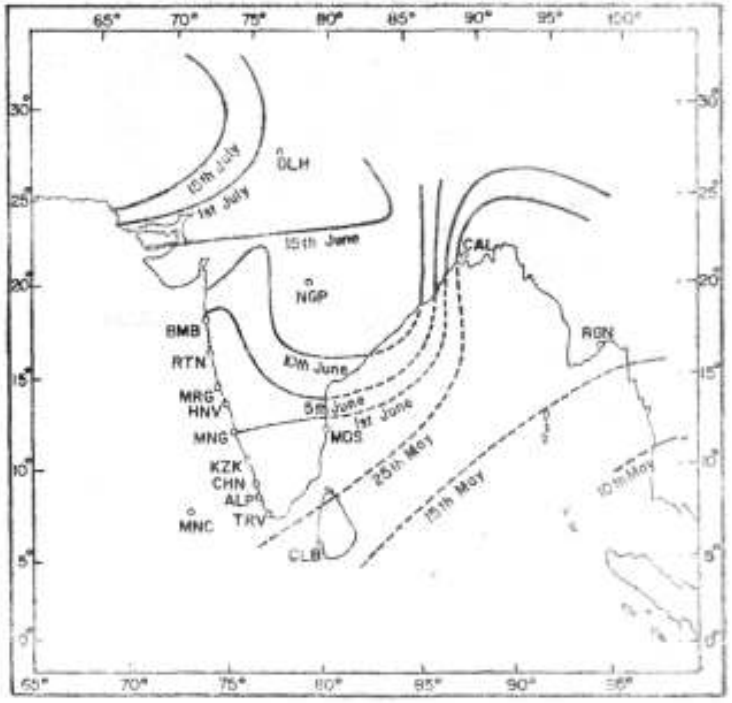

FIG. 1 (a)

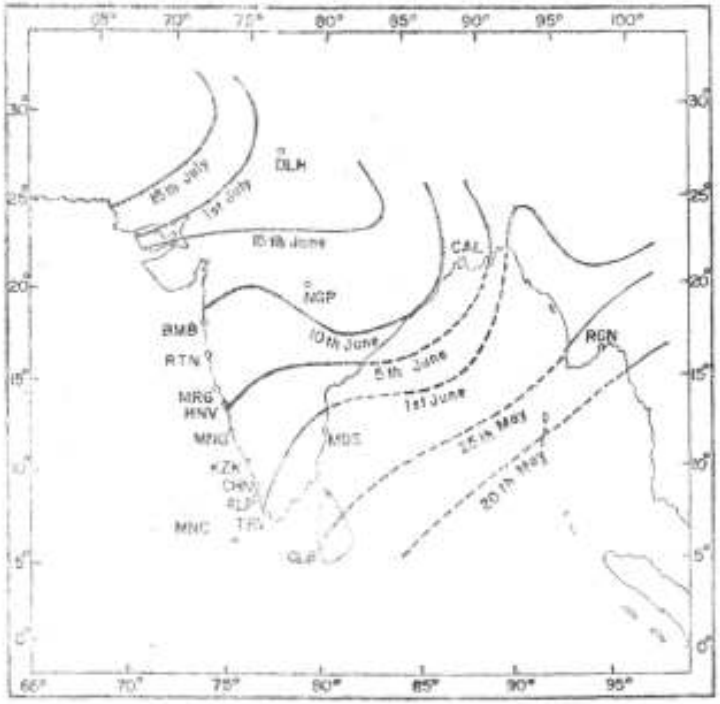

FIG. 1 (b)

NORMAL PENTAD RAINFALL
(mm)

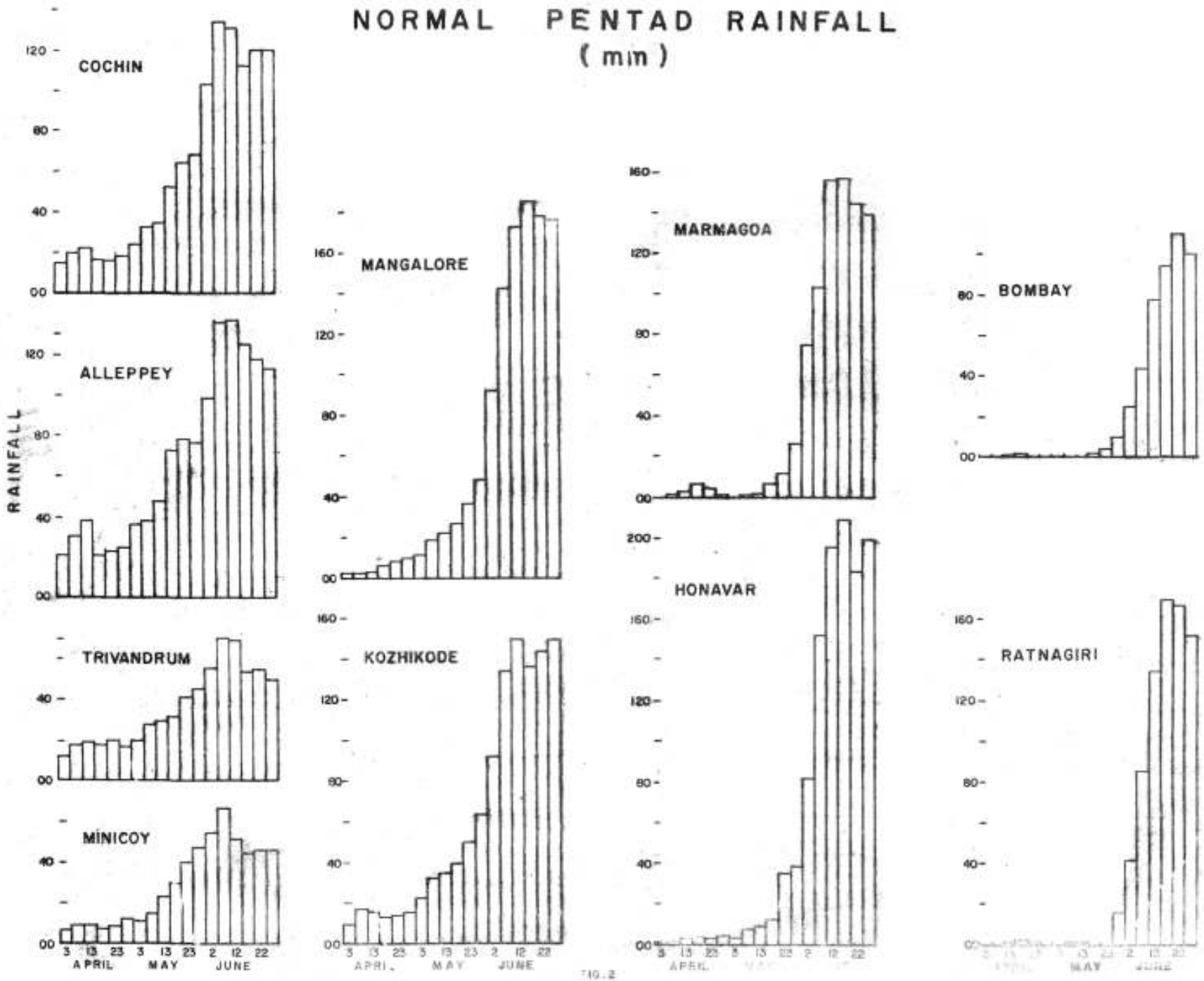

FIG. 2

the monsoon. Mr. S. Basu's letter to the Asst. Director of the Ceylon Met. Service — —item (v) of Appendix I — gives an excellent exposition of the practice followed in the Department for identifying the arrival of the southwest monsoon. While rainfall is the primary parameter, other factors such as clouds, isobaric gradients and winds also serve as guides to the forecaster. The statement that "it has not so far been possible to evolve a single, reliable and definite criterion to uniquely identify its arrival" contained in Mr. Basu's letter written fifteen years ago holds good even now.

2.8 It is of interest to examine critically the rainfall histograms for the six stations Minicoy, Trivandrum, Alleppey, Cochin, Kozhikode and Mangalore in Fig. 2. From near about 10 May an increase in the slope of the rainfall curve can be seen at all the stations. Notice the appreciable increase in rainfall at Minicoy in the pentad centred on 13 May as compared with the previous pentad. At the other five stations such a rise is noticed even a pentad earlier. At Alleppey and Cochin a further rapid increase in rainfall occurs in the pentad centred on 18 May. The next conspicuous rise that occurs in the pentad centred on 2 June is noticed at all the stations from Trivandrum to Mangalore. At the last station, the rainfall during this pentad is almost double that in the previous pentad. The peak of rainfall activity is reached at Minicoy, Trivandrum, Alleppey and Cochin in the pentad centred on 7 June; at Kozhikode this occurs in the next pentad and at Mangalore in the pentad centred on 17 June. Notice also that at Minicoy the rainfall activity decreases from 10 June and at Trivandrum, Alleppey and Cochin from 15 June. At Kozhikode and Mangalore the rainfall activity remains near about the peak value till the end of June. We shall have occasion to comment upon some of these features in a subsequent section.

3. Year to year variations : 1901-1967

3.1 In the light of the facts set out in the previous section, it was considered to be of interest and importance to make a comprehensive survey and examination of the factual information pertinent to the onset of the monsoon over Kerala for an extensive period. The period 1901 to 1967 was chosen for this study and the relevant Indian Daily Weather Reports (IDWR), Weekly Weather Reports (WWR) and Monthly Weather Reports (MWR) were scrutinised. The period covered is sufficiently long to give insight into the year to year variation of rainfall associated with the onset of the monsoon and the phraseology employed to portray these variations by a number of officers of the department from the beginning of this century to the present time. Apart from affording a historical perspective, such a survey is also of value to assess whether any increase in precision has been achieved over the years in the description of the most important phenomenon of Indian weather and the complexities associated with it.

3.2 In Appendix II are given extracts from the IDWR and MWR for the years 1901-1967 relating to the initial advance of the southwest monsoon and its onset on the Malabar (now Kerala) coast. Reading through these extracts it will be seen that from the early years Indian meteorologists had realised the pulsatory and fluctuating nature of the southwest monsoon during the initial stages of its onset over the extreme south of the peninsula.

3.3 Since rainfall, which is the end product of various physical and dynamical processes taking place in the atmosphere, is the primary index of monsoon activity over land, a series of rainfall diagrams were prepared for the 67-year period (1901 to 1967) depicting the daily rainfall of the following seven stations for the months of May and June. (The rainfall data were obtained from the Hydrology section of DDGO's office.)

Station	Lat °N	Long °E
Colombo	06° 54'	79° 52'
Minicoy	08° 18'	73° 00'
Trivandrum	08° 28'	76° 57'
Alleppey	09° 33'	76° 25'
Cochin	09° 58'	76° 14'
Kozhikode	11° 15'	75° 47'
Mangalore	12° 52'	74° 51'

The diagrams are reproduced in Appendix III. The rainfall amounts are represented pictorially according to the legend given at the bottom of each chart; amounts less than 0.5 mm have been omitted.

3.4 The rainfall patterns show large variations from year to year. For instance, the years 1917, 1920, 1923, 1935, 1939, 1945, 1950, 1953 and 1966 show feeble pre-monsoon thunderstorm activity. In these years the onset of the monsoon rains towards the end of May or the beginning of June was fairly abrupt. As a contrast, the years 1905, 1918, 1922, 1932, 1933, 1944, 1948, 1955, 1958 and 1960 had plenty of rainfall activity almost throughout the month of May. In the years 1908, 1909, 1915, 1929, 1930, 1934, 1965 and 1967 there was a period of good rainfall activity in May which was followed by a spell of comparatively dry weather after which rainfall activity again increased. More complicated rainfall patterns are noticed in some other years.

3.5 There is a general impression that the southwest monsoon is a meteorological phenomenon of the Asian tropics that repeats year after year with great regularity and in a nearly identical manner. The factual position, however, is that large variations occur from year to year not only in the date and manner of its initial onset, but also in the spatial and temporal distribution of rainfall over the country. The wind circulation both in the lower and in the upper troposphere undergoes a radical change with the onset of the monsoon but the transition is fairly abrupt in some years and more gradual in other years. The forecaster, however, leans heavily on the rainfall at the coastal stations of Kerala, the west coast of Ceylon and the Arabian sea islands for tracing the advance of the monsoon over Kerala.

3.6 A scrutiny of the daily weather bulletins issued during the 67-year period (Appendix II) reveals the difficulty experienced by forecasters in fixing the date of onset of the monsoon and in describing the observed complex features associated with it. It is instructive to examine the extracts from the IDWR for the individual years in Appendix II with the rainfall diagrams for the corresponding years in Appendix III. While doing so it is important to remember that the bulletin relating to any day is based on the assessment by the forecaster of the rainfall data of that day and of the previous days in conjunction with the relevant synoptic weather charts. A brief and rapid survey of the weather bulletins for some years is given in the next few paragraphs. ~~graphs~~.

3.7 In 1901 although rainfall was continuing at almost all the seven stations since 4 June, the onset of the monsoon on the Malabar coast was announced only on 7 June. In 1922 "a slight temporary advance of the monsoon on the Malabar coast" was mentioned on 12 May. The bulletin issued on 20 May stated that "the temporary advance of the monsoon in the peninsula has almost disappeared". On 31 May the bulletin stated that "monsoon conditions are gradually establishing themselves on the Malabar coast".

3.8 In 1924 the weather bulletin issued on 21 May mentioned that "a temporary advance of the monsoon is occurring off Malabar". Two days later it was stated that the temporary advance of the monsoon had ceased. Thereafter the bulletin issued on 2 June stated that "an advance of monsoon is occurring off Malabar". The rainfall diagram shows that almost all the seven stations had experienced rainfall not only on the day of issue of this bulletin but also on the previous two days.

3.9 In 1928 a "feeble advance of the monsoon in the southeast Arabian sea" was indicated on 23 May; two days later it was stated that the monsoon was receding from the southeast Arabian sea. Thereafter, the bulletin of 4 June stated that "the monsoon has appeared on the Malabar coast with rough seas and squally weather".

3.10 In 1932 temporary advance of the monsoon in the southeast Arabian sea having caused locally very heavy rain in Malabar was mentioned on 19 May. The bulletin on 27 May announced that "the monsoon has receded from off Malabar". Thereafter a revival was indicated on 8 June, a further recession on 14 June and a fresh arrival of the Arabian sea monsoon along and off the Malabar Kanara coasts" on 17 June. It is interesting to compare these statements with the rainfall pattern for May-June 1932. The advance and recession of the monsoon mentioned in the bulletins more or less reflect the behaviour of the observed rainfall at the seven stations.

3.11 The bulletins for the period 6 to 14 June 1935 illustrate the phraseology that has been employed by the forecaster in a year in which the initial rainfall activity was feeble and the onset of the monsoon over the Kerala coast was rather gradual. In 1936, "a temporary advance of the southwest monsoon in the southeast Arabian Sea" was mentioned on 20 May. Notice that on 19 and 20 May Colombo recorded more than 12 cm of rain. The bulletin for 21 May stated that "temporary advance of the monsoon is maintained off the Ceylon and Travancore coasts". In 1939 there was a spell of rainfall activity from 6 to 10 May. Presumably after watching this for 3 days, it was announced on 9 May that "associated with a temporary advance of the monsoon in the southeast Arabian Sea nearly general rain has occurred in Malabar". With the decrease in rainfall the monsoon was "weakened" on 11 May, after which it was announced on 5 June that "an advance of the monsoon is occurring off Malabar and the Konkan". In 1941 the southwest monsoon "burst over Malabar" on 23 May. The weather bulletins for 1948 mentioned "temporary advance", "feeble advance" and "retreat into the Laccadive region" of the monsoon during the second half of May.

3.12 As seen from the rainfall chart for 1950, this is a year of "burst" of the southwest monsoon over Kerala on 27 May. The bulletins mentioned about advance and retreat (probably) of "equatorial maritime air into Travancore-Cochin" early in May and

"temporary advance of monsoon in Travancore-Cochin" on 27 May. 1955 was a year of uniform and good rainfall activity in May and June and the bulletins for this year illustrate how expressions such as "temporary advance" and "revival" of the monsoon are used in the bulletins more or less, in synchronism with the behaviour of the rainfall at the coastal and island stations.

3.13 The bulletins for 1957 and the corresponding rainfall chart make interesting study. The decrease and increase of rainfall over Kerala after 8 June have been indicated as "temporary weakening" of the monsoon on 9 June, "temporary recession" of the monsoon from Kerala on 10 June and "revival" of monsoon over Kerala on 11 June.

3.14 The bulletins for the period 1958-1967 illustrate the current practice. The term "temporary advance" of the monsoon is still being used although the term "temporary recession" has not been used during these years.

3.15 1965 and 1966 were years of subnormal monsoon rainfall resulting in near-famine conditions in certain parts of the country. In 1967, widespread rain fell over Kerala from 12 May onwards. In the IMWR issued on the 15 May it was announced that " temporary advance of southwest monsoon has taken place into the Arabian Sea islands and Kerala". Fairly widespread rain with some heavy falls continued till 26 May after which the monsoon activity practically died down till its revival on 9 June. The question arose within the Department as to whether the spell of rain during the period 12 to 26 May should be associated with "temporary advance of the monsoon". It was apprehended that in the prevailing psychological atmosphere that existed in the country on account of the poor monsoon rainfall of the previous two years, one should exercise caution in announcing the arrival of the monsoon as early as the middle of May. In this connection, the departmental records for the period 1901 to 1967 were examined with particular reference to announcements relating to the onset of the monsoon over Kerala.

4. Statistical Analysis of Dates of Onset of the SW Monsoon over Kerala as per IMD records

4.1 In the IMWR bulletins for May/June the southwest monsoon is often ushered in as a "temporary advance". The bulletins for the succeeding days portray the behaviour of the monsoon as judged from the observed rainfall distribution and intensity. The date of permanent onset of the monsoon over Kerala is given in the Monthly Weather Report in the compilation of which a post-mortem assessment is made of the data for the entire month. The dates as given in the MWR can, therefore, be taken as "official" dates of permanent onset of the monsoon.

4.2 Examination of the IMWR for the 67-year period shows that in 16 years announcement had been made of the temporary onset ~~of the temporary onset~~ of the southwest monsoon over the Kerala coast on or before 20 May. In some years the temporary onset turned out to be the permanent one. Table 2 gives particulars of the years in question.

Table 2 : Years of temporary/permanent onset of the SW Monsoon before 20 May

Date of onset of monsoon (May)	9	10	11	12	13	14	15	16	17	18	19	20	Total
Years	1939	33	18*	22		44 60*	67		62*	40 57 61*	32 36* 55	52* 56	
Total	1	1	1	1	-	2	1	-	1	3	3	2	16
Pentad Total	2				5					9			16

* permanent onset

It is clear that there is nothing unusual about the temporary advance of the monsoon over Kerala that took place by the middle of May in 1967. Such an advance may or may not be sustained. In the years 1918, 1936, 1952, 1960, 1961 and 1962, the monsoon established itself over Kerala on or before 20 May and there was no recession of the monsoon after its initial onset. This can be readily appreciated by a reference to the rainfall charts in Appendix III. Notice that in all these years the IMD dates of onset and the dates fixed as per the rules formulated in para 6.2 differ very little.

4.3 The dates of permanent onset of the SW monsoon as per Monthly Weather Reports were analysed to find out their temporal frequency distribution. The results are presented in Table 3.

Table 9 : Frequency distribution of IMD Dates of permanent onset of the SW Monsoon

Date (MAY)	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Year	18			60			62	61	36	52	56	33	41				25		29		17
													49				27		43		22
																	50		46		51
																			55		54
																					59
																					63
Total	1	-	-	1	-	-	1	1	1	1	1	1	2	-	-		3	-	4	-	6
Pentad Frequency			2					4					4					9			

Date (JUNE)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Year	57	09	19	14	39	02	01	07	67	05	08	03	06	40	15
	66	10	20	31	45	11	04	12		42	23	35		58	
		13	28	37		26	53	30			48				
		16	44			64		34							
		21	47												
		24													
		32													
Total	2	7	5	3	2	4	3	4	1	2	3	2	1	2	1
Pentad Frequency		23					14					10			1

It will be seen that the dates are dispersed from 11 May to 15 June. In 42 years out of 67 the permanent onset of the monsoon over Kerala coast has been on or after 1 June; in 25 years it has been on or before 31 May. The pentad frequencies of onset commencing from 11 May are also shown in Table 9. Notice the pronounced peak in the frequency distribution that occurs in the pentad centred on 2 June during which the onset of the monsoon occurred in 23 years out of 67. Both the median and the mode lie in this pentad. The ten-day period from 31 May to 9 June contains the dates of onset in 37 years out of 67 ; the 20-day period from 21 May to 9 June comprises the dates of onset in 50 years out of 67 or nearly 75% of the total.

5. Need for Criteria for Declaring the Onset of the SW Monsoon over Kerala

5.1 The forecaster issues the daily weather bulletin after careful study and critical assessment of all the relevant synoptic charts (surface and upper air) at his disposal. From the beginning of May he is alert about indications relating to the advance of the southwest monsoon. While the progressive changes in the isobaric pattern and the wind circulation no doubt furnish useful guidance to the forecaster, the announcement about the advance of the monsoon is always made giving weightage to the rainfall at the observatories along the west coast of Ceylon, the Arabian sea islands and the Kerala coast. No objective criteria, however, exist for this purpose. Hence we come across certain difficulties when we examine the rainfall diagrams in Appendix III vis a vis the IMD dates of onset of the southwest monsoon over Kerala indicated by dotted arrows in these diagrams.

5.2 Let us consider the year 1904. The date of onset is given as 7 June, although rainfall commenced from 1 June. Similar remarks apply to several other years; for example, 1911, 1913, 1916, 1919, 1927, 1931, 1932, 1940, 1955 and 1959. In all these years there appears to be no strong reason why the onset of the monsoon cannot be announced a few days earlier on the basis of the rainfall. It may be asked whether we should not also take into consideration the upper air circulation features. Since rainfall is linked with the upper air circulation and is the most important feature of the southwest monsoon it is not illogical to look at the question of the onset of the monsoon on the basis of the rainfall only. It is, therefore, of interest to consider whether we can work out some objective criteria for the onset of the monsoon over Kerala on the basis of the observed daily rainfall at the seven stations that we have considered.

5.3 In the earlier years, the weather bulletins relating to the advance and onset of the monsoon were being issued only from a single forecasting office of the Department. With the formation of the Regional Meteorological Centres in 1945 and with the coming into being of the Northern Hemisphere Exchange and Analysis Centre (NHEAC) and

the Indian Ocean and Southern Hemisphere Analysis Centre (INCOHAC) more recently, weather bulletins are being originated by a large number of forecasting units of the Department. While it is not practicable to introduce absolute uniformity in the weather bulletins issued by the different offices, it is desirable that some measure of uniformity is achieved in announcing the onset of the southwest monsoon over Kerala which marks the beginning of the monsoon season for the country. For this purpose, we have to lay down certain criteria and conventions which do not exist at present. Such criteria and conventions have to be evolved essentially on the basis of the study of the past records so that the dates we arrive at by applying them are not widely divergent from the dates of onset now available in the records of the Department. It is also necessary to ensure that all the relevant factors associated with the onset of the monsoon, especially the pulsatory nature of the monsoon, are taken note of.

6. Objective Criteria for Declaring the Onset of the Monsoon over Kerala

6.1 A fact revealed by the statistics in Table 3 is that during a period of 67 years, the dates of onset of the monsoon over Kerala have been between 11 May and 15 June. If we make the reasonable assumption that this period is sufficiently long to include various possible patterns of monsoon behaviour, we may lay down the convention that rainfall occurring on the Kerala coast and the Arabian Sea islands earlier than 11 May shall not be associated with the southwest monsoon.

6.2 We have now to lay down criteria based on the rainfall at the seven stations for fixing the date of onset of the monsoon over Kerala. After a careful study of the rainfall patterns it is found that the following working rules give results which are reasonably satisfactory :-

(i) Beginning from 10 May if at least five out of the seven stations report 24-hourly rainfall ~~exceeding~~ 1 mm or more for two consecutive days the forecaster should declare on the second day that the monsoon has advanced over Kerala.

(ii) Thereafter, the daily rainfall distribution should be watched and if it is found that three or more stations out of seven report no rainfall for three consecutive days, the forecaster should indicate on the third day that the monsoon has receded from Kerala. The recession of the monsoon will thus be preceded by weak monsoon conditions at least for a day or two. (There is nothing wrong in saying that the monsoon has receded in the early stages of its onset if we bear in mind the pulsatory character of the monsoon. As a matter of fact, such announcements have been made in the daily weather bulletins in the past.)

(iii) One important point has to be borne in mind in the practical application of rule (ii). This rule can be applied only if the monsoon has not advanced into Konkan and is still confined to south of latitude 13°N. If the monsoon has advanced north of this latitude it is illogical to recede it from Kerala on the basis of the rainfall criteria given under (ii). In that case we can only say that the monsoon is weak over Kerala.

(iv) After stating that the monsoon has receded on the basis of criteria (ii) and (iii), the forecaster should continue to keep a watch of the rainfall of the seven stations and when criterion (i) is again satisfied he should declare that "the monsoon has revived over Kerala" or alternatively "a fresh advance of the monsoon has taken place over Kerala".

(v) Rules (ii) and (iii) can again be applied if required.

(vi) The date of permanent onset of the monsoon for the purpose of records may be taken as that date after which it does not become necessary to recede the monsoon from Kerala.

6.3 By applying the above rules the dates of onset of the monsoon were fixed for the individual years. The revised dates are indicated by thick arrows on the rainfall diagrams in Appendix III. The dates of "Advance" and "Recession" of the monsoon before the permanent onset are indicated by the letters A and R in the rainfall diagrams. The interval separating the thick arrow and the dotted arrow shows the extent to which the IMD and revised dates of permanent onset of monsoon differ.

6.4 It is of interest to examine in how many years temporary/permanent onset of the monsoon took place on or before 20 May according to the working rules formulated in para 6.2. This information is presented in Table 4.

Table 4 : Dates of temporary/permanent onset of the Monsoon

Date of onset of SW Monsoon (May)	11	12	13	14	15	16	17	18	19	20	Total
Years	1906	08	33	15	03	02	25*	24	27*	59*	
	1918*	~~1399~~		22	10	34	42*	32*	57		
	1930		58	26	32*	40		44	61*		
	1950*		67	38	62*	56*					
				48							
				60*							
Total	4	1	4	6	4	4	2	3	3	1	32
Pentad Total				19				13			32

* permanent onset

The application of the criteria that we have drawn up would demand the announcement of the onset of the monsoon over Kerala coast on or before 20 May in 32 years out of 67. Of these, the onset will be considered as permanent in 12 years. These figures are nearly double the corresponding numbers as per Table 2. To what extent the announcement of advance and recession of the monsoon (that is temporary advance) is justified in the individual years on the basis of the actual rainfall pattern can be seen by reference to the rainfall diagrams in Appendix III. It is obvious that the application of any objective criterion based on a single parameter cannot give results which are satisfactory in every case. For instance, the rainfall spells isolated by the letters A and R during the years 1902, 1910, 1934, 1938 and 1948 are not impressive and one can question their association with temporary advance of the monsoon. Let us, however, consider the following spells of rainfall activity that are demarcated by the application of the objective criteria:-

Year	1903	1904	1905	1915	1922	1924	1932*	1943	1944*	1957*	1967*
Date (May)	15-29	22-30	12-28	14-21	14-30	18-25	14-31	13-30	18-27	19-28	13-22

The spells in 1932, 1944, 1957 and 1967 (marked by asterisk) have been associated with "temporary advance of the monsoon" in the daily weather bulletins. Similar spells in the other years find no such association with "temporary advance" of the monsoon. Although isobaric patterns, clouds and circulation features are used as general guides by the forecaster in addition to rainfall, examination of the synoptic charts for a few years that we have made provides no convincing reason for associating the spells of rainfall with "temporary advance" of the monsoon only in some years and not in the other years. It appears reasonable to associate widespread and prolonged spells of rainfall activity occurring over Kerala and the Arabian Sea islands after 11 May with the southwest monsoon. Whether the advance is temporary or permanent will have to be decided by post-mortem study.

6.5 Table 5 gives a statistical analysis of the temporal frequency distribution of the dates of permanent onset of the monsoon over Kerala worked out on the basis of the rainfall criteria of para 6.2. It will be seen that in 31 years out of 67 the date of onset of the monsoon was between 11 and 31 May; in 36 years the onset falls between 1 and 15 June. The pentad frequencies are also given in the table. The ten-day period from 31 May to 9 June accounts for the onset in 33 years out of 67 years, the frequencies being more or less equal in the two pentads. The 20-day period from 21 May to 9 June comprises the onset in 52 years out of 67. As compared with Table 3, there is a shift in the dates of onset towards somewhat earlier dates, the frequencies in the pentads in May being larger. ~~(However the frequency in the pentad 10-14 June is less)~~ This is essentially a consequence of the fact that the forecaster often waits to see the persistence of the rainfall for a day or two before declaring the onset of the monsoon while the objective criteria fix the onset on the second day after the commencement of widespread rainfall.

6.6 For the sake of comparison, the dates of permanent onset of the monsoon as per IMD records and as fixed by our rainfall criteria are given side by side in Table 6 for the individual years 1901 to 1967. These are also shown diagramatically in Fig. 3. The number of days by which the revised dates are earlier than the IMD dates is given in the last column of this table. The two dates agree within $\pm$ 3 days in 40 years out of 67 and within $\pm$ 5 days in 48 years out of 67. It is of interest to examine the years in which the two dates differ by ten days or more. The years in question are 1911, 1916, 1925, 1932, 1942, 1955, 1959 and 1965. On the basis of rainfall alone, there are no strong reasons against revising the IMD dates of onset to an earlier date in almost all these years. It is ~~evident~~ necessary to look into this aspect in greater detail along with the synoptic charts.

Table 5 : Frequency distribution of the revised dates of persistent onset of the SW Monsoon (1901-1967)

Date	MAY 11	12	13	14	15	--	16	17	18	19	20	--	21	22	23	24	25	--	26	27	28	29	30	--	31	JUNE 1	2	3	4	--	5	6	7	8	9	--	10	11	12	13	14	--	15
Year	1918			60	32		56	25	33	27	59		36	16	41	49	11			37	50	14	29			07	04	30	02		01	26	05	67	48						06		15
	1955				62			42		61			52	54			13			38		17	44			21	09	47	10		03	35	08								58		
																						19	46			22	45	66	20		12	39	34										
																						31	57			24					23	40	53										
																										28					63	65	64										
																										43																		
																										51																		
Total	2	-	-	1	2		1	2	1	2	1		2	2	1	1	2		-	2	1	4	4		-	7	3	3	3		5	5	5	1	1		-	-	-	-	2		1
Pentad Frequency			5						7						8							11						16						17						2		1

Table 6 : Dates of Onset of the SW Monsoon over Kerala

Year	IMD Date (a)	Revised Date (b)	Difference (a)-(b) days
1901	7 J	5 J	2
02	6 J	4 J	2
03	12 J	5 J	7
04	7 J	2 J	5
05	10 J	7 J	3
06	13 J	14 J	- 1
07	8 J	1 J	7
08	11 J	7 J	4
09	2 J	2 J	0
10	2 J	4 J	- 2
11	6 J	25 M	12
12	8 J	5 J	3
13	2 J	25 M	8
14	4 J	29 M	6
15	15 J	15 J	0
16	2 J	22 M	11
17	31 M	29 M	2
18	11 M	11 M	0
19	3 J	29 M	5
20	3 J	4 J	- 1
21	2 J	1 J	1
22	31 M	1 J	- 1
23	11 J	5 J	6
24	2 J	1 J	1
25	27 M	17 M	10
1926	6 J	6 J	0
27	27 M	19 M	8
28	3 J	1 J	2
29	29 M	30 M	- 1
30	8 J	3 J	5
31	4 J	29 M	6
32	2 J	15 M	18
33	22 M	18 M	4
34	8 J	7 J	1
35	12 J	6 J	6
36	19 M	21 M	- 2
37	4 J	27 M	8
38	26 M	27 M	- 1
39	5 J	6 J	- 1
40	14 J	6 J	8
41	23 M	23 M	0
42	10 J	17 M	24
43	29 M	1 J	- 3
44	3 J	30 M	4
45	5 J	2 J	3
46	29 M	30 M	- 1
47	3 J	3 J	0
48	11 J	9 J	2
49	23 M	24 M	- 1
50	27 M	28 M	- 1
951	31 M	1 J	- 1
52	20 M	21 M	- 1
53	7 J	7 J	0
54	31 M	22 M	9
55	29 M	11 M	18
56	21 M	16 M	5
57	1 J	30 M	2
58	14 J	14 J	0
59	31 M	20 M	11
60	14 M	14 M	0
61	18 M	19 M	- 1
62	17 M	15 M	2
63	31 M	5 J	- 5
64	6 J	7 J	- 1
65	26 M	6 J	- 11
66	1 J	3 J	- 2
67	9 J	8 J	1

DATES OF ONSET OF THE SOUTHWEST MONSOON OVER KERALA

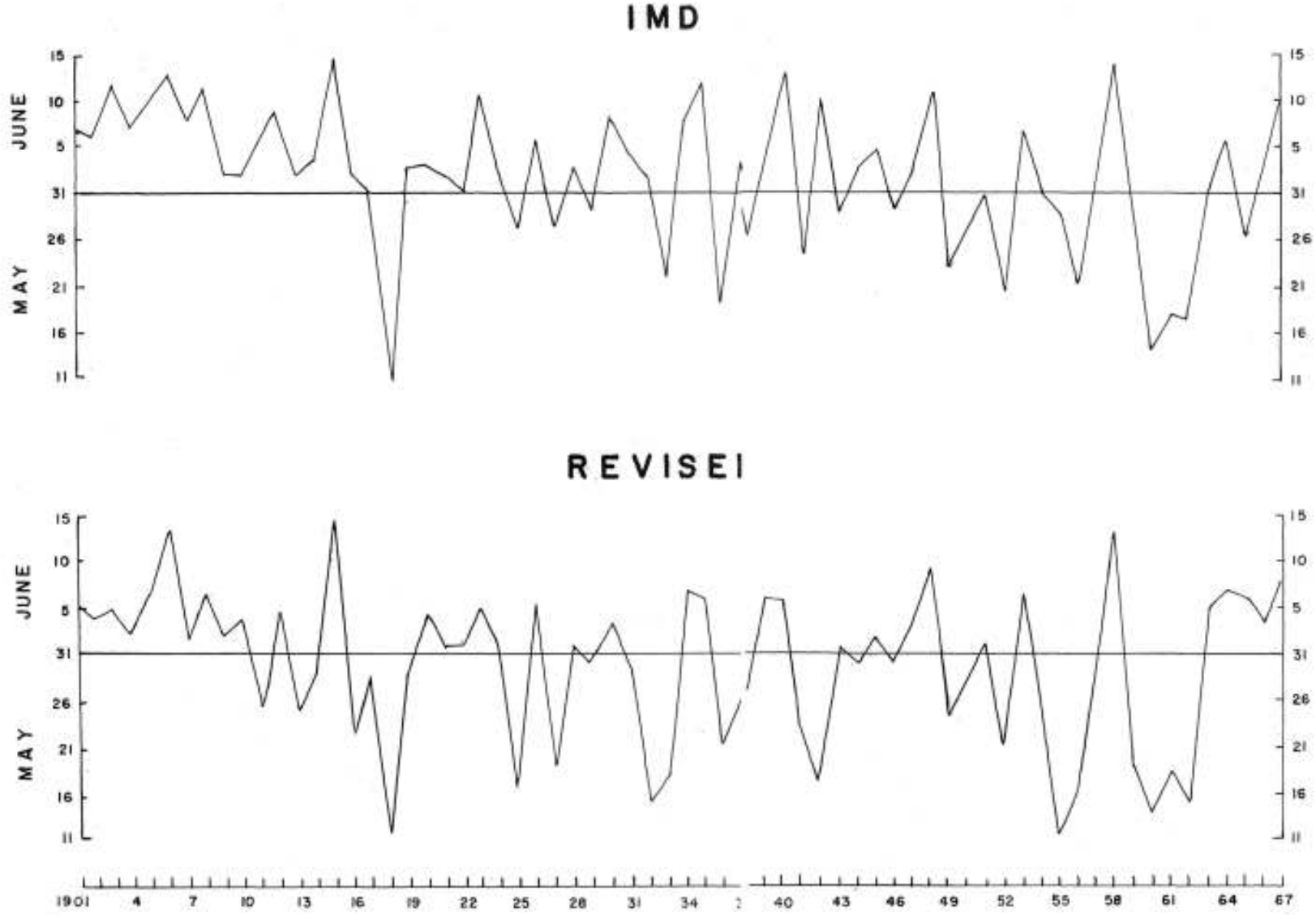

FIG. 3

7. Ramdas - Jagannathan - Gopal Rao Criteria for Establishment of Southwest Monsoon over Kerala

7.1 In a paper entitled "Prediction of the date of establishment of southwest monsoon along the West Coast of India", Ramdas, Jagannathan and Gopal Rao (1954) have worked out dates of establishment of the monsoon over Travancore-Cochin year by year for the 60-year period 1891-1950. The method adopted by them will be clear from the following quotation from their paper :-

" For fixing the actual date of establishment of the southwest monsoon in different areas, the mean daily rainfall was plotted day by day for the months of May and June for each year. x x x x x x . An inspection of these daily rainfall graphs makes it possible to fix the date of actual commencement of the persistent rainfall which is characteristic of the monsoon. Owing to the incidence of pre-monsoon rainfall, often in the form of thundershowers, the wet season starts earlier in the southern areas like Travancore-Cochin and South Kanara and merges into the later monsoon rainfall without an abrupt or sudden increase in some years. Nevertheless, it is possible to fix the date of establishment of the monsoon even in these areas. x x x x x x . In our present studies, we have fixed the date of commencement of the monsoon by looking at the charts showing the mean daily rainfall. The commencement of persistent heavy rainfall has been our main criterion so that the dates given often occur a few days later than the date which the weather forecaster is tempted to indicate in his forecasts, based on the synoptic situations and the lie of the air masses and their movements.

7.2 The date of commencement of persistent heavy rainfall fixed by visual inspection of the daily rainfall graph for the Travancore-Cochin area for May - June has been taken by Ramdas and coworkers as the "date of establishment" of the monsoon over the area. They apparently make a distinction between the "date of onset" of the monsoon as given in the weather records of the India Meteorological Department and the "date of establishment" of the monsoon as arrived at by them. The last sentence in the extract reproduced from their paper suggests that the dates of establishment would tend to be a few days later than the dates of onset as per IMD records. It appeared to be of interest to examine this matter further to find out the time interval between these two dates in different years as well as on the mean. For this purpose we have listed in Table 7 the dates of establishment of the monsoon over Travancore-Cochin as given in the paper of Ramdas and coworkers (called RJG dates in the Table) and the dates of onset of the monsoon as per IMD records, for the 50-year period 1901 to 1950. The number of days by which the IMD dates are ahead or behind the RJG dates are also given in the Table.

Table 7 : "RJG Dates of Establishment" and "IMD Dates of Onset" of the SW Monsoon over Kerala

Year	R J G Date (a)	I M D Date (b)	Difference (b)-(a) days	Year	R J G Date (a)	I M D Date (b)	Difference (b)-(a) days
1901	1 June	7 June	6	1926	28 May	6 June	9
02	31 May	6 June	6	27	23 May	27 May	4
03	8 June	12 June	4	28	31 May	3 June	3
04	29 May	7 June	9	29	29 May	29 May	0
05	6 June	10 June	4	30	21 May	8 June	18
06	3 June	13 June	10	31	23 May	4 June	12
07	31 May	8 June	8	32	14 May	2 June	19
08	8 June	11 June	3	33	22 May	22 May	0
09	1 June	2 June	1	34	6 June	8 June	2
10	28 May	2 June	5	35	10 June	12 June	2
11	1 June	6 June	5	36	20 May	19 May	- 1
12	4 June	8 June	4	37	3 June	4 June	1
13	24 May	2 June	9	38	1 June	26 May	- 6
14	28 May	4 June	7	39	6 June	5 June	- 1
15	3 June	15 June	12	40	7 June	14 June	7
16	26 May	2 June	7	41	23 May	23 May	0
17	26 May	31 May	5	42	4 June	10 June	6
18	7 May	11 May	4	43	12 May	29 May	17
19	16 May	3 June	18	44	29 May	3 June	5
20	27 May	3 June	7	45	1 June	5 June	4
21	1 June	2 June	1	46	29 May	29 May	0
22	25 May	31 May	6	47	31 May	3 June	3
23	4 June	11 June	7	48	25 May	11 June	17
24	31 May	2 June	2	49	23 May	23 May	0
25	27 May	27 May	0	50	26 May	27 May	1

7.3 The most surprising result revealed by Table 7 is that the RJG dates fall on or before the IMD dates in 47 years out of 50. This would imply that in most of the years the date of establishment of the monsoon is earlier than its date of onset as per IMD records. The differences are indeed very large in some years. We have examined the RJG dates of establishment of the monsoon over Travancore-Cochin with reference to the rainfall diagrams in Appendix III. It is difficult to reconcile these dates with the commencement of persistent heavy rainfall in a number of years, eg. 1901, 1902, 1904, 1910, 1915, 1917, 1919, 1920, 1922, 1926, 1930 and 1948. On the average the RJG

Table 8 : Frequency distributions of establishment and IMD dates of onset of the SW Monsoon (1901-1950)

Date May - June	6	7	8	9	10	—	11	12	13	14	15	—	16	17	18	19	20	—	25	—	26	27	28	29	30	—	31	1	2	3	4	—	5	6	7	8	9	—	10	11	12	13	14
Year			18						43		32			19				36	32		16	20	10	04			02	01		06	12			05	40	03			35					
																			8		17	25	14	29			07	09		15	23			34		08								
																					50		26	44			24	11		37	42			39										
																								46			28	21																
																											47	38																
																												45																
Total	-	1	-	-	-		-	1	-	1	-		1	-	-	-	1		2		3	2	3	4	-		5	6	-	3	3		-	3	1	2	-		1	-	-	-	-
Pentad Frequency			1						2					2									12						17						6						1		

Date May - June	11	12	13	14	15	—	16	17	18	19	20	—	21	22	23	24	25	—	29	—	31	1	2	3	4	—	5	6	7	8	9	—	10	11	12	13	14	—	15	16	17	18	19
Year		18								36				33	41				31		17	09	19	14		39	02	01	07			05	08	03	06	40		15				
															49						22	10	20	31		45	11	04	12			42	23	35								
																						13	28	37			26		30				48										
																						16	44						34														
																						21	47																				
																						24																					
																						32																					
Total	1	-	-	-	-		-	-	-	1	-		-	1	2	-	-		-		2	-	7	5	3		2	3	2	4	-		2	3	2	1	1		1	-	-	-	-
Pentad Frequency			1						1					3									17						11						9						1		

dates are 5.4 days earlier than the IMD dates. To illustrate this point further we have given in Table 8 the temporal frequency distribution of the RJG dates of establishment of the monsoon over Travancore-Cochin and the IMD dates of its onset. The mean and median of the RJG dates fall on 29 May; the mode falls on 1 June. The mean of the IMD dates falls on 5 June, the median on 3 June and the mode on 2 June.

7.4 The discrepancy pointed in the previous paragraph needs investigation and reconciliation since Ramdas and coworkers have made use of the dates of establishment derived by them as the basis for statistical prediction formulae which they have worked out for predicting the dates of establishment of the southwest monsoon over the southern parts of the west coast of India. Using their formulae the anticipated date of establishment of the monsoon is worked out in EDOC's office before the commencement of each monsoon season and supplied for use within the department by the Forecasting Offices. In the light of the facts revealed by Tables 7 and 8, this matter needs thorough examination.

8. Discussion

8.1 Examination of the departmental records has shown that for declaring the onset of the monsoon over Kerala there is no single, reliable and definite criterion. Besides rainfall, a number of other factors such as isobaric patterns, wind circulation,

etc. are considered by the forecaster in a qualitative manner for arriving at a decision about the onset of the monsoon. The fixation of the date of onset, therefore, becomes rather subjective and this fact is high-lighted when the records over a long period are examined. As a matter of fact, such an examination provided the motivation for our seeking plausible objective criteria which, though not satisfactory in every respect, can still provide a large measure of agreement when tested with past data. If the criteria are to be capable of rough and ready application on a day to day basis, they should be based on a single parameter which is a good index of monsoon activity and which can be quantitatively assessed. There can be little difference of opinion that rainfall is the only parameter which satisfies these conditions. Indeed, the fact that rainfall is the parameter that has been chosen for deciding the normal dates of onset of the monsoon shows the over-riding importance of this parameter as an index of monsoon activity. Moreover it is also the parameter that has been adopted by the Department to define the strength of monsoon activity over land. It may be mentioned that as a rough measure of the over-all activity of the monsoon over the country, the Daily Weather Summary issued by the Weather Central, Poona gives the actual total rainfall of all reporting stations during the preceding 24 hours side by side with the total normal rainfall of these stations.

8.2 The procedure adopted in publication A (cited in Section 2) to arrive at the normal dates of onset of the monsoon has certain drawbacks. On account of the fact that the dates of onset of the monsoon show a wide scatter over a period of nearly a month, the normal pentad rainfall of a station will show a progressive increase over such a period. This is clearly illustrated by the histograms of Minicoy, Trivandrum, Alleppey and Cochin which show a progressive increase in rainfall activity from about 10 May to about 10 June. In the circumstances, the attempt to detect the "characteristic monsoon rise" on such rainfall diagrams cannot lead to conclusive results. Indeed, it is not clear from the histograms of Minicoy and Trivandrum why the date of onset of the monsoon should have been fixed as 27 May in Fig. 1(a).

8.3 Taking into account the fact that the date of onset of the monsoon differs from year to year, and that the dates over a 67-year period lie dispersed between 11 May and 15 June, we can consider the three statistical parameters, the mean, the median and the mode for the date of onset of the monsoon over Kerala. The three different dates are listed in Table 9.

Table 9: Normal Date of Onset of the SW Monsoon (1901-1967)

Statistical Parameter	Mean	Median	Mode*
Based on IMD data	2 June	2 June	2 June
Based on rainfall criteria only	30 May	1 June	1 June

It is interesting that the mean, median and mode are all coincident when we consider the IMD dates of onset of the monsoon as given in Table 3. On the basis of the dates of onset given in Table 5 the mean date is earlier by 3 days while the median and mode are earlier by 1 day. From these considerations we may conclude that the normal date of onset of the monsoon over Kerala can be taken as 1 June as per Fig. 1(b). The earlier date of 27 May as per Fig. 1(a) cannot be accepted as the normal date.

8.4 The large variations from year to year are indeed noteworthy and are an essential characteristic of the monsoon. Among the years that we have examined, the year in which the earliest permanent onset of the monsoon occurred over Kerala was 1918. It is interesting to recall that this is one of the three severe drought years on record, the other two years being 1877 and 1899. In contrast to this, the year 1917 in which the month of May was practically dry over Kerala, and the monsoon set in at the end of May, was a year of floods over the country.

8.5 During the past decade the first five years (1958-1962) were characterised by good rainfall activity in the month of May with early onset of the monsoon (either temporary or permanent) on or before 20 May. As contrasted with this, the onset of the monsoon was towards the end of May or in the first week of June in the remaining five years. Although in 1967 the temporary advance of the monsoon over Kerala by the middle of May was followed by a dry spell and the permanent onset of the monsoon took place only by 9 June, the overall monsoon activity for the country as a whole was normal as contrasted with 1965 and 1966 during which the monsoon rainfall was in deficit over large areas in the northern and central parts of the country. The manner and date of onset of the monsoon do not provide any clue about its subsequent behaviour during the whole season.

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* Because of the irregular nature of the frequency distribution in Tables 3 and 5, it is not very meaningful to talk of a "mode" in the statistical sense. What is meant here is merely the date corresponding to the maximum in the daily frequency distribution.

8.6 It is of interest to examine the number of occasions of onset of the monsoon in May and June in decade intervals during the 67-year period covered by our study. The results are shown in Table 10 in respect of IMD dates, and the Revised dates. Similar results in respect of the RJG dates of establishment of the southwest monsoon are also given in the Table.

Table 10 : Onset of the SW Monsoon in May and June during decade intervals

Decade	IMD date of Onset		Revised date of Onset		RJG date of Establishment	
	May	June	May	June	May	June
1901--1910	0	10	0	10	4	6
1911--1920	2	8	7	3	7	3
1921--1930	4	6	3	7	8	2
1931--1940	3	7	6	4	4	6
1941--1950	5	5	6	4	8	2
					31	19
1951--1960	7	3	7	3		
1961--1967	4	3	2	5		
Total	25	42	31	36		

Notice that during the first 50 years, the IMD dates of onset of the monsoon were in May only in 14 years; the revised dates of onset fell in May in 22 years. As against this, the RJG dates of establishment of the monsoon fell in May in 31 years. During the past 17 years the IMD dates of onset fell in May in 11 years and the revised dates in 9 years. This shows that as compared with the previous years there is a tendency for the onset of the monsoon to take place earlier in the recent years. It is interesting to note that in ~~four~~ three successive years ~~1959~~, 1960, 1961, and 1962 the monsoon set in permanently on the Kerala coast near about the middle of May.

8.7 The rainfall diagrams included in Appendix III constitute the basis on which the study presented in this paper is essentially based. They provide a pictorial representation of the daily rainfall over the coast of Kerala, the Arabian Sea islands and Colombo for the two months during which the transition from the pre-monsoon to the fully-established monsoon conditions ~~are~~ is accomplished year after year. The year to year variations are considerable. The monsoon may advance over Kerala as early as the second week of May or as late as the second week of June. The advance of the monsoon can be spectacular in some years when it commences with a "burst" of rainfall on the Kerala coast preceded by a comparatively dry spell (eg. 1920, 1936, 1939, 1950, 1957) or it may creep in gradually getting merged with and almost indistinguishable from the pre-monsoon thunderstorm rain (eg. 1912, 1922, 1930, 1933, 1940, 1944, 1948, 1958,1960). In between these extremes there are patterns of varying degrees of complexity. All these pose a great challenge to the forecaster, when he is called upon to answer questions about the behaviour of the monsoon often several days in advance.

9. Association of Heavy Rainfall with the Onset of the Monsoon

The criteria for declaring the onset of the monsoon which we have considered in Section 6 lay emphasis primarily on the widespread nature of the rainfall and its persistence and not explicitly on the intensity of the rainfall. The question arises whether the intensity of rainfall is also a point that should be taken into consideration. To examine this, the rainfall amounts at the seven stations as recorded on the dates of onset of the monsoon (both IMD and Revised) have been analysed. The results are shown in Table 11(a) and (b) for rainfall amounts exceeding 2 cm and 4 cm in 24 hours respectively.

Table 11(a) : Frequency distribution: Rainfall exceeding 2 cm in 24 hours

No. of stations recording rainfall >2 cm		All 7 stations	At least 6	At least 5	At least 4	At least 3	At least 2	At least 1	N
No. of years	I M D	0	4	13	25	36	51	63	67
	Revised	1	1	5	14	25	42	58	67

Table 11(b) : Frequency distribution: Rainfall exceeding 4 cm in 24 hours

No. of stations recording rainfall >4 cm		All 7 stations	At least 6	At least 5	At least 4	At least 3	At least 2	At least 1	N
No. of years	I M D	0	0	~~2~~ 1	11	18	~~29~~ 30	~~49~~ 50	67
	Revised	0	1	2	5	11	19	43	67

N = Total number of years

Notice that 3 or more stations out of seven recorded rainfall of 2 cm or more in 36 years on the IMD dates of onset and in 25 years on the revised dates of onset. Similarly 3 or more stations recorded rainfall exceeding 4 cm in 18 years on IMD dates of onset

and in 11 years on the revised dates. The IMD dates show a bias towards higher rainfall indicating that the forecaster generally announces the onset of the monsoon after watching that some heavy falls of rain have occurred. However, from the examination of the IMD dates and the Revised dates in conjunction with the rainfall patterns it is not considered necessary to bring in the intensity of rainfall as an additional parameter to declare the onset of the monsoon.

10. Rainfall Data of Provincial Raingauge Stations

At the time of issue of the daily weather bulletins the forecaster has at his disposal only the rainfall data of the observatory stations. Hence the criteria that we have attempted to evolve for declaring the onset of the monsoon have been based purely on the rainfall data of these stations. It is well known that what distinguishes the monsoon rainfall from the pre-monsoon thunderstorm rain is the widespread nature of the former in space and in time. It is, therefore, interesting to inquire to what extent the observatory stations are representative of the surrounding areas. The daily provincial raingauge data of 22 stations around Trivandrum, Alleppey and Cochin for the period 15 May to 15 June for the years 1959 to 1965 were examined for this purpose. The occurrence of rainfall at zero, one, two or all of the three observatory stations on individual days, in relation to the number of provincial raingauge stations that recorded rainfall on the same days was examined. As is to be expected, there is a high degree of correlation between the two sets of data which indicates that the dates of onset of monsoon based on the rainfall records of the observatory stations alone, are not likely to be materially different even if we take into consideration the rainfall data of the provincial raingauge stations also.

11. Phraseology of the Daily Weather Bulletins

11.1 Declaring the initial advance of the monsoon as 'temporary' has been a practice that has continued for a long period in the department. This qualifying word is often used especially when the advance of the monsoon over Kerala occurs in May perhaps because the normal date of onset is 1 June and it covers the contingency that the monsoon may weaken and even recede. However, we have seen that the date of permanent onset of the monsoon can be as early as 11 May. Also the forecaster has no sure means at his disposal to judge beforehand whether the onset of monsoon will be temporary or permanent. In any case if the monsoon recedes, it can be indicated in the bulletin accordingly. Hence in the first part of the weather bulletin which is the description of the synoptic situation it is advisable not to use the word 'temporary' for the onset of the monsoon. Besides, the qualifying term 'temporary' is in the nature of a forecast. On occasions when the forecaster is reasonably sure that the monsoon might weaken or recede after an initial spell of activity, this information may be conveyed in suitable language in the 'forecast' part of the weather bulletin.

11.2 In the light of these discussions we may now lay down the following general rules regarding the phraseology to be used for declaring the onset of the monsoon :-

(i) The advance of the southwest monsoon over Kerala is unlikely before 11 May and any rainfall over the coastal stations of Kerala before this date should not be associated with the southwest monsoon.

(ii) From 11 May onwards the forecaster should announce the advance of the monsoon over Kerala when criterion (i) of para 6.2 is satisfied.

(iii) The qualifying term 'temporary' should not be used to describe the onset of the monsoon because at this stage the forecaster has no means of judging whether the onset of the monsoon will be temporary or permanent.

(iv) After the announcement of the onset of the monsoon, the subsequent rainfall should be described as weak, moderate, active or vigorous as the case may be, according to the departmental convention given in Table I.

(v) When weak monsoon conditions persist and criteria (ii) of para 6.2 are satisfied, the forecaster should indicate that the monsoon has receded from Kerala.

(vi) The next spell of rainfall should be indicated as 'revival' of the monsoon or 'fresh advance' of the monsoon over Kerala when criterion (i) of para 6.2 is again satisfied.

(vii) The monsoon should not be receded from Kerala after it has advanced into Konkan. Thereafter the rainfall activity over Kerala should be described as weak, moderate, active or vigorous as the case may be.

(viii) If the forecaster is confident on synoptic grounds that the rainfall associated with the onset of the monsoon will decrease and the monsoon will recede from Kerala, this may be indicated in the forecast portion of the Daily Weather Report.

(ix) The words 'temporary' and 'permanent' onset of the monsoon over Kerala may be used in the Monthly Weather Report and Annual Weather Summary because these are compiled by a post mortem scrutiny of all the past data.

(x) The date of permanent onset of the monsoon over Kerala will be the date as fixed by criterion (vi) of para 6.2.

11.4 A few examples are given below. The relevant rainfall diagrams in Appendix III should be consulted while going through the examples.

(i) 1906 :- Based on the objective rainfall criteria, onset and recession of the monsoon will have to be indicated this year three times, the corresponding spells being demarcated by A and R on the rainfall diagrams. The first onset on 11 May will be indicated as a "feeble advance of the monsoon over south Kerala coast". Notice the rather long spell of comparatively dry weather between 17 and 26 May. The application of the rainfall criteria would necessitate recession of the monsoon on 3 June and again on 17 June. The fresh advance on 14 June will be the permanent advance as the monsoon advanced beyond Konkan after this date.

(ii) 1912 :- The advance of the monsoon would be announced on 21 May and recession on 27 May. The fresh advance of the monsoon would be announced on 5 June. This will be the date of permanent onset of the monsoon.

(iii)1915 :- In this year the first advance of the monsoon is on 14 May followed by recession on 21 May. The next advance of the monsoon is on 15 June which is also the date of permanent onset.

(iv) 1927 :- The advance of the monsoon will be announced on 15 May which is also the date of permanent onset as there was no need for recession of the monsoon according to the rainfall criteria.

(v) 1928 :- In this year the advance of the monsoon will be announced on 24 May; the recession has to be indicated on 29 May, and a revival of the monsoon activity on 1 June which will be the date of permanent onset.

(vi) 1938 :- The onset of the monsoon will be announced in the bulletin issued on 15 May.

(vii) 1939 :- The 'burst of the monsoon' on the Kerala coast will be announced on 5 June.

(viii)1944 :- Advance of the monsoon will be announced in the bulletin on 18 May and recession on 27 May. The fresh advance of the monsoon will be announced on 30 May which will be the date of permanent onset.

(ix) 1945 to 1953 :- There is only one date of onset in all these years except in 1948 when two spells of advance and recession occur as shown on the rainfall diagram.

(x) 1954, 1955, 1956 :- The objective rainfall criteria give earlier dates for the onset of the monsoon than the IMD dates in these three years.

(xi) 1967 :- Advance of the monsoon will be announced on 13 May and recession on 22 May. A fresh advance will be announced on 8 June. This will be the date of permanent onset of the monsoon on the Kerala coast.

12. Conclusion

It will be seen that the objective criteria based on rainfall for declaring the onset and recession of the monsoon over Kerala and the phraseology used to describe these events based on widespread and persistent rainfall more or less conform to the practice already in vogue in the Department. By laying down certain conventions and empirical rules as suggested in this paper a large measure of uniformity both in the contents as well as in the language of the weather bulletins issued by the different forecasting offices of the Department can be achieved during the period of onset of the southwest monsoon over Kerala which marks the commencement of the monsoon season for the country. In the light of the experience gained, say over a period of five years, the matter may be revised and refinements and improvements effected as considered necessary.

Our thanks are due to the staff members of the Forecasting Manual Unit and the Investigation and Development Section of DGOF's office for assistance in the preparation of this Report. Our thanks are also due to Shri. R. N. Pandya for assistance in typing.

Summary

The records of the India Meteorological Department for the period 1901 to 1967 have been examined with specific reference to the problem of declaring the onset of the southwest Monsoon over Kerala. It has been found that the date of the onset of the monsoon can be anywhere between 11 May and 15 June. In 52 years out of 67, the date of the onset was between 21 May and 9 June. It is noticed that the date of onset has been more often in May than in June in recent years as compared with the earlier years.

No definite criteria exist at present for declaring the onset of the monsoon although rainfall at the coastal stations of Kerala and the Arabian Sea islands is the most important guide to the forecaster. The daily rainfall data of the seven stations Colombo, Minicoy, Trivandrum, Alleppey, Kozhikode and Mangalore for May and June for all the 67 years have been examined to see whether any criteria for declaring the onset of the monsoon can be evolved. The following working rules which give satisfactory results have been formulated.

If after 10 May, any five stations out of these seven get rainfall for two consecutive days, the onset of the monsoon over Kerala may be announced on the second day. If after this, any three or more stations out of these seven do not get any rain for three consecutive days, the recession of the monsoon may be announced on the third day provided the monsoon has not already advanced into Konkan. The date of onset of the monsoon over Kerala for the purpose of records may be taken as that date after which it does not become necessary to recede the monsoon any more from Kerala. The onset of the monsoon may not be described as 'temporary' or 'permanent' in the Daily Weather bulletins although this terminology can be employed in the Monthly Weather Reports, Annual Summary etc.

The dates of onset of the monsoon fixed on the basis of the objective rainfall criteria are found to be generally in good agreement with the 'official' dates of onset as per IMD records. The two dates agree within ± 3 days in 40 years out of 67. In years when the two dates show appreciable divergence, the revised dates which often fall earlier appear to be more reasonable.

The 'dates of establishment' of the southwest monsoon over Kerala worked out by Ramdas, Jagannathan and Gopal Rao (called by us RJG dates) have been compared with the 'dates of onset' of the monsoon as per IMD records. It is found that the IMD dates are later in most of the years. The contradiction involved here is pointed out and attention drawn to the importance of reconciling the two dates in view of the fact that the RJG dates form the basis of prediction formula employed in the Department for predicting the expected date of establishment of the monsoon over the Kerala coast.

References

1. ' Climatic Charts of India and Neighbourhood for Meteorologists and Airmen ' — Ind. Met. Deptt. (1943).
2. ' Climatological Charts for Airmen ' — Ind. Met. Deptt. (1943).
3. Ramdas, L.A., Jagannathan, P., and Gopal Rao, S. — 1954 Ind. J. Met. & Geophysics Vol. 5, p. 305.
4. ' Normals of Daily Accumulated Rainfall ' — Ind. Met. Deptt. (1965).

October, 1967.

Note :- The study presented in this report was made in connection with the preparation of an article on the ' Monsoons of India ' to be included in Part IV of the Forecasting Manual. The scope of this part of the Manual has been defined as ' Comprehensive articles on selected topics summarising existing knowledge and furnishing guidance for prognosis as far as possible ' .

The material of this report was presented and discussed at a Colloquium held in the Weather Central Poona on the afternoon of 11 October 1967, which was attended by several officers from the Meteorological Offices at Poona. The comments and criticisms which were stimulating mainly centred round the empirical rainfall criteria suggested in the report for trial for declaring the onset of the monsoon over Kerala. It is understandable that meteorologists should be sceptical of criteria for defining the onset of the monsoon which do not explicitly take into consideration isobaric patterns and upper air circulation features. At the opposite extreme we have attempts to evolve monsoon definitions which want to do away with rainfall and focus attention only on the circulation features (C.R.V. Raman, 1964). The reasons for our focussing attention only on the single parameter of rainfall have been stated in the report. The surface and upper air synoptic features at the time of the onset of the monsoon are not exactly repetitive from year to year despite broad similarities. Hence specification of objective criteria including explicitly these parameters also may not be easy, especially if the criteria are to be capable of rough and ready use by the forecaster. Nevertheless, it is interesting to examine the synoptic surface and upper air patterns at the time of onset of the southwest monsoon over a period of years to illustrate their diversity on the one hand and similarity on the other. Such a study will be presented in a future report. Meanwhile, it is hoped that the variety of rainfall patterns illustrated by the diagrams in Appendix III of this report will stimulate the thinking of research workers to evolve more satisfactory objective criteria, based perhaps on several parameters, for declaring the onset of the monsoon over Kerala, which marks the beginning of the monsoon season for the country. It is important that before attempting to tackle the problem of predicting the date of onset of the monsoon we should have an agreed definition of the onset.

Another criticism centred on the apparently arbitrary boundary condition set for the date of onset of the monsoon — not earlier than 11 May. The report presents results based on a factual study of the departmental records for the past 67 years and the conclusions drawn from such a study. The limit in question, has been derived from the data examined. This does not preclude the monsoon setting in earlier than 11 May in some future year; but the probability of such an event is very small.

In the years in which the monsoon 'bursts' on the Kerala coast there is no difficulty about fixing the date of onset; whatever criteria we employ should lead to the same result for the date of onset in such years. The difficulty is in respect of years in which there is no such burst. The question that arises is whether in such cases it is correct to associate widespread and persistent spells of rainfall activity along and off the Kerala coast after 10 May with 'temporary advance' of the monsoon , if the spell of rainfall activity dies down to be followed by a subsequent commencement of rainfall activity. We have taken the view that this can be done, be it in association with a well-defined synoptic system or not. Indeed, in some years the formation of a low pressure area or depression in the Comorin-Maldive area of the Southern Arabian Sea and its northward movement leads to the onset of monsoon rainfall over Kerala and its northward progress along the coast.

The normal ' date of establishment ' of the southwest monsoon over the Kerala coast utilised in the RJG prediction formula is 31 May. The predicted dates of establishment and the actual dates of onset as per IMD records for the period 1954 to 1967 are given below.

Year	RJG Date (a)	IMD Date (b)	(b)-(a) (days)
1954*	29 M	31 M	2
55*	2 J	29 M	- 4
56	1 J	21 M	-11
57*	3 J	1 J	- 2
58	30 M	14 J	15
59*	2 J	31 M	- 2
60	Not predicted	14 M	--
61	27 M	18 M	- 9
62	28 M	17 M	-11
63	23 M	31 M	8
64	27 M	6 J	10
65	4 J	26 M	- 9
66*	3 J	1 J	- 2
67	26 M	9 J	14

M - May ; J - June

Dates of establishment have been predicted using RJG formula for thirteen years so far. In the five years marked by asterisk, the predicted dates of establishment and the observed dates of onset as per IMD records agree within ± 4 days; in the remaining eight years the two dates have been divergent by one to two weeks. Notice that while the predicted dates have varied from 29 May to 4 June (17 days) the actual dates of onset have varied from 14 May to 14 June (32 days) in the thirteen year period.

References

Raman, C.R.V. " Monsoon Definition " Ind. Jour. Met. & Geophys. Vol. 15, pp. 375-378(1964).

APPENDIX I

(i) Extract from D.O. No.SC188 dated 31 August, 1948 from Shri P.S.Harihara Iyer, Asst. Met., Poona to Rao Bahadur V. Doraiswamy Iyer, retired Meteorologist, Bangalore.

My dear Rao Bahadur,

You are, no doubt, aware that the charts showing "Normal dates of onset of the S.W. Monsoon" given in the two publications "Climatic Charts of India and neighbourhood for Meteorologists and Airmen" and "Climatological Atlas for Airmen" are slightly different, especially for the Bengal area. The chart given in the "Climatological Atlas for the Airmen" which is a later publication is being taken to be the revised and hence the correct one. An attempt was made here recently to trace the notes etc. leading to the preparation of the revised chart but without success. It is, however, seen in the explanation given against 1-3 on page iii (under "normal dates of onset and withdrawal of the Southwest Monsoon" of the "Climatological Atlas for Airmen") that "at stations where the pre-monsoon thunderstorm rains merge into the monsoon rain, and the transition is gradual, other factors have also been taken into consideration." It has not been possible to find out from records here what the phrase "other factors" denotes. Since the revised chart was prepared by you, you may perhaps recollect the "other factors" used in the revision. I shall be obliged if you will let me know exactly what these factors are. I know that I am giving you a lot of trouble, but you will be good enough to excuse me.

Yours sincerely,

Sd/ P.S.H.

* * * * *

(ii) Copy of reply dated 5 September, 1948 from Rao Bahadur V.Doraiswamy Iyer to Shri P.S. Harihara Iyer.

My dear Hariharan,

Your D.O. letter No.SC188 dated 31st August, to hand. As you probably know the work in connection with the "Climatic Charts for Meteorologists and Airmen" was done mostly by Mr. S.P. Venkiteswaran. He plotted the five day normals of rainfall for the observatories and, as explained in the notes, accepted the middle date of the five-day period which showed a characteristic sudden rise of rainfall curve as the date of the onset of the monsoon.

When preparing the charts for the Climatological Charts for Airmen, I re-examined the dates of these diagrams as I had not agreed to charts as drawn, especially on the west coast and in northeast India. As is well known, thunderstorms precede the burst of the monsoon in these areas and give sometimes very heavy rainfall; and on the average therefore a sudden increase in the rainfall curve is seen even before the onset of the monsoon. But this increase is caused by the moist currents from the north and centre of the Bay of Bengal in northeast India and by temporary advances of humid currents in the southeast Arabian sea in the west coast of India.

In revising the charts I examined the work which had been done previously on the subject. A chart giving the dates of onset and withdrawal of the monsoon for the different sub-divisions of India was prepared as early as 1920. The dates of onset of the monsoon on the Malabar coast and at Bombay in individual years had been listed after an examination of the daily working charts of each year by Mr. Basu, myself and Dr. Savur. Dr. Ramdas had worked out the dates of onset of the monsoon from the district rainfall for some of the west coast districts. In the earlier Monthly Weather Reviews the dates of onset had been given for individual sub-divisions. Please see relevant file in Statistical or Climatological Branch.

On the Burma coast and in Bengal I looked into the rainfall curves of Mr. Venkiteswaran (five day normal rainfall curves) and picked out the dates of rise which were more in consonance with the gradual advance of the monsoon current up the Bay after its onset in south Tenasserim - vide pencil notes in working charts sent by you.

After the examination of all these factors I changed the dates on the west coast and on Burma coast and northeast India and modified the curves. These are reproduced in the charts of the Atlas for Airmen. I do not know where the rough chart showing the changes is.

The withdrawal of the monsoon is usually a more gradual process than the onset, and no dates have been worked out for individual years. Thus we had no certain criterion apart from the sharp decreases in the five-day normal rainfall curves. The chart agreed generally with one's ideas of the withdrawal of the monsoon and the curves were accepted. But I feel that the dates on the west coast after the 1st October require re-examination and that some slight changes may result in the shapes of the curves. I would like this to be done before the charts are finally accepted. The changes however are not likely to be large.

Hope I have satisfied you, and that the papers I have referred to and the file in which the dates of the onset of the monsoon in different sub-divisions in individual years has been listed will give you further information.

Yours sincerely,

Sd/ V. Doraiswamy Iyer.

* * * * * *

(iii) Copy of letter dated 19th January, 1959 from Sir Ronald A. Fisher, F.R.S., University of Cambridge, Department of Genetics, Whittingham Lodge, 44 Storey's Way, Cambridge, England to Professor P.C. Mahalanobis, Indian Statistical Institute, 204 Barrackpore Trunk Road, Calcutta 35 received by DDGF through DGO, New Delhi.

I have been following up some very curious slow changes in the date of winter rainfall observed by Cornish at Adelaide, and have just been delighted to find that Cape Town (roughly on the same latitude, but 120° away in longitude) has been doing almost the same thing. It may indeed be a phenomenon affecting only the southern hemisphere, but I recall Gilbert Walker's work on the monsoon, and the use he made of, I think, mean barometric pressure at Valparaiso in his prediction formula. Hence what is turning up around the southern continent may not be irrelevant to the Indian monsoon.

I believe the onset is rather sharp, and it has occurred to me that perhaps records have already been compiled giving the day of each year on which the monsoon breaks in Calcutta, for example, or in Poona. Some such easy convention as the first day with more than one-tenth of an inch of rain would give a definite date. If it is available at once I could get such a series treated comparably with the others before coming to India. Alternatively I could work them up while in Calcutta.

There may not be anything in it, but it would take rather little trouble to find out if, as I guess, good records are available perhaps for 80 or 100 years or more

(iv) Copy of draft reply sent on 23rd February, 1959 by DDGF to DGO to Prof. Fisher's query.

With reference to para 2 of Sir Ronald A. Fisher's letter dated 19.1.59 to you, I would like to offer the following remarks.

The onset of the monsoon even over the coastal stations of India is not quite sharp on many occasions. The monsoon rainfall more often than not, merges with the premonsoon thundershowers. However, once the monsoon has set in over an area, the thunderstorm activity decreases considerably and rainfall occurs over most of the stations within the area for the next few days. (There is also a change in the nature of cloudiness as well as the state of the sea at coastal stations). The dates of onset of the monsoon for the different areas have been fixed up in the India Met. Department, by taking into consideration this spacial and temporal distribution of rain over an area about 2 degrees of latitude square.

Although it has been customary to call days of rainfall with one-tenth of an inch or more as a rainy day, this amount of rainfall has not been fixed as a criterion for deciding the onset of the monsoon because the premonsoon thundershowers often give even more rain.

The progress of the Indian southwest monsoon is from the west to the east across the Peninsula and the adjoining seas. Its onset over the west coast is relatively sharper than over the Bengal area. Therefore, the dates of onset in respect of Bombay could be worked out with greater confidence and may serve the purpose of Prof. Fisher better.

The dates of onset of the monsoon at Bombay (really speaking over a radius of 100-150 miles around Bombay) fixed generally on the considerations explained in para 1 above are given for the period 1879-1959 in the enclosure.
(Enclosure not reproduced)

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(v) Extract from letter No. W630/7757 dated 10th October, 1952 from Shri S. Basu, DDGF to Mr. R.D. Kreltzheim, Asst. Director, Department of Meteorology, Ceylon.

Sub: Criteria for identifying the arrival of the southwest Monsoon.

Dear Sir,

Regarding your question, I may say that there is considerable variation year by year in the dates of onset and establishment of the southwest monsoon in the different parts of India, as well as in the speed with which the monsoon advances up from the west coast of India into the interior and the northern parts of the country. The monsoon current sometimes comes suddenly, and sometimes gradually; very often it advances temporarily, weakens and advances afresh sometime later. Under the circumstances, it has not so far been possible to evolve a single reliable and definite criterion to uniquely identify its arrival. Forecasters in this Department have used various factors for determining the arrival of the southwest monsoon along the west coast. Some of these are recapitulated below:

1. Type of clouds and the distribution and intensity of rainfall; when the monsoon is approaching the west coast, and the current is shallow, usually convective clouds (Cu or Cb) are reported from the coastal stations, and rainfall is scattered and small in amount. As soon as the monsoon has arrived, widespread rain (usually associated with thunderstorms) is reported and is heavy at places. Such a situation is described as "burst" of the monsoon. Thereafter, widespread rain occurs for a number of days, the cloud type changing to nimbostratus and alto-stratus and thundershowers generally cease.

2. Increase in the number of isobars running east-west over the Arabian Sea and Bay of Bengal between Latitudes 5° to 20°N.

3. Establishment of a low pressure area over the northwest India and trough of low pressure along the Gangetic Plain.

4. Reports of marked gustiness or squalliness along the coast. The anemograms of a station would exhibit gustiness or squalliness associated with wind shift to the southwest.

5. Sudden increase in the upper wind velocities (between surface and 10,000 ft. a.s.l.) at stations along the Malabar coast, and changes in their direction from northwest to west.

Yours faithfully,

Sd/- S.Basu
D.D.G.F.

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APPENDIX II

EXTRACTS FROM THE INDIAN DAILY WEATHER REPORTS AND MONTHLY WEATHER REPORTS.

Year	Date	Issued by	Report
1901	5 June	W.A. Bion	A Cyclonic storm is apparently forming in the southeast of the Arabian Sea probably accompanying an advance of the monsoon current.
	7 June	,,	The monsoon has broken on the Malabar coast.
	M.W.R. (June)		The first advance of the monsoon on the Malabar coast apparently occurred on the 6th.
1902	1 June	W.A. Bion	This morning's observations indicate that an advance of monsoon winds is probably taking place in the Arabian Sea.
	3 June	,,	The suspicious conditions over the Arabian sea have apparently passed away and there are no indications of any immediate advance of monsoon winds to the west coast.
	6 June	,,	Advances of the monsoon currents are apparently taking place simultaneously in both the Arabian sea and the Bay of Bengal.
	M.W.R. (June)		The monsoon rains proper set in on the south Konkan coast on the 7th and spread rapidly southwards along Malabar coast during next 24 hours.
1903	21 May	W.A. Bion	The observer at Calicut reports that the monsoon is setting in and along the Malabar coast and the rainfall and squally weather over the Peninsula and Arabian Sea apparently point to atleast a temporary advance of monsoon winds. Rain has extended along the west coast as far as Bombay.
	29 May	,,	There is upto the present no monsoon in the Arabian Sea.
	9 June	,,	There is at present no monsoon along the west coast.
	12 June	,,	The monsoon has broken at Colombo and South Malabar.
	M.W.R. (June)		On the 12th a slight cyclonic storm was shown off the north Malabar coast and the monsoon had broken at Colombo and in Travancore where heavy rainfall had fallen.
1904	20 May	H.I. Dallas	There has occurred an advance of moist southwest winds over Ceylon and the extreme south of the Peninsula.
	7 June	,,	Monsoon conditions appear to be established over Burma and the southwest of the Peninsula.
	M.W.R. (June)		On the 6th the monsoon set in on the southwest coast.
1905	19 June	J.H. Field	An advance of monsoon is taking place over the Malabar coast but it is not unlikely that the rainfall will again diminish as on the occasion of the temporary advance shown in the chart of 10th June.
	M.W.R. (June)		On the 10th a burst of monsoon rainfall occurred over the Malabar and Kanara coast districts.
1906	5 June	J. Patterson	Conditions suggest that owing to an advance of monsoon conditions, weather may be disturbed in the south of the Arabian sea at a considerable distance from the coast.
	12 June	,,	Although the precipitation on the coast has been fairly widespread, it is very doubtful whether it is connected with monsoon conditions.
	13 June	,,	The monsoon appears to be setting in on the west coast.
	M.W.R. (June)		On the 12th the monsoon broke on the Konkan coast with less than its usual strength.....The breaking of the monsoon occurred later than its normal date over the greater part of India, most notably in Malabar.
1907	2 June	G.T. Walker	There is an area of low pressure in the Arabian Sea due to an advance of monsoon winds.
	5 June	,,	Local rainfall has occurred in the extreme south Peninsula probably in connection with the advance of the monsoon winds.
	6 June	,,	The monsoon conditions which were still present to a slight extent 2 days ago in the Peninsula owing to the temporary advance of humid winds have now in great measure disappeared.
	7 June	,,	In the Peninsula, it cannot yet be said that monsoon conditions are established.

Year	Date	Issued by	Report
	8 June	,,	On the Malabar coast, another advance of the monsoon is apparently taking place.
	M.W.R (June)		The second advance of the Arabian sea current began on 3th and it established monsoon conditions on the west coast.
1908	11 June	J. Patterson	The Arabian sea monsoon has set in on the south of the west coast.
	M.W.R. (June)		The monsoon broke on the Malabar coast on 11th June being about a week over due.
1909	2 June	G.C. Simpson	On the Malabar coast there has been an advance of the monsoon which may however prove to be only of a temporary character.
	3 June	,,	The advance of the monsoon reported yesterday has been maintained.
	5 June	,,	It would appear as though monsoon conditions were gradually becoming established.
	M.W.R. (June)		The Arabian sea current arrived on the 2nd on the Malabar coast.
1910	31 May	G.T. Walker	A few falls have occurred in the extreme south where conditions have become more favourable for the approach of Arabian Sea monsoon.
	2 June	,,	The signs of the approach of the monsoon on the Malabar coast are clearer.
	3 June	,,	The area of squally weather which usually precedes the advance of the Bombay monsoon now extends along the west coast from Malabar to Gujarat.
	4 June	,,	The advance of the Bombay monsoon may be only temporary.
	6 June	,,	Stronger advance of the monsoon is now taking place on the Malabar coast. Rain due to the previous advance has been general but light in the Konkan and East Gujarat.
	M.W.R. (May)		There were no temporary irruptions of monsoon winds on the west coast such as occur there during May in most years.
	(June)		The monsoon conditions set in on the west coast of the Peninsula on the 2nd.
1911	31 May	J.H. Field	There are indications that the Arabian Sea branch of the monsoon will either be late in arrival or prove fitful in its early stages.
	2 June	,,	An advance of monsoon winds is taking place over the west and centre of the Arabian Sea.
	3 June	,,	The pressure conditions over the land area are gradually becoming more favourable to the approach of monsoon but from the scanty sea information available it appears that the advance towards India is not progressing normally.
	8 June	,,	It is probable that the present burst of rain on the west coast is due to a merely temporary advance of the monsoon.
	M.W.R. (June)		The first burst of monsoon rainfall occurred on the 6th in Malabar.
1912	28 May	G.T. Walker	Monsoon conditions have appeared in the southeast of the Arabian Sea but the advance appears temporary and feeble.
	29 May	,,	The advance still appears feeble.
	31 May	,,	The recent advance of the monsoon has exhausted itself.
	2 June	W.A. Harwood	Monsoon conditions are reappearing over the south of the Arabian Sea.
	3 June	G.T. Walker	The monsoon conditions are less evident to-day.
	4 June	J.H. Field	The monsoon is doubtless now in action out to sea off the Malabar coast.
	6 June	G.T. Walker	Monsoon conditions are not so well marked today in south India.
	7 June	,,	The advance of the monsoon has given fairly heavy rainfall on the Malabar coast.
	8 June	,,	The advance of the monsoon on the Malabar coast has extended very slightly northwards but shows very little vitality.
	M.W.R. (June)		During the first week the permanent advance of the monsoon was in progress over the Arabian Sea and thunderstorms were of almost daily occurrence on the Malabar coast but it was not until the 8th that there was heavy rainfall such as characterises the burst of the monsoon.
1913	24 May	G.C. Simpson	The conditions indicate that the monsoon is entering the southeast of the Arabian Sea.

Year	Date	Issued by	Report
	25 May	G.C.Simpson	The advance of monsoon winds into the southeast of the Arabian Sea continues.
	26 May	,,	The northward advance of the monsoon winds in the Arabian Sea continues but heavy rain has not yet appeared on the Malabar coast.
	27 May	,,	The advance of the monsoon in the south Arabian Sea has apparently been deflected towards the west.
	29 May	,,	Monsoon conditions have intensified slightly in the extreme south.
	3 June	,,	The advance of the monsoon along the west coast has temporarily stopped and the monsoon rainfall has not reached the Konkan coast.
	M.W.R. (June)		Moderate to heavy rainfall such as marks the advent of the monsoon began on the Malabar coast on the 2nd.
1914	2 June	G.T. Walker	Conditions on the Malabar coast are now such as usually precede by a few days an advance of the monsoon.
	3 June	,,	Conditions are slowly becoming more favourable for an advance of the monsoon on the Malabar coast.
	4 June	,,	Indications of the approach of the monsoon in the Arabian Sea are to-day more marked.
	5 June	,,	The monsoon has appeared on the west coast.
	M.W.R. (June)		The Arabian Sea monsoon appeared on the west coast of the Peninsula on the 4th June.
1915	5 June	G.C. Simpson	The conditions now prevailing in the south of the Peninsula are such as usually precede by a few days the appearance of the monsoon on the Malabar coast.
	6 June	,,	Indications still point to an advance of the monsoon over the south Arabian Sea.
	7 June	,,	There has been no development of the condition over the south of the Arabian Sea.
	9 June	,,	The indications of the approach of the monsoon are slightly more marked today.
	10 June	,,	There has been a further development of monsoon conditions over the south of the Arabian Sea.
	12 June	,,	Monsoon conditions now prevail over the southeast of the Arabian Sea.
	13 June	,,	The monsoon appears to have made no further advance towards the Malabar coast.
	15 June	,,	On the Malabar coast the sea is rough.....indicating that the monsoon is setting in on that coast.
	16 June	,,	The monsoon has now set in on the southwest coast where moderately heavy rain has fallen as far north as Karwar.
	M.W.R. (June)		On the 15th, the first burst of the monsoon occurred on the Malabar coast.
1916	31 May	G.T. Walker	Conditions on the west coast of the Peninsula are such as usually precede by some days the appearance of the monsoon
	2 June	,,	The monsoon has appeared on the west coast.
	M.W.R. (June)		The Arabian Sea monsoon arrived on the west coast at about the average date.....The first burst of the monsoon rainfall on the Malabar coast was reported at the beginning of the month.
1917	31 May	G.T. Walker	A feeble advance of the monsoon is occurring in the east of the Arabian Sea.
	M.W.R.(June)		At the beginning of the month the first advance of the monsoon was in progress over the Arabian Sea and rain was falling in Malabar, and the interior of the Peninsula.
1918	9 May	G.T. Walker	A feeble temporary advance of monsoon winds is probably occurring over the south of Arabian Sea.
	11 May	,,	The temporary advance of the monsoon has given rain in the south and northwest of the Peninsula.
	16 May	Hem Raj	The recent temporary advance of the monsoon over the Indian Seas has spent itself but another is in progress.
	17 May	G.T. Walker	The temporary advance of the monsoon has given nearly general rain in the south of the Peninsula.
	20 May	,,	The monsoon has weakened appreciably in North Malabar.
	21 May	,,	The advance of the monsoon continues strong in Malabar.
	M.W.R. (May)		The monsoon appeared over 3 weeks before the usual date on the Malabar coast.

Year	Date	Issued by	Report
1919	29 May	G.C. Simpson	Conditions over India have not yet become favourable for an early advance of the monsoon.
	31 May	,,	There are indications that an advance of the monsoon is taking place over the Arabian Sea.
	1 June	,,	There has been little rain on the west coast of the Peninsula but the indications of the advance of the monsoon over the Arabian Sea are more marked.
	2 June	,,	The monsoon is fairly active over the east of the Arabian Sea but it is not yet giving much rain on the west coast of the Peninsula.
	3 June	,,	The advance of the monsoon in the Arabian Sea has resulted in light to moderate rainfall in Rajputana and the neighbouring regions to the south although little or no rain has occurred on the west coast of the Peninsula.
	M.W.R. (May)		Towards the end of the month a severe storm formed in the front of the advancing monsoon current in the Arabian Sea.
	(June)		There was on the 3rd a marked increase of rainfall in the southern half of the Peninsula and by the 6th, the monsoon had penetrated practically over the whole of the Peninsula.
1920	30 May	G.T. Walker	The monsoon has not broken yet in south India.
	3 June	,,	The monsoon has set in on the Malabar coast with heavy rain and rough seas.
	M.W.R. (June)		The monsoon arrived on the Malabar coast on the 2nd.
1921	20 May	G.T. Walker	A slight temporary advance of the monsoon is apparently occurring in the south Arabian Sea.
	21 May	,,	The slight temporary advance of the monsoon has not been maintained.
	26 May	,,	The temporary advance of the monsoon has strengthened in the south of Arabian Sea.
	27 May	,,	The temporary advance of the monsoon has weakened in the Arabian Sea.
	31 May	,,	The monsoon in the Arabian Sea has not yet reached Socotra.
	1 June	,,	A feeble advance of the monsoon has occurred in the south of the Peninsula.
	2 June	,,	The feeble advance of the monsoon in the south of the Peninsula has extended into the Konkan and the south Bombay-Deccan.
	3 June	,,	The monsoon has broken on the Malabar coast.
	M.W.R.		The Monthly Weather Reviews have been discontinued in 1921 and 1922.
1922	12 May	G.T. Walker	There is a slight temporary advance of the monsoon on the Malabar coast.
	19 May	,,	The temporary advance of the monsoon has extended northwards in the Peninsula and is probably weakening.
	20 May	,,	The temporary advance of the monsoon in the Peninsula has almost disappeared.
	29 May	,,	On the Malabar coast no change is yet noticeable.
	31 May	,,	Monsoon conditions are gradually establishing themselves on the Malabar coast.
	1 June	,,	The monsoon is establishing itself in the Peninsula without the usual burst.
	2 June	,,	The monsoon has developed with unusual rapidity and has given widespread rain along the Himalayas while the customary burst of heavy rain is only now occurring along the west coast.
1923	26 May	J.H. Field	A temporary advance of the monsoon is occurring in the southeast of the Arabian Sea.
	29 May	,,	The temporary advance of the monsoon in the southeast of the Arabian Sea has weakened considerably.
	7 June	,,	There has been an increase of rainfall on the Malabar coast but the pressure distribution there has not yet changed to the monsoon type.
	9 June	,,	Rough seas are reported from the Malabar coast but the appearance of the monsoon there is still delayed.
	10 June	,,	There has been some increase of rainfall on the Malabar and the pressure distribution on west coast is tending to assume the monsoon type.
	11 June	,,	The pressure distribution today indicates that monsoon rain may be expected within a day or two along the west coast.
	12 June	,,	The monsoon has appeared on the west coast of the Peninsula from which heavy falls of rain are reported as far north as Marmagoa.

Year	Date	Issued by	Report
	M.W.R. (June)		The Arabian Sea monsoon appeared on the west coast on the 11th.
1924	21 May	C.W.B. Normand	A temporary advance of the monsoon is occurring off Malabar
	23 May	,,	The temporary advance of the monsoon in the southeast Arabian Sea has ceased.
	31 May	,,	Weather remains unsettled in the southeast Arabian Sea where an advance of monsoon appears to be occurring.
	2 June	,,	An advance of monsoon is occurring off Malabar.
	3 June	,,	Moderately heavy rain has occurred on the Kanara coast in connection with the advance of the monsoon in the southeast Arabian Sea; this advance however is not associated with the rough seas and pressure changes characteristic of the appearance of the main monsoon current.
	4 June	,,	The monsoon has appeared on the Malabar coast with rough seas and heavy rain.
	M.W.R. (May)		Rainfall increased in the south and centre of the Peninsula owing to three temporary advances of the monsoon in the southeast of Arabian Sea:- The 1st occurred on the 12th and persisted till the 16th. The 2nd lasted from 18th to 21st and the third between 27th and 29th. At the end of the month another advance was in progress.
		(June)	The Arabian Sea monsoon appeared on the Malabar coast on the 2nd.
1925	29 May	C.W.B. Normand	A weak advance of monsoon is occurring on the west coast of the Peninsula and rainfall has extended northwards to Bombay as well as in the central parts of the country.
	30 May	,,	The advance of the monsoon on the west coast of the Peninsula is maintained.
	31 May	,,	The advance of the monsoon persists on the west coast and has extended temporarily into Northwest India.
	M.W.R. (May)		On the 27th an advance of monsoon was marked by an increase of rainfall in Malabar.
		(June)	An almost complete break prevailed in its field (the Arabian Sea monsoon) during 8th to 15th. On the 16th, the Arabian Sea monsoon began to revive.
1926	7 May	B.N. Banerji	A feeble temporary advance of the monsoon is occurring in the southeast of the Arabian Sea.
	14 May	,,	Conditions are favourable for a temporary advance of monsoon in the south of the Peninsula.
	15 May	S.N. Sen	A temporary advance of the monsoon is occurring in the southeast of the Arabian Sea.
	17 May	B.N. Banerji	The advance of the monsoon in the southeast of the Arabian Sea persists but apparently no depression has yet formed there.
	18 May	,,	The unsettled conditions in the southeast Arabian Sea have disappeared.
	2 June	,,	There is as yet no indications of the approach of the monsoon in the southeast Arabian Sea.
	5 June	,,	Conditions are generally favourable for the advance of the monsoon on the west coast.
	6 June	,,	Light general rain has fallen in Malabar in connection with the advance of the Monsoon in the southeast Arabian Sea but the pressure distribution and rough seas characteristic of an active monsoon current have not yet appeared.
	7 June	,,	The advance of the Arabian Sea monsoon is still feeble.
	10 June	,,	The Arabian Sea monsoon is fairly vigorous in Malabar.
	M.W.R. (June)		On the 4th, an advance of the monsoon occurred in the southeast of the Arabian Sea and moderate to heavy rainfall in Malabar.....The Arabian Sea monsoon arrived on the west coast 5 days later than usual.
1927	20 May	S.N. Sen	There has been a temporary advance of monsoon in the neighbourhood of Ceylon.
	30 May	,,	A temporary advance of monsoon is occurring in the southeast Arabian Sea.
	2 June	,,	The monsoon is strong on the Malabar coast and is extending northwards into the south Konkan.
	M.W.R. (June)		The advance of the monsoon in the southeast Arabian Sea was practically established in Malabar on the 27th May.
1928	21 May	S.C. Roy	An advance of the monsoon is probably occurring in the south of the Indian Seas.

Year	Date	Issued by	Report
	22 May	S.C. Roy	Conditions are becoming favourable for an advance of the monsoon into the southeast Arabian Sea.
	23 May	"	Nearly general rain has fallen in Malabar and Mysore in connection with a feeble advance of the monsoon in the southeast Arabian Sea.
	25 May	"	The feeble monsoon is receding from the southeast Arabian Sea.
	2 June	"	The pressure distribution and rough seas characteristic of an active advance of the Arabian Sea monsoon have not yet appeared.
	3 June	"	Conditions are now generally favourable for the appearance of the monsoon in Malabar.
	4 June	"	The monsoon has appeared on the Malabar coast with rough seas and squally weather.
	M.W.R. (June)		The active advance of the Arabian Sea monsoon occurred on the Malabar coast on the 3rd.
1929	22 May	S.C.Roy	Conditions are gradually becoming favourable for an advance of the monsoon on the Malabar coast.
	23 May	"	On the Malabar coast rainfall has increased but rough seas and squally weather characteristic of an active advance of the monsoon have not appeared as yet.
	24 May	"	An advance of the monsoon is occurring in the neighbourhood of Ceylon.
	25 May	"	Conditions are less favourable today for a northward advance of the monsoon in the Arabian Sea.
	30 May	"	The monsoon has appeared on the west coast with heavy falls in Kanara.
	M.W.R. (May)		The Arabian Sea monsoon appeared on the west coast on the 29th with heavy falls of rain in Kanara.
1930	1 June	K.J.Kabraji	Conditions have become favourable for an advance of the monsoon on the Malabar coast.
	2 June	"	Associated with the advance of the monsoon in the southeast Arabian Sea, local rain has fallen in Malabar, but rough seas and squally weather characteristic of an active monsoon Front have not yet appeared.
	4 June	"	The feeble advance of the monsoon in the southeast Arabian Sea is not being maintained.
	7 June	K.J.Kabraji	Conditions are becoming favourable for an advance of the monsoon on the Malabar coast.
	8 June	"	An advance of the monsoon is occurring in the southeast Arabian Sea off Malabar.
	12 June	"	The Arabian Sea monsoon is reviving on the west coast south of Bombay.
	M.W.R. (June)		A weak advance of the Arabian Sea monsoon occurred on the west coast south of Bombay on the 8th.
1931	4 June	S.Basu	An advance of the southwest monsoon is occurring in the Andaman Sea and probably also in the southeast Arabian Sea.
	6 June	"	Nearly general rain has again fallen in Malabar and south Konkan in connection with an advance of the monsoon in the southeast Arabian Sea but rough seas and squally weather characteristic of an advance of the active monsoon have not yet appeared on the west coast.
	7 June	"	Conditions are favourable for an advance of the southwest monsoon on the Malabar coast.
	8 June	"	Conditions for an advance of the monsoon on the Malabar coast are less favourable.
	9 June	"	An advance of the Arabian Sea monsoon is occurring in Malabar
	M.W.R. (June)		The Arabian Sea monsoon advanced in a shallow current in Malabar and south Konkan on the 4th.
1932	19 May	S. Basu	In connection with a temporary advance of the monsoon in the southeast Arabian Sea locally very heavy rain has fallen in Malabar.
	23 May	"	The monsoon continues strong in southeast Arabian Sea and fairly widespread rain has fallen in the west coast upto Bombay.
	26 May	"	The monsoon is receding from the southeast Arabian Sea.
	27 May	"	The monsoon has receded from off Malabar.
	8 June	"	The monsoon is reviving in the southeast Arabian Sea and nearly general rain has fallen on the west coast upto Ratnagiri.
	11 June	"	The monsoon remains weak in the southeast Arabian Sea.
	14 June	"	The Arabian Sea monsoon has receded from off Malabar.

Year	Date	Issued by	Report
	17 June	S. Basu	Arrival of the Arabian Sea monsoon along and off the Malabar Kanara coasts is noticeable and nearly general rain has fallen on the west coast upto Bombay.
	M.W.R. (June)		A weak advance of the Arabian Sea monsoon occurred in Malabar, and the Konkan on 2nd.
1933	23 May	S. Basu	A temporary advance of the monsoon is occurring in the southeast Arabian Sea.
	24 May	,,	The temporary advance of the monsoon in the southeast Bay is maintained.
	M.W.R. (May)		Widespread and locally heavy rain on the Malabar coast between 9th and 12th indicated a temporary incursion of monsoon winds in the southeast Arabian Sea.....The monsoon current flowing across the extreme south of the Peninsula may be said to have established itself in Malabar on the 21st.
1934	3 June	S. Basu	Signs are noticeable for an advance of the monsoon in the southeast Arabian Sea.
	4 June	,,	The monsoon current in the south of the Indian Seas is still weak.
	8 June	,,	Signs are noticeable of a northward extension of the monsoon current in the southeast Arabian Sea.
	9 June	,,	The advance of the monsoon in the southeast Arabian Sea is maintained.
	10 June	,,	The monsoon is fairly active in the south of the Indian Seas.
	11 June	,,	The Arabian Sea monsoon has set in Malabar and has also extended into the Konkan and the Deccan.
	M.W.R. (June)		An advance of the monsoon occurred in the southeast Arabian Sea about the 2nd. The monsoon gradually strengthened thereafter and appeared in Malabar on 8th.
1935	6 June	S. Basu	A feeble advance of the monsoon appears to be occurring in the southeast Arabian Sea.
	8 June	,,	The Arabian Sea branch of the monsoon is weak.
	10 June	,,	The monsoon has been weak but showing signs of strengthening in the Southeast Arabian Sea.
	14 June	,,	The Arabian Sea monsoon has strengthened and there has been nearly general rain along the west coast of the Peninsula with heavy falls in Kanara.
	M.W.R. (June)		The Arabian Sea branch of the monsoon advanced in the southeast Arabian Sea towards the end of the 1st week of June and established itself in Malabar by the 12th June.
1936	20 May	S. Basu	Signs are noticeable of a temporary advance of the southwest monsoon in the southeast Arabian Sea.
	21 May	,,	Temporary advance of the monsoon is maintained off the Ceylon and Travancore coasts.
	25 May	,,	The Arabian Sea branch of the monsoon remains active but is not yet showing signs of northward advance along the west coast.
	M.W.R. (May)		The Arabian Sea branch of the monsoon established itself in Malabar on the 19th/20th May.
1937	19 May	S.N. Sen	The monsoon is still active in the neighbourhood of Ceylon.
	20 May	,,	The monsoon has weakened in the neighbourhood of Ceylon after a feeble advance along the Malabar coast.
	27 May	,,	The monsoon is strong in the southeast Arabian Sea.
	3 June	,,	Conditions are apparently becoming favourable for an advance of the Arabian Sea branch of the monsoon on Malabar coast.
	4 June	,,	There has been a feeble advance of the Arabian Sea branch on Malabar coast.
	5 June	,,	The monsoon is strengthening on the Malabar coast.
	M.W.R. (June)		The Arabian Sea monsoon advanced as a feeble current on the Malabar coast on the 4th/5th June, strengthened and established itself there on June 9th/10th.
1938	12 May	S.N. Sen	A preliminary advance of the southwest monsoon is taking place in the southeast Arabian Sea.
	13 May	,,	The advance of the monsoon is maintained over the region from the southeast Arabian Sea to the Andaman Sea.
	15 May	,,	The monsoon is weakening in the southeast Arabian Sea.
	26 May	,,	The monsoon is strengthening in the southeast Arabian Sea.

Year	Date	Issued by	Report
	27 May	S.N. Sen	The monsoon has advanced on the Malabar coast.
	M.W.R. (May)		The southwest monsoon made a preliminary advance into the SE Arabian Sea west of Ceylon about the 12th. The monsoon advanced on the Malabar coast about the 26th.
1939	9 May	N.K. Sur	Associated with a temporary advance of the monsoon in southeast Arabian Sea nearly general rain has occurred in Malabar.
	11 May	,,	The monsoon has weakened in the southeast Arabian Sea.
	4 June	,,	Conditions are becoming favourable for the advance of the monsoon in the east Arabian Sea.
	5 June	,,	An advance of the monsoon is occurring off Malabar and the Konkan.
	M.W.R. (June)		The Arabian Sea branch of the monsoon appeared on the west coast of the Peninsula on the 5th June.
1940	18 May	N.K. Sur	A temporary advance of the southwest monsoon is taking place in the southeast Arabian Sea off the Malabar and Ceylon coasts.
	19 May	,,	The temporary advance of the monsoon is maintained in the southeast Arabian Sea.
	21 May	,,	The advance of the monsoon in the southeast Arabian Sea is less marked.
	22 May	,,	The advance in the southeast Arabian Sea is maintained.
	23 May	,,	The monsoon is retreating from the southeast Arabian Sea.
	5 June	B.N. Desai	The western disturbance has induced an advance of the monsoon in the Kanara and the Konkan.
	6 June	,,	The advance of the monsoon in the Kanara, Konkan coast is not maintained.
	14 June	,,	An advance of the monsoon is apparently occurring in the southeast Arabian Sea off Malabar.
	15 June	,,	The monsoon has apparently weakened in the southeast Arabian Sea off Malabar.
	17 June	,,	Weak monsoon has extended along the westcoast upto Ratnagir.
	M.W.R. (May)		In the beginning of the third week, the monsoon advanced into the southeast Arabian Sea.
	(June)		The first 5 days of the month were marked by an active western disturbance which moved through northwest India and caused fairly extensive thunder showers there. On account of its unusually southerly course it induced an advance of the Arabian Sea monsoon along the west coast on the 4th which was however not maintained.....The Arabian Sea monsoon again advanced into Malabar on the 14th.
1941	22 May	S. Mal	An advance of the southwest monsoon is taking place in the southeast Arabian Sea off the Malabar coast and to the west of Ceylon.
	23 May	,,	The southwest monsoon has burst over Malabar where locally heavy rain has fallen.
	M.W.R. (May)		The monsoon advanced into the southeast Arabian Sea on the 22nd. By the morning of 23rd it had burst along the Malabar coast.
1942	29 May	S.K. Pramanik	An advance of the monsoon is occurring in the southeast Arabian Sea west of Ceylon
	4 June	,,	Conditions are favourable for advance of the monsoon in the southeast Arabian Sea.
	6 June	,,	Conditions this morning are apparently less favourable, for advance of monsoon in the southeast Arabian Sea.
	9 June	,,	Conditions are favourable for advance of monsoon in the southeast Arabian Sea.
	10 June	,,	Monsoon has advanced in the southeast Arabian Sea.
	11 June	,,	Monsoon has burst over Malabar where widespread and locally heavy rain has fallen.
	M.W.R. (June)		The monsoon advanced into the southeast Arabian Sea by the 2nd week of June and burst over Malabar on the 10th June..
1943	20 May	S.L. Malurkar	A temporary advance of monsoon is occurring in southeast and east central Arabian Sea.
	23 May	,,	Monsoon is strong in the southeast Arabian Sea.
	0 June	,,	Monsoon is active in Malabar and is extending into the Konkan.
	M.W.R. (May)		The Arabian Sea current appeared on the west coast on the 29th.

Year	Date	Issued by	Report
1944	13 May	S.I. Malurkar	A temporary advance of the southwest monsoon is occurring upto Lat 9°N in the southeast Arabian Sea.
	14 May	,,	The temporary advance of southwest monsoon is maintained in the southeast Arabian Sea.
	30 May	,,	A pulse of the southwest monsoon is advancing in Comorin and probably in the southeast Arabian Sea.
	1 June	,,	The monsoon is probably moderate in the southeast Arabian Sea and Comorin.
	3 June	,,	The monsoon is moderate to strong in the southeast Arabian Sea and off the south Konkan.
	4 June	,,	The monsoon is fairly strong in the southeast Arabian Sea and is probably advancing into the East Central Arabian Sea.
	7 June	,,	The monsoon is strengthening in the southeast Arabian Sea. It is weak in the east Central Arabian Sea.
	M.W.R. (May)		By the 10th weather became markedly unsettled in the southeast Arabian Sea and neighbourhood and ushered in a temporary advance of the southwest monsoon between the 12th and 15th.....There was another temporary advance of the monsoon in the southeast Arabian Sea in the last two days of the month.
	(June)		The feeble advance of the southwest monsoon which occurred towards the end of the previous month caused widespread rainfall in Malabar, Mysore and the south Konkan in the first four days of the month.
1945	5 June	P.R. Pisharoty	Conditions are favourable for an advance of the monsoon in the southeast Arabian Sea during the next 48
	8 June	,,	The southwest monsoon has burst on the west coast with heavy rainfall in Malabar.
	M.W.R. (June)		The Arabian Sea monsoon burst on the south Malabar coast on the 5th..... A fresh pulse of the monsoon caused heavy rain in Malabar on the 7th.
1946	28 May	P.R. Pisharoty	The southwest monsoon is advancing in the southeast Arabian Sea.
	2 May	,,	The southwest monsoon is strengthening in the southeast Arabian Sea and is advancing along Malabar.
	M.W.R. (May)		The southwest monsoon which advanced over Malabar on 29th established itself there by the 31st. However the advance was not accompanied by the usual rough seas and heavy rains on the Malabar coast.
	(June)		A fresh vigorous pulse of the monsoon arriving on the morning of the 2nd June caused widespread and locally heavy rain in Malabar.
1947	29 May	P.R. Pisharoty	A temporary advance of the monsoon is taking place in Comorin area.
	30 May	,,	The advance of the monsoon in the Comorin area is not being maintained.
	3 June	,,	A weak advance of the monsoon is occurring along the west coast of the Peninsula and has extended northwards to the south Konkan.
	M.W.R. (June)		The monsoon advanced into Comorin area on the 28th of May; but its further extension northwards was delayed till 3rd of June on which date a feeble advance occurred over Malabar.
1948	15 May	C. Ramaswamy	A temporary advance of the monsoon is taking place in the Comorin area.
	16 May	,,	The advance of the monsoon in the Comorin area is not maintained.
	28 May	,,	A feeble advance of the monsoon is taking place in the Comorin and Maldive area and the neighbourhood.
	29 May	,,	The monsoon is advancing into the Laccadives region.
	30 May	,,	The monsoon has temporarily advanced into Malabar, yesterday evening but has retreated into the Laccadives region this morning.
	31 May	,,	The monsoon in the Arabian Sea has retreated into the Maldives region and is feeble.
	3 June	,,	The southwest monsoon has advanced into southwest Arabian Sea and the adjoining parts of southeast Arabian Sea.
	6 June	,,	The monsoon is strengthening in the Maldive region.
	10 June	,,	A fresh advance of the monsoon is taking place in the southeast Arabian Sea south of 11°N.
	11 June	,,	The monsoon has burst in Malabar where locally heavy rain has fallen.
	M.W.R. (June)		The monsoon burst in Malabar on the 10th giving widespread heavy rain there.

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1949	23 May	S.N. Ray Chaudhuri	A temporary advance of the monsoon is taking place in Malabar where widespread heavy rain has fallen.
	28 May	,,	The monsoon has established itself in south Malabar.
	3 June	,,	Monsoon has established itself in North Malabar and the south Konkan.
	10 June	,,	The monsoon has been fairly active in Malabar and has weakened in south Konkan.
	13 June	,,	The monsoon has been weak in south Konkan and Malabar.
	14 June	,,	The monsoon has temporarily withdrawn from the west coast of the Peninsula.
	15 June	,,	The temporary break of the monsoon over the west coast of the Peninsula continues.
	17 June	,,	Conditions are becoming favourable for revival of monsoon in the southeast Arabian Sea and Malabar.
	18 June	,,	The monsoon is strengthening in the southeast and east central Arabian Sea and may revive along the west coast of the Peninsula.
	20 June	,,	The monsoon has revived in Malabar.
	M.W.R. (May)		The depression brought the southwest monsoon into the southeast Arabian Sea and on to Malabar where widespread heavy rain was recorded on the 23rd morning.
1950	3 May	C. Ramaswamy	Equatorial maritime air is probably advancing into Travancore Cochin.
	5 May	,,	A fresh advance of equatorial maritime air is probably again taking place in the Comorin area.
	6 May	,,	The equatorial maritime air has probably receded from the Comorin Area.
	27 May	,,	There has been a temporary advance of monsoon in Travancore Cochin.
	M.W.R.((May)		The monsoon advanced into Travancore Cochin on the 27th May and into Malabar--South Kanara on the next day.
1951	30 May	C. Ramaswamy	The southwest monsoon is advancing into the Comorin area.
	31 May	,,	The Arabian Sea branch of the monsoon is advancing into Travancore Cochin and is likely to advance into Malabar, south Kanara within the next 36 hrs.
	M.W.R. (May)		The southwest monsoon advanced into Travancore-Cochin on the 31st.
1952	17 May	T.M.K. Nedungadi	Due to the weakening of the depression there is less chance of the advance of the monsoon along the Malabar coast.
	20 May	P.K. Das	A temporary advance of monsoon has taken place in Travancore Cochin.
	M.W.R. (May)		Under the influence of the storm the southwest monsoon has ushered in [illegible]e-Cochin on the 20th May-about ten days before the normal [illegible]e.
1953	4 June	P.K. Das	Conditions are becoming favourable for the advance of the monsoon in south Ceylon and the Comorin Maldive area.
	6 June	,,	Monsoon is advancing into Ceylon and Comorin-Maldive area.
	7 June	,,	An advance of the monsoon has taken place over Ceylon and Travancore Cochin.
	M.W.R. (June)		The Arabian Sea branch of the monsoon advanced into the southeast Arabian Sea and Travancore Cochin on the 7th, about a week later than the usual date.
1954	29 May	P.R. Pisharoty	The monsoon is expected to burst over Ceylon tomorrow.
	30 May	,,	The monsoon has not yet burst over Ceylon.
	31 May	,,	The Arabian Sea branch of the monsoon has advanced over Travancore Cochin as a feeble current without rough seas and squally weather often associated with the burst of the monsoon.
	M.W.R. (May)		The Arabian Sea branch of the monsoon advanced into Travancore-Cochin on the 31st as a feeble current.
1955	11 May	P.R. Pisharoty	A temporary incursion of Equatorial Maritime air is taking place in the Maldives area.
	14 May	,,	A temporary advance of Equatorial Maritime air is taking place into Comorin area.
	17 May	,,	Conditions are becoming favourable for a temporary advance of southwest monsoon in the Comorin-Maldive area within the next 48 hrs.

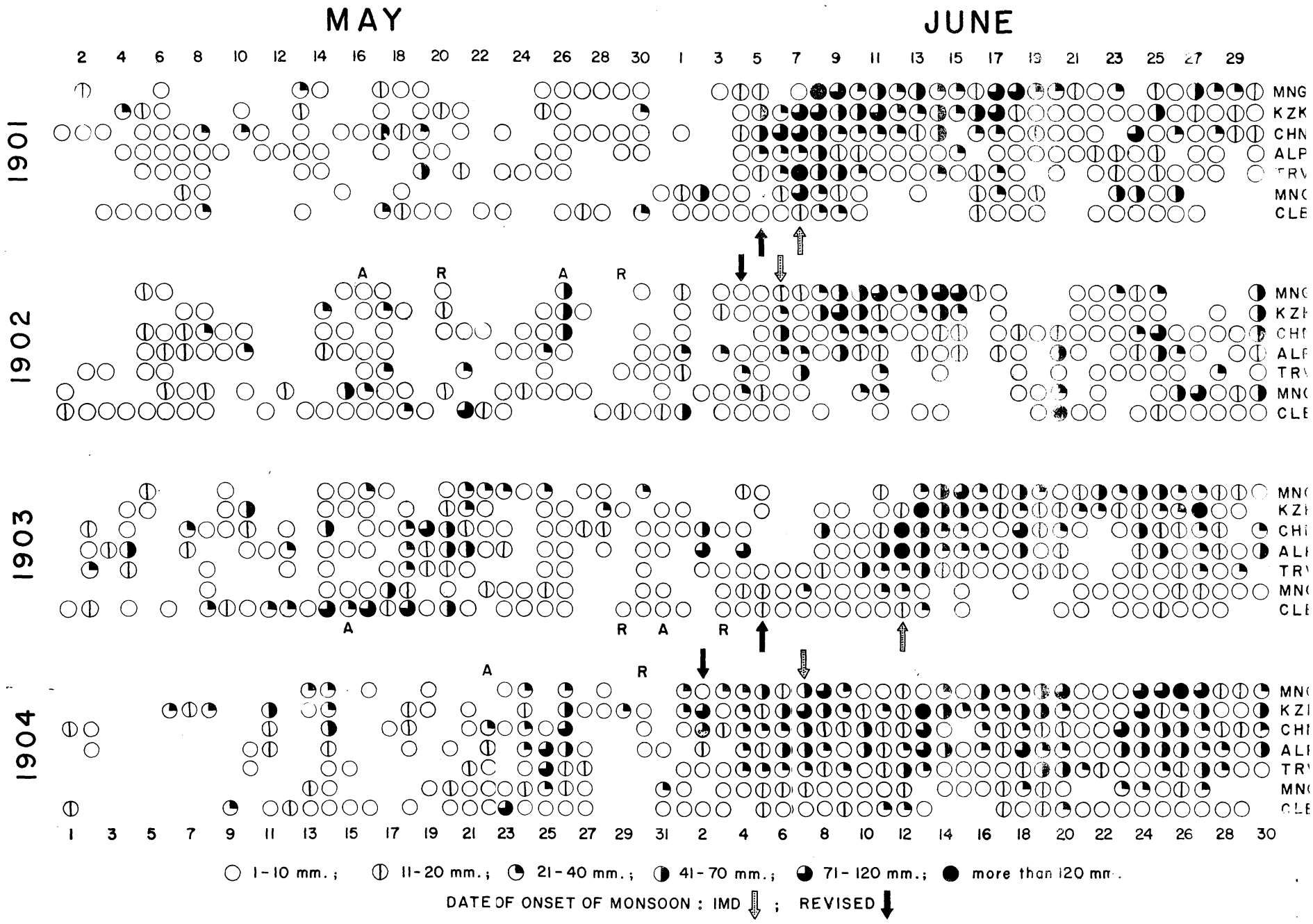
Year	Date	Issued by	Report
	18 May	P.R. Pisharoty	Monsoon is temporarily advancing into the Comorin and the Maldives area.
	19 May	"	The monsoon has temporarily advanced along and off the Malabar south Kanara coasts.
	28 May	"	The monsoon is reviving in the southeast Arabian Sea.
	29 May	"	The monsoon has revived over Travancore Cochin and Malabar south Kanara.
	M.W.R.(May)		The depression was responsible for a temporary advance of the southwest monsoon along and off Travancore-Cochin and */ very heavy rain occurred between the 18th and 20th ..... The temporary advance was however not maintained. ..... the southwest monsoon advanced in Travancore-Cochin and Malabar-South Kanara where it finally established itself on the 29th. */ Malabar-South Kanara coasts where widespread and locally
1956	15 May	P.R. Pisharoty	A temporary advance of the monsoon is taking place into the Laccadives area.
	16 May	"	Temporary advance of the monsoon into the Laccadives area is not maintained.
	18 May	"	A temporary advance of the monsoon is apparently again taking place into the Maldive-Laccadive area.
	19 May	"	The temporary advance of the monsoon into the Maldives-Laccadives area is maintained and may extend to the Malabar coast within next 48 hrs.
	20 May	S.N. Ray Chaudhuri	A temporary feeble advance of the monsoon is taking place into Travancore Cochin and south Malabar.
	21 May	P.R. Pisharoty	A temporary advance of the monsoon in Travancore-Cochin and south Malabar is maintained.
	M.W.R. (May)		The Arabian Sea branch of the monsoon advanced into Maldives Comorin area on the 18th into Travancore-Cochin and Malabar on the 21st.
1957	11 May	P.R. Pisharoty	A temporary incursion of equatorial maritime air is taking place into Ceylon and the extreme south Peninsula.
	12 May	"	Temporary incursion of equatorial maritime [illegible] extreme south Peninsula is maintained.
	14 May	"	The influx of equatorial maritime air into the extreme south Peninsula is not maintained.
	18 May	"	Equatorial Maritime air is spreading into the south Peninsula.
	22 May	P.R. Pisharoty	A temporary advance of monsoon has taken place into Kerala and neighbourhood.
	27 May	"	Yesterday's depression in east central Arabian Sea was centred at 0830 hrs. IST about 200 kms west of Bombay. Comparatively dry Arabian air which has come round the depression has served to completely cut off supply of equatorial maritime air into the south Peninsula.
	30 May	"	The southwest monsoon is advancing into Comorin-Maldive area.
	31 May	"	The Arabian Sea branch of the monsoon is confined to Maldives-Comorin area. The northern limit of the monsoon air at 1 km a.s.l. passes through Trivandrum and Port Blair.
	1 June	"	The northern limit of monsoon air at 1.0 km a.s.l. passes through Alleppey, Trichy and Port Blair.
	8 June	"	The northern limit of monsoon air 1.0 km a.s.l. passes through Honavar, Nellore, Chittagong and Imphal.
	9 June	"	The monsoon has temporarily weakened over Kerala. The northern limit of monsoon air at 1.0 km a.s.l. passes through Cochin, Trichy and thence to Akyab.
	10 June	"	Monsoon has temporarily receded from Kerala. Northern limit of monsoon air at 1.0 km a.s.l. passes through Mannar and Sandoway.
	11 June	"	The monsoon is reviving over Kerala. Northern limit of monsoon air at 1.0 km a.s.l. passes through Kozhikode, Cuddalore and Sandoway.
	M.W.R. (May)		A temporary advance of the monsoon took place into Kerala and neighbourhood on the 21st .....
		(June)	The Arabian Sea branch of the monsoon set in over Kerala on the 1st June.
1958	13 May	S.N.Ray Chaudhuri	A temporary advance of the monsoon is taking place into the Ceylon-Comorin areas.
	14 May	"	The temporary advance of the monsoon into Ceylon-Comorin areas is maintained.
	17 May	"	The temporary advance of the monsoon into Ceylon-Comorin areas is not maintained.
	24 May	"	Conditions are apparently becoming favourable for the advance of the monsoon into Ceylon-Comorin area.
	3 June	"	Conditions are favourable for an advance of the monsoon into Comorin-Maldives area.

Year	Date	Issued by	Report
	9 June	S.N. Ray Chaudhuri	Conditions are favourable for the advance of the monsoon into the southeast Arabian Sea within the next 48 hrs.
	13 June	"	Conditions are favourable for the advance of the monsoon into Kerala and southcoastal Mysore within the next 48 hrs.
	14 June	"	The monsoon has advanced into Kerala and south coastal Mysore.
	M.W.R. (June)		The monsoon advanced into Kerala and south coastal Mysore on 14th as much as about a fortnight later than the normal time.
1959	17 May	N.C. Rai Sircar	A temporary advance of the southwest monsoon may take place in the south Arabian Sea south of Lat 7°N.
	27 May	"	Conditions are becoming favourable for the advance of the monsoon into Comorin and Maldives areas.
	29 May	"	The southwest monsoon is apparently advancing into the Comorin and Maldives areas.
	30 May	"	The southwest monsoon has advanced into the Comorin and Maldives areas and is likely to burst in south Kerala within the next 36 hrs.
	31 May	"	The southwest monsoon has advanced into the south Malabar coast.
	M.W.R. (May)		The Arabian Sea branch of the monsoon advanced into the Comorin Maldives area on 30th and into south Kerala on 31st.
1960	10 May	A.A. Rama Sastry	The monsoon air is temporarily advancing into the Arabian Sea Islands and into south Kerala.
	13 May	"	Temporary advance of monsoon is likely to take place into Kerala within next 36 hrs.
	14 May	"	Monsoon has temporarily advanced into Kerala and is feeble.
	17 May	"	Monsoon has been vigorous in south Kerala.
	21 May	"	The monsoon has strengthened over Kerala and is likely to advance into coastal Mysore during next 24 hrs.
	22 May	"	Northern limit of monsoon runs through Honavar, Nellore Coco Island and Amherst.
	29 May	"	The Arabian Sea branch of the monsoon is strengthening along the Malabar-Kanara coasts and is likely to advance into the extreme south Peninsula within next 36 hrs.
	31 May	T. M.K. Nedungadi	The monsoon current is weak along the west coast and is likely to be weak.
	8 June	T.M.K. Nedungadi	The monsoon current has advanced into the south Konkan and its northern limit runs through Harnai, Kakinada and Akyab.
	M.W.R. (May)		Monsoon advanced into Kerala on 14th more than a fortnight earlier than usual.
1961	19 May	P.S.Pant	The Arabian Sea branch of the monsoon is advancing into the extreme south Arabian Sea south of Lat 7°N and conditions are favourable for its advance into south Kerala within the next 48 hrs.
	20 May	"	The Arabian Sea branch of the monsoon is confined to south of Lat 7°N.
	21 May	"	The Arabian Sea branch of the monsoon has rapidly advanced along the west coast upto Lat 13°N.
	M.W.R. (May)		The Arabian Sea branch of the monsoon advanced into extreme south Kerala on 18th and rapidly extended northwards upto Lat 16°N by 22nd.
1962	14 May	T.M.K. Nedungadi	The southwest monsoon has temporarily advanced into the Maldives, Comorin area and may extend into the Laccadive area within the next 48 hrs.
	15 May	"	The southwest monsoon is confined to Comorin Maldive area and Ceylon.
	17 May	"	The southwest monsoon has set in over south Kerala.
	18 May	"	The monsoon has advanced into Kerala and south coastal Mysore and is likely to extend temporarily north coastal Mysore and South Kanara.
	M.W.R. (May)		The southwest monsoon advanced into south Kerala on 17th May and extended steadily northwards along the west coast.
1963	21 May	K.K. Saha	The monsoon has temporarily advanced into the Arabian Sea upto Lat 10°N.
	22 May	"	The temporary advance of the Arabian Sea branch of the monsoon is maintained upto Lat 10°N.
	25 May	"	The Arabian Sea branch of the monsoon is advancing into Kerala.
	1 June	"	The monsoon is generally moderate over the Arabian Sea south of Lat 10°N.

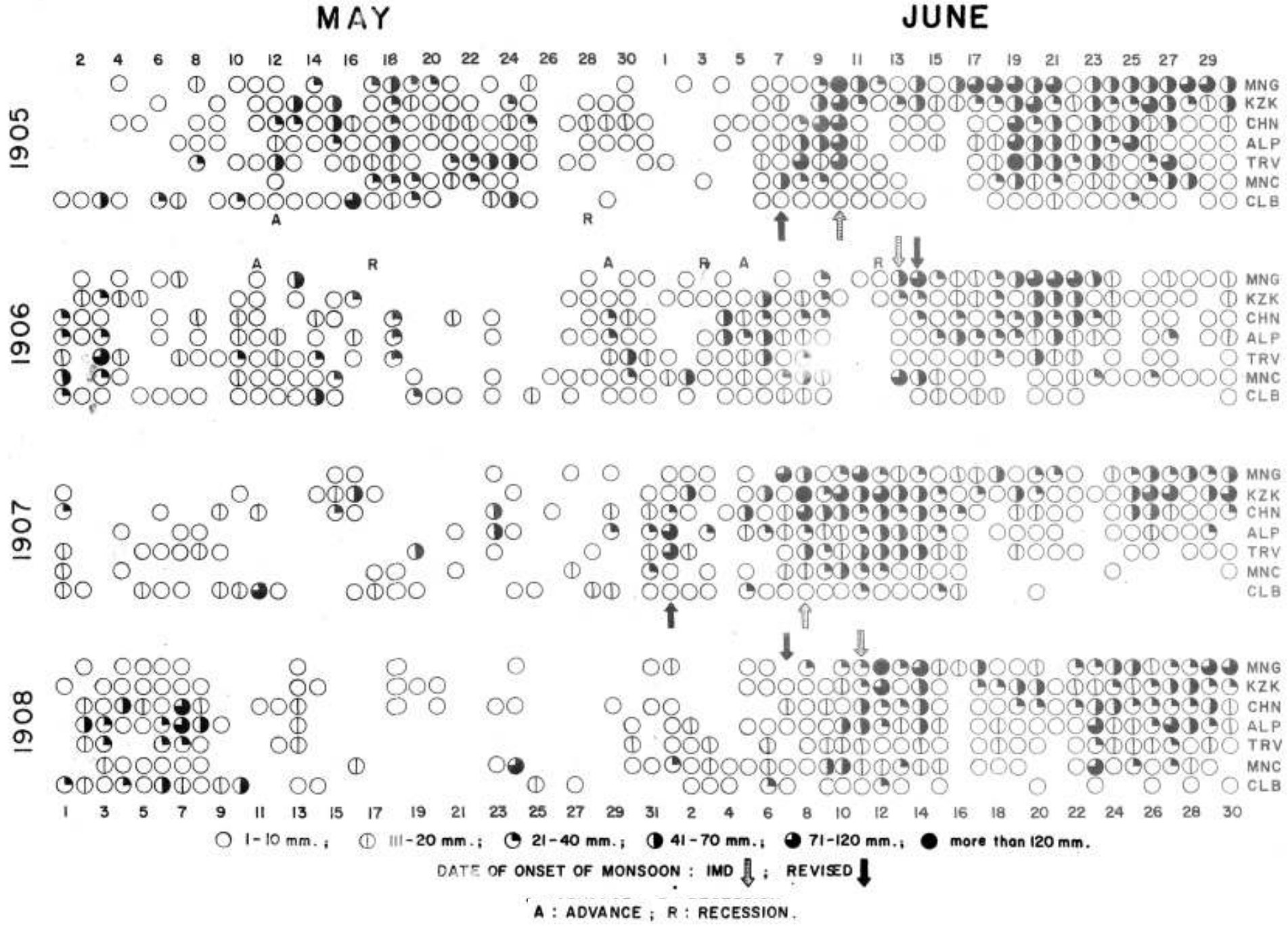
Year	Date	Issued by	Report
	3 June	K.R. Saha	The monsoon has advanced as a weak current into Kerala. Its northern limit runs through Amini Divi, Calicut, Nagapattinam and Diamond Island.
	M.W.R. (May)		Southwest monsoon advanced into the extreme south Kerala on 31st May which is about the normal date.
	(June)		The southwest monsoon extended rapidly northwards upto the south Konkan by 5th June.
1964	26 May	K.R. Saha	The southwest monsoon is establishing over southeast Arabian Sea south of Lat 10°N.
	28 May	,,	Initial indications of establishment of southwest monsoon over southeast Arabian Sea south of Lat 10°N are not maintained.
	4 June	,,	Conditions are becoming favourable for extension of monsoon over Comorin, Maldives areas.
	6 June	,,	The southwest monsoon has advanced into south Kerala and southeast Arabian Sea upto lat 10°N. The northern limit of the monsoon runs through Cochin, Nagapattinam and thence to Rangoon.
	M.W.R. (June)		The southwest monsoon advanced slowly and set in over south Kerala on 5th, which is about 5 days later than the normal date.
1965	25 May	K.L. Sinha	The southwest monsoon is advancing into the Comorin, Maldive area.
	26 May	,,	The southwest monsoon has advanced into Kerala south of lat 10°N. The northern limit of the monsoon current passes through Cochin, Nagapattinam and thence to Diamond Island.
	M.W.R. (May)		The Arabian Sea branch of the monsoon advanced into south Kerala on 26th of May.
1966	26 May	T. Ramanada Rao	The southwest monsoon is advancing into the Comorin area.
	29 May	,,	The Arabian Sea branch of the monsoon is advancing into Maldive area and the adjoining southeast Arabian Sea south of Lat 8°N.
	3 June	E.V. Chelam	Monsoon has advanced into south Kerala and into south Arabian Sea south of Lat 10°N.
	4 June	,,	The monsoon is advancing into north Kerala.
	5 June	,,	The monsoon has advanced into north Kerala.
	M.W.R. (May)		The Arabian Sea branch of the monsoon advanced upto lat 8°N by the end of the month.
	(June)		The southwest monsoon set in over south Kerala on 1st June which is about the normal date.
1967	15 May	K.L. Sinha	Temporary advance of southwest monsoon has taken place into the Arabian Sea Islands and Kerala.
	9 June	,,	The monsoon has revived over Kerala.

DAILY RAINFALL

APPENDIX III



DAILY RAINFALL



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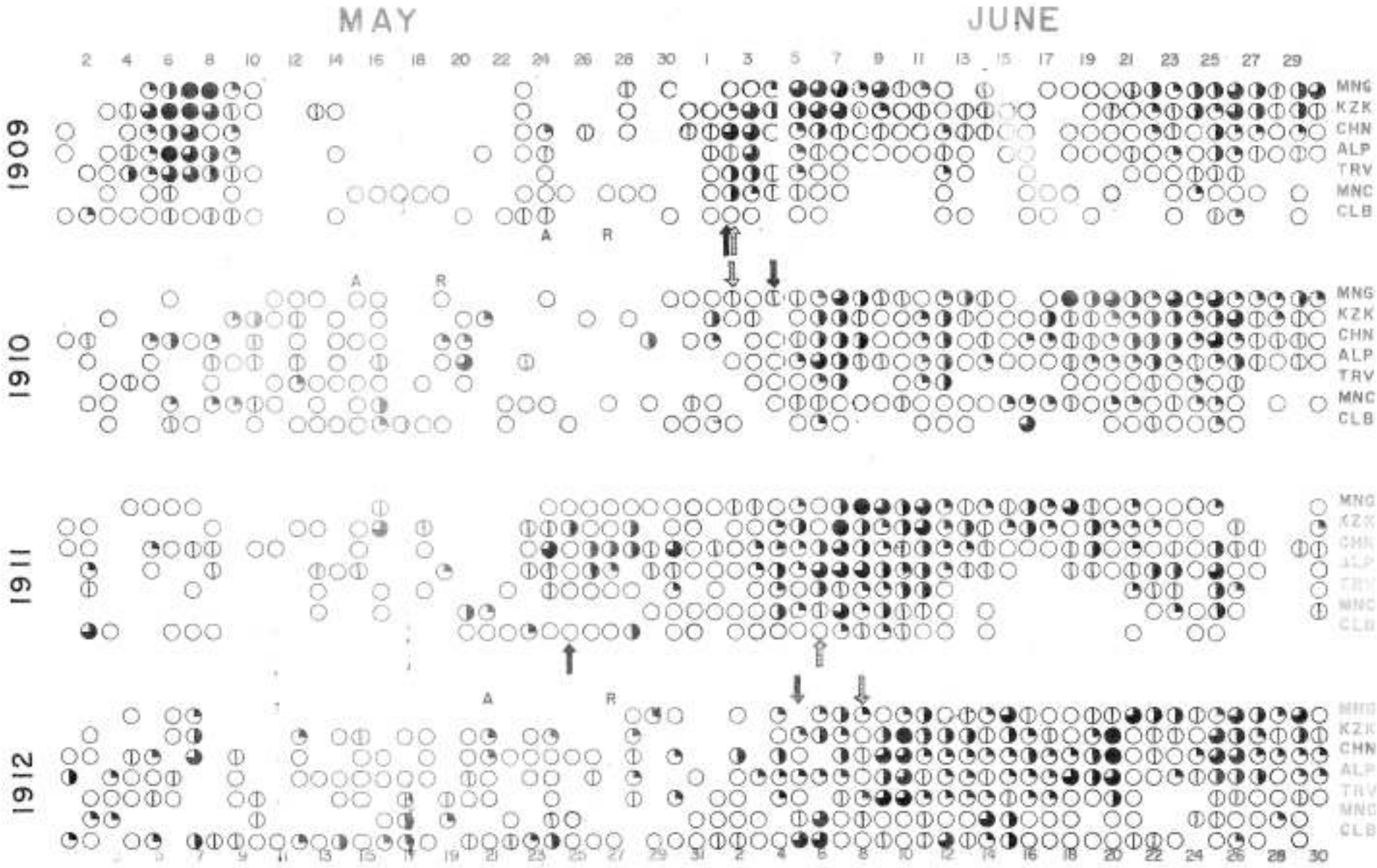
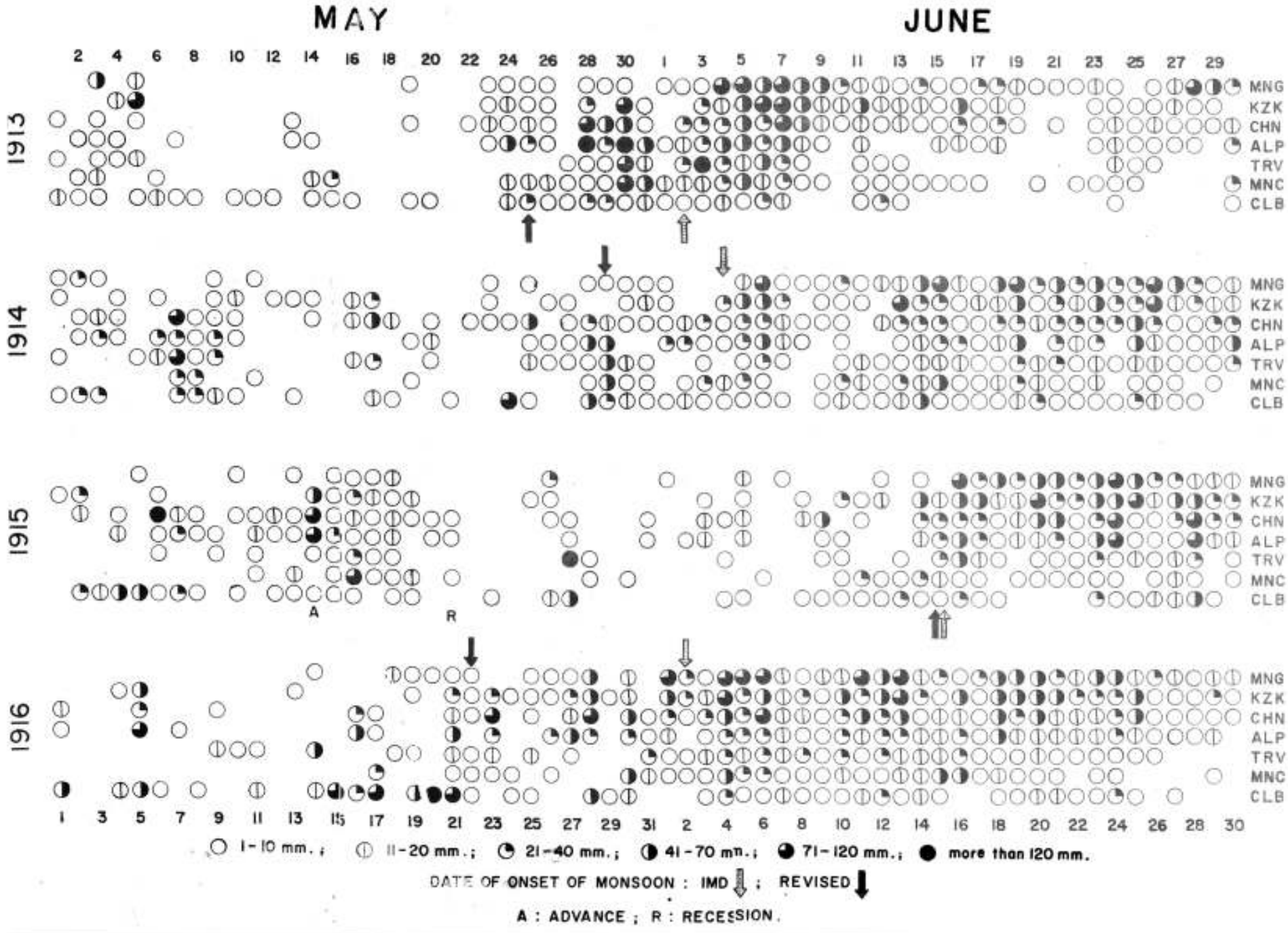


○ 1 - 10 mm. ; ◔ 11 - 20 mm. ; ◔ 21 - 40 mm. ; ◑ 41 - 70 mm. ; ◕ 71 - 120 mm. ; ● more than 120 mm.

DATE OF ONSET OF MONSOON : IMD ⇩ ; REVISED ⬇

A : ADVANCE ; R : RECESSION.

DAILY RAINFALL



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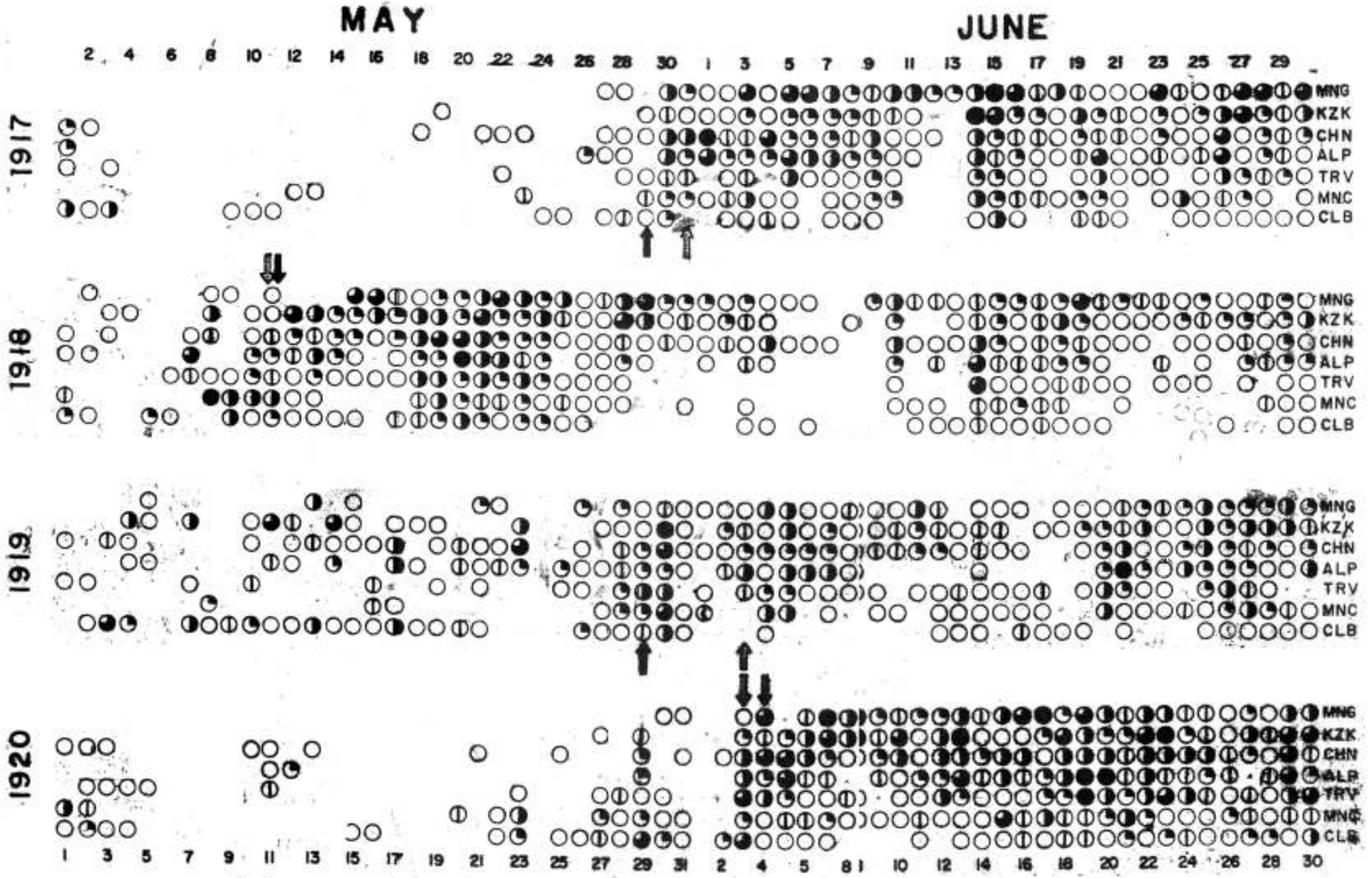

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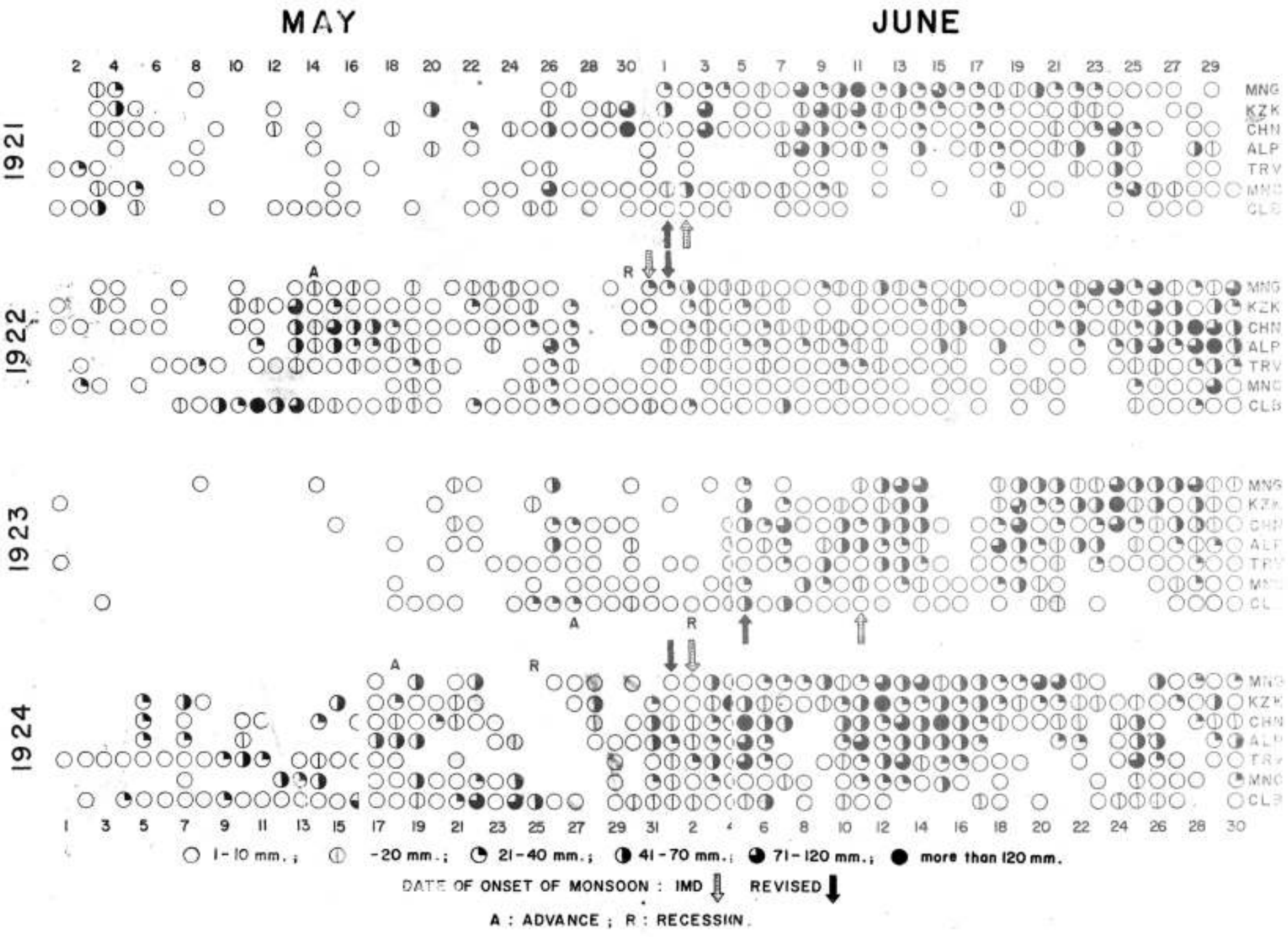
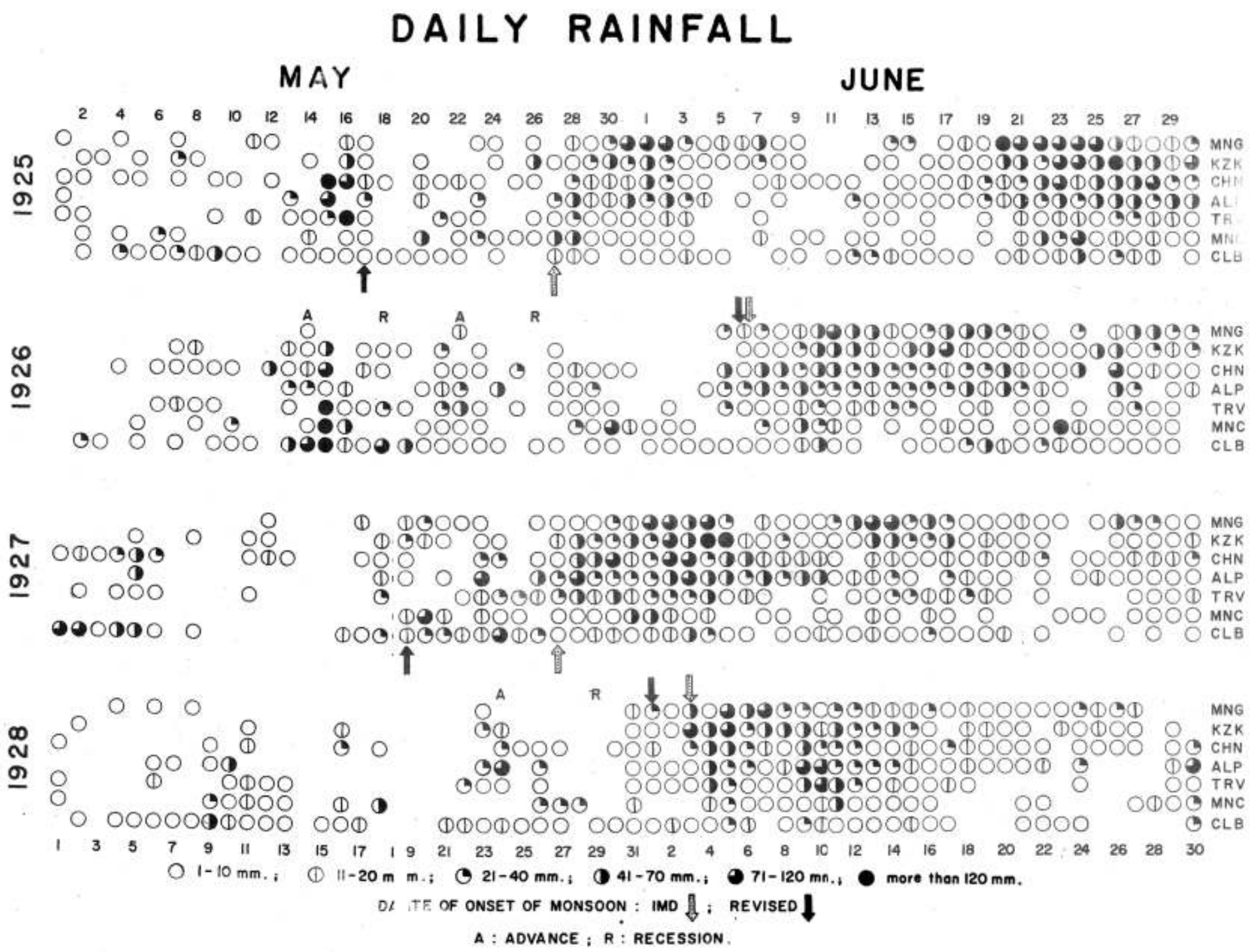
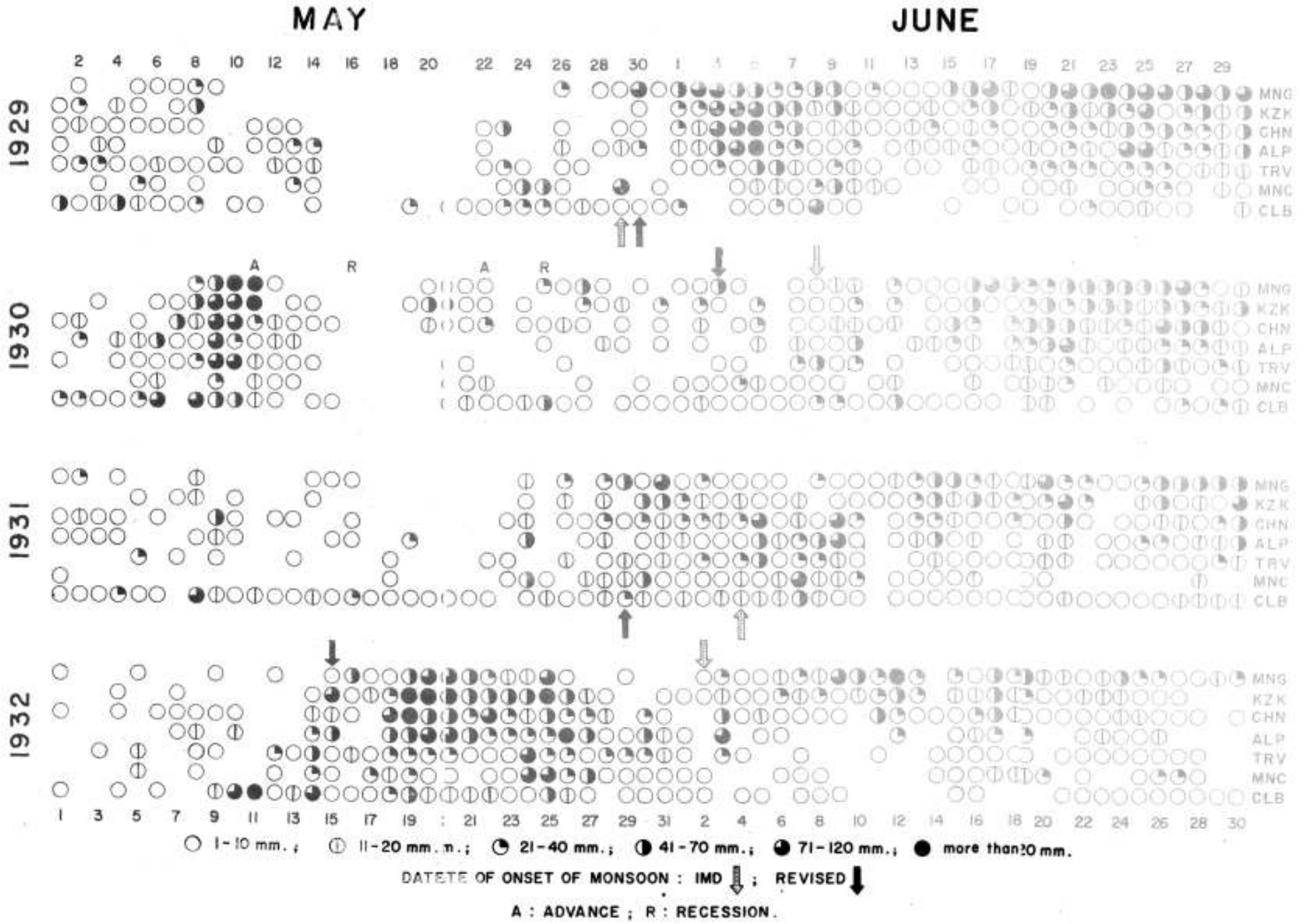



DAILY RAINFALL
MAY
JUNE
1925
1926
1927
1928
MNG
KZK
CHN
ALP
TRV
MNC
CLB
A
R
1 - 10 mm. ; 11 - 20 m m. ; 21 - 40 mm. ; 41 - 70 mm. ; 71 - 120 mm. ; more than 120 mm.
DATE OF ONSET OF MONSOON : IMD ; REVISED
A : ADVANCE ; R : RECESSION.

DAILY RAINFALL



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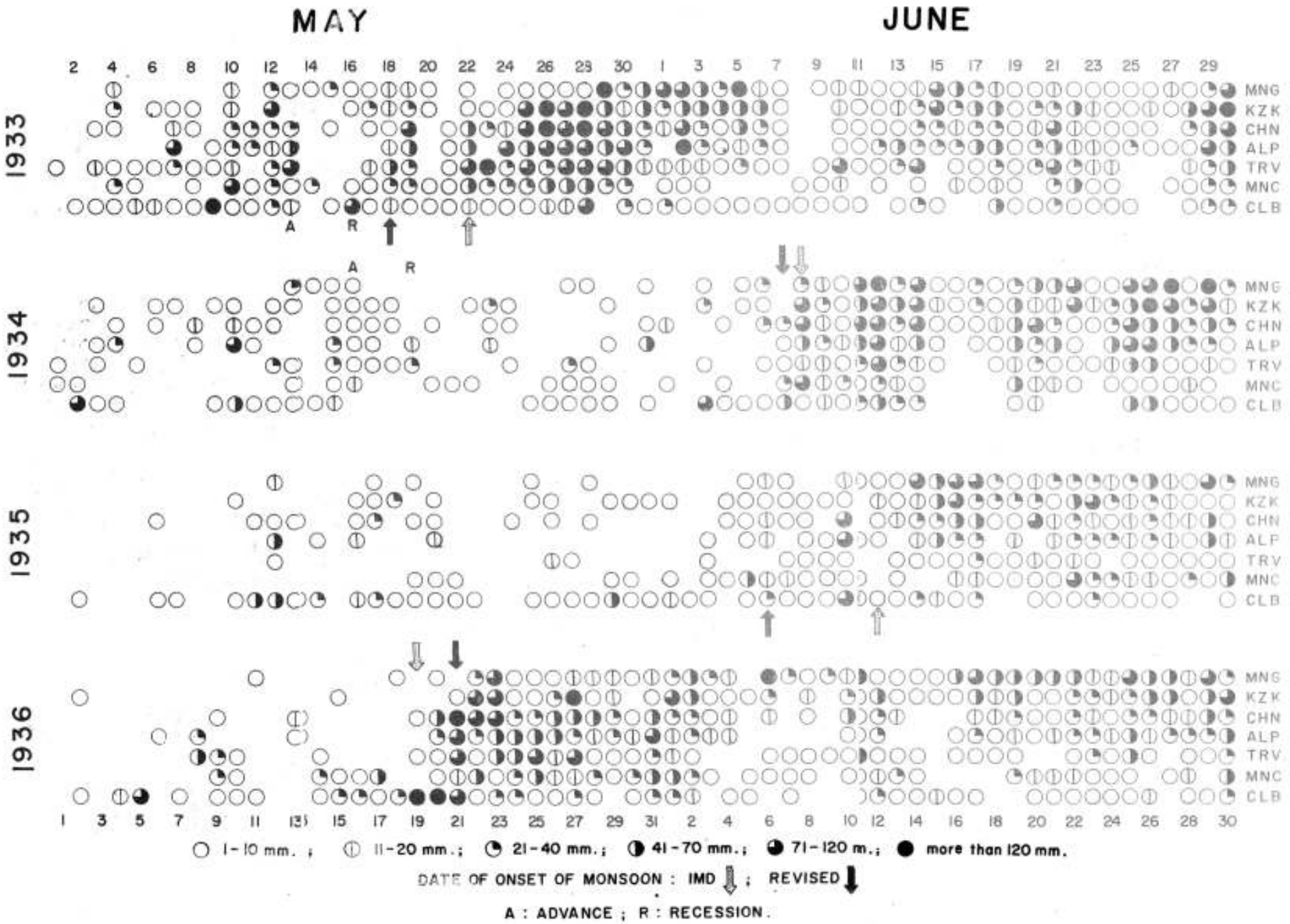

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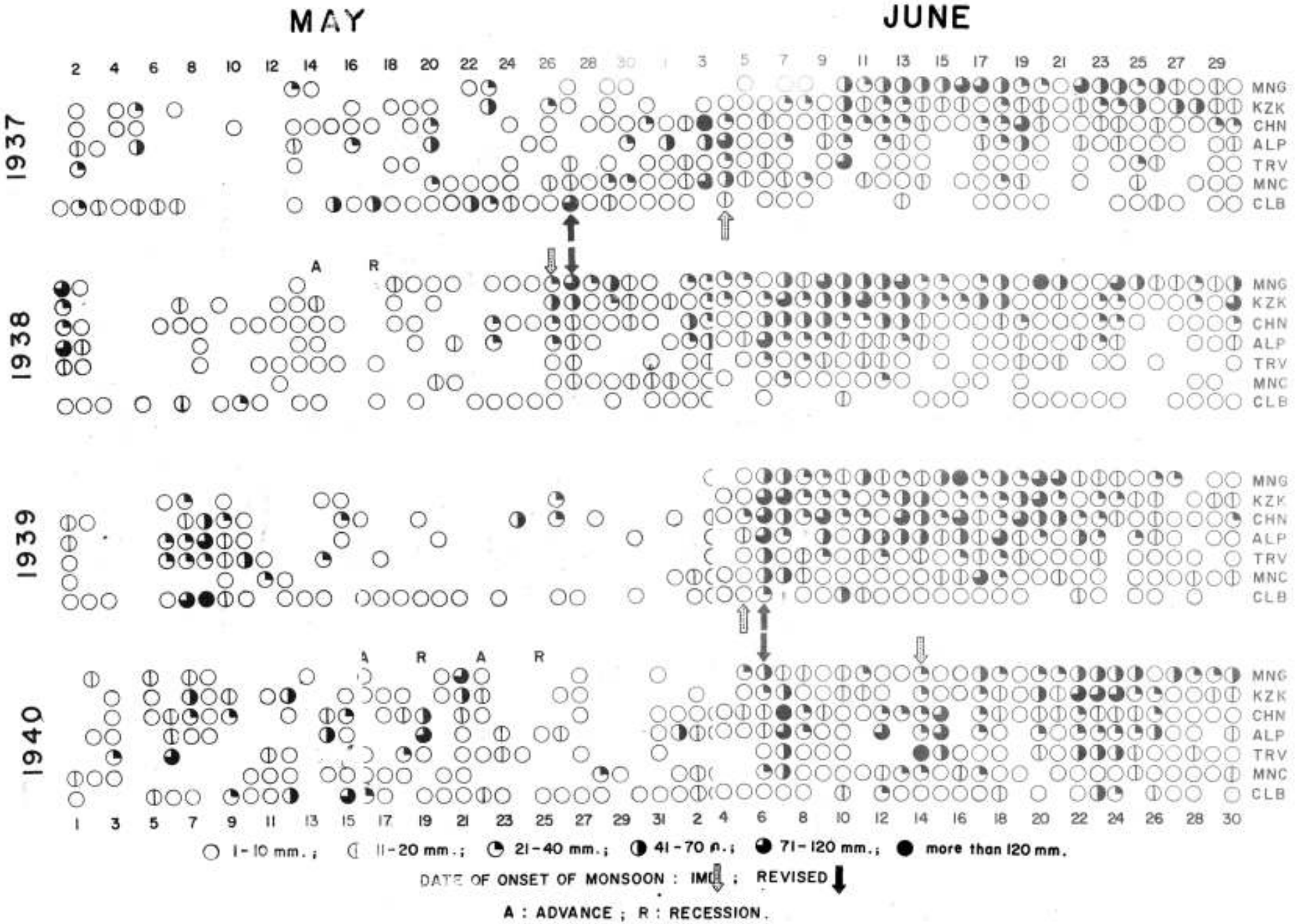

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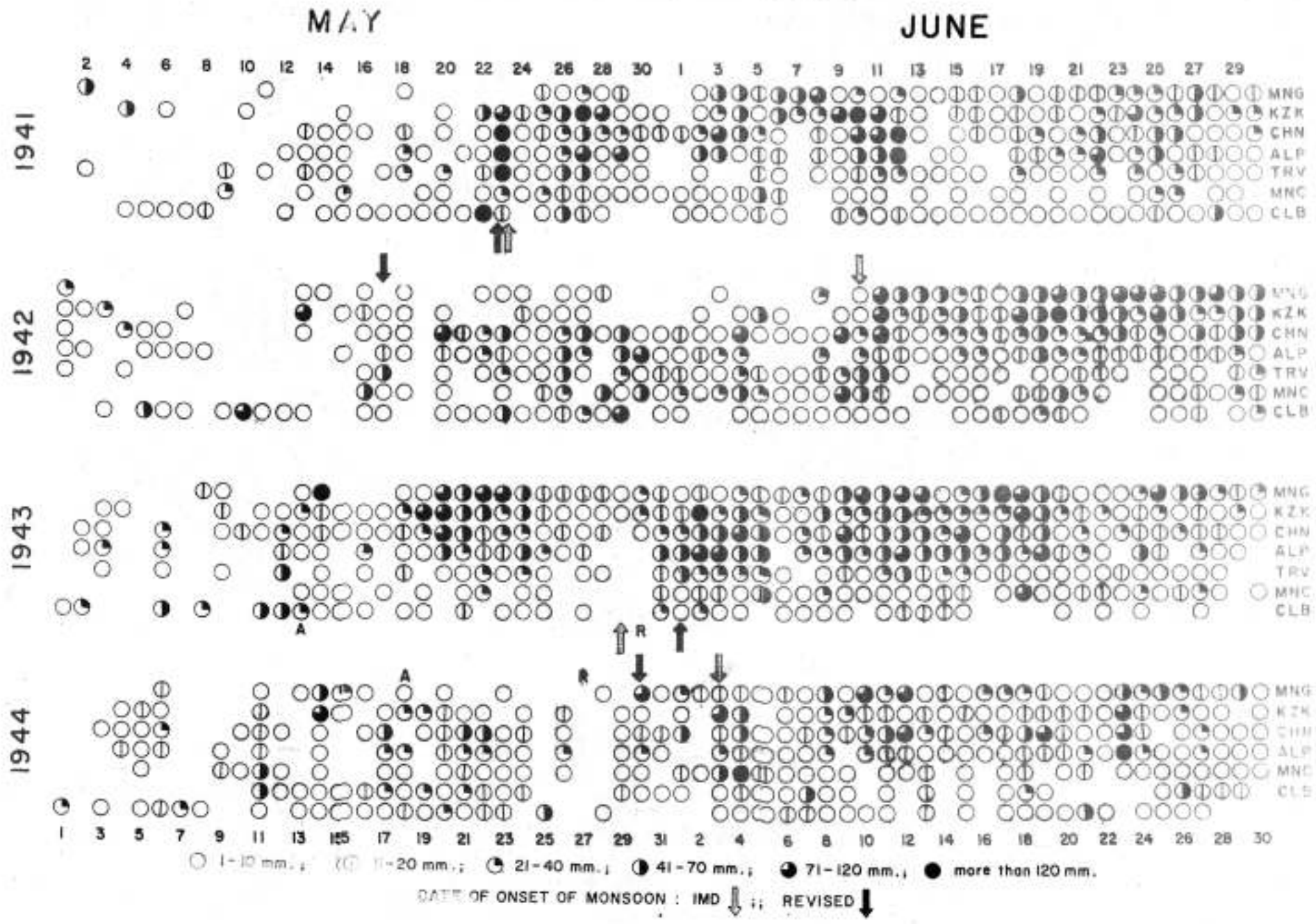
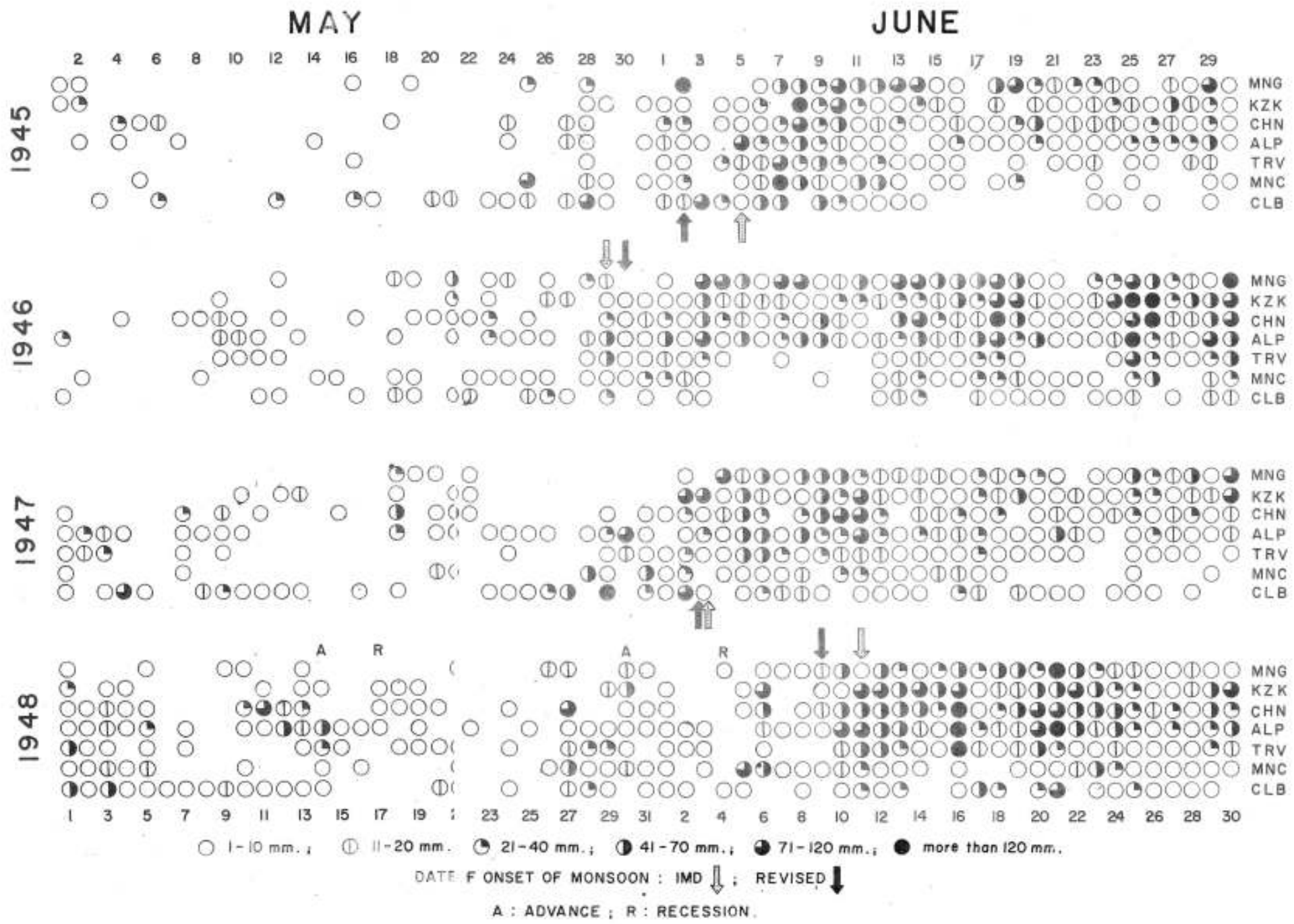


A : ADVANCE ; R : RECESSION.

DAILY RAINFALL



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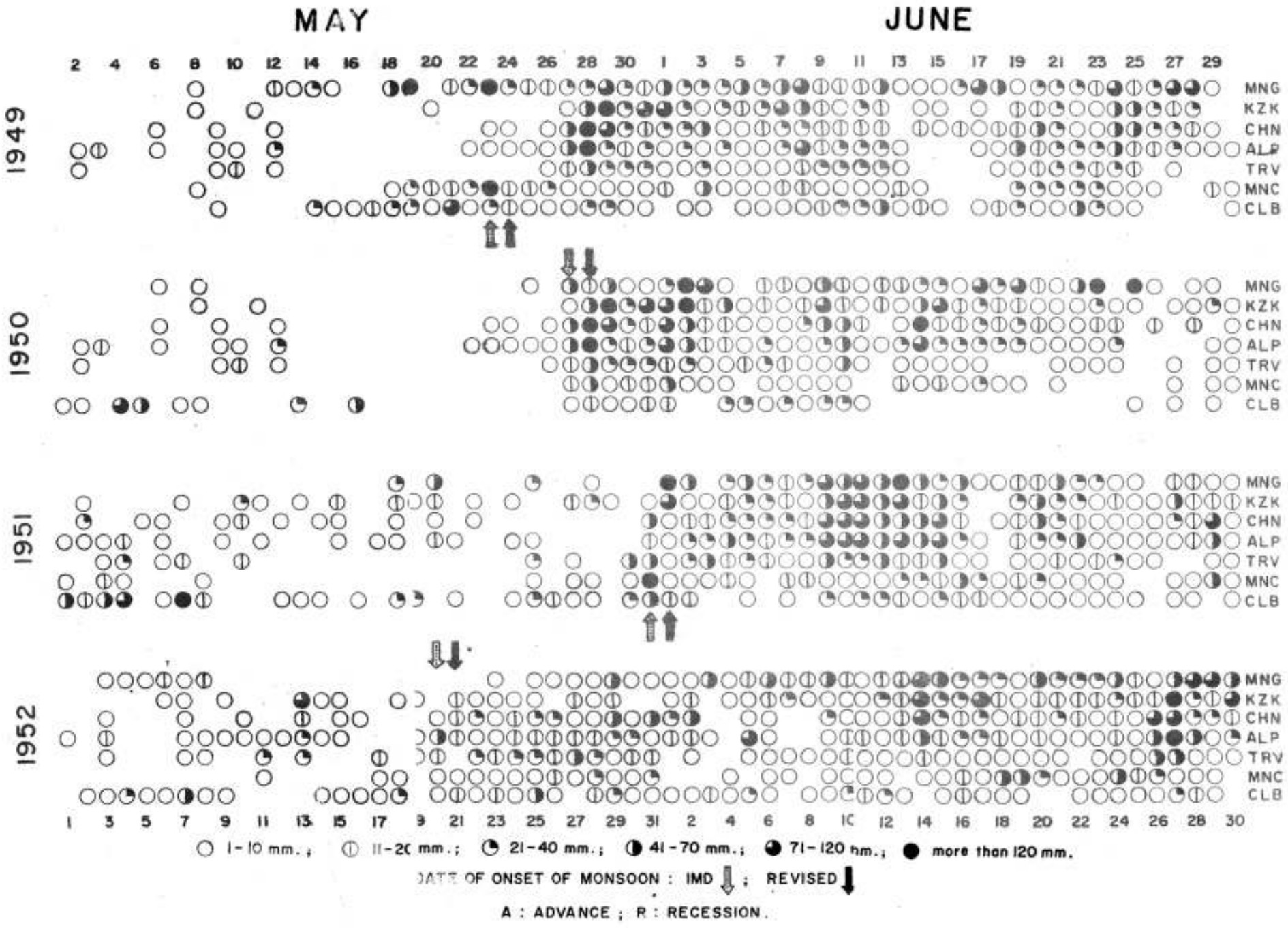

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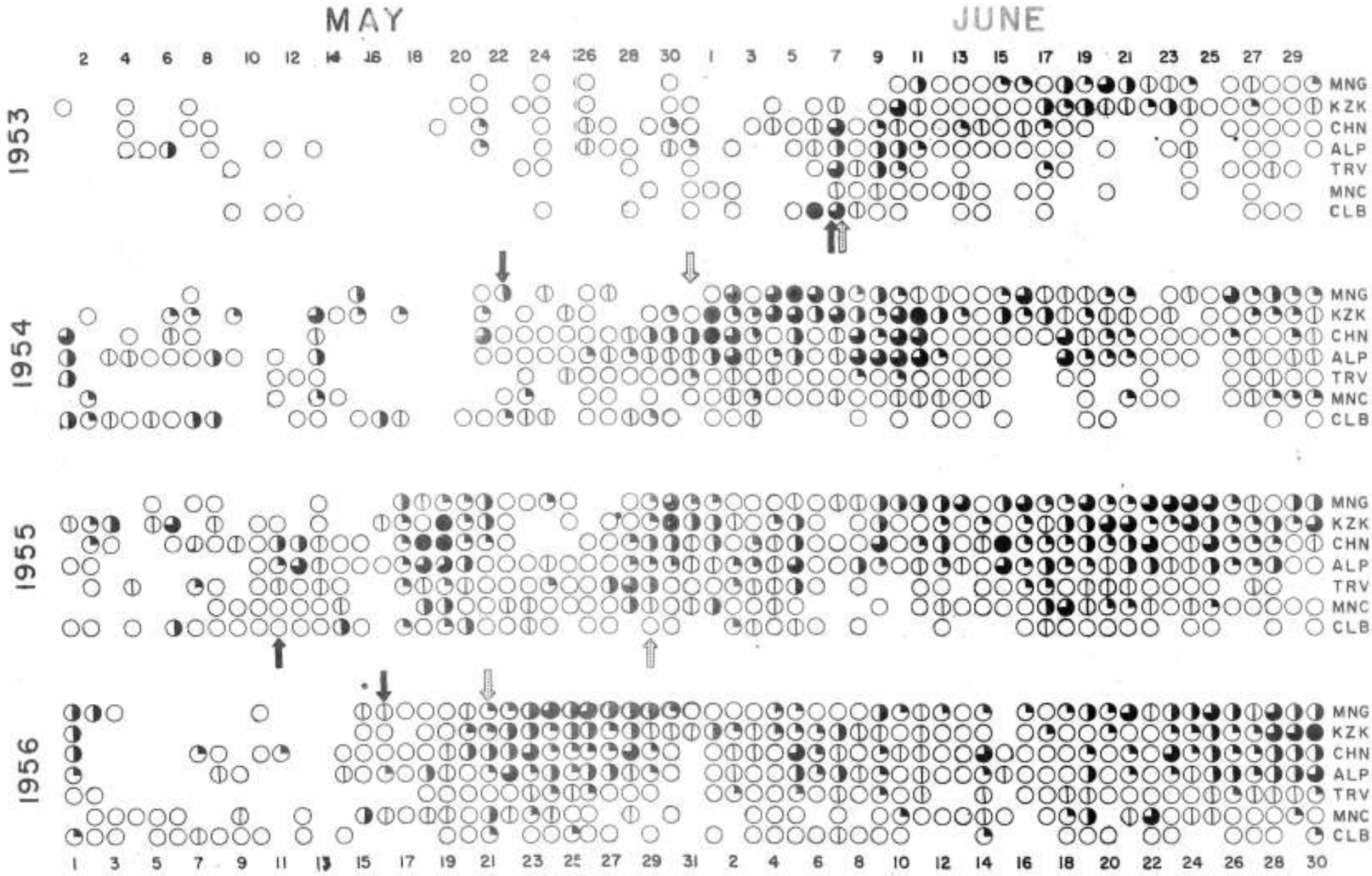

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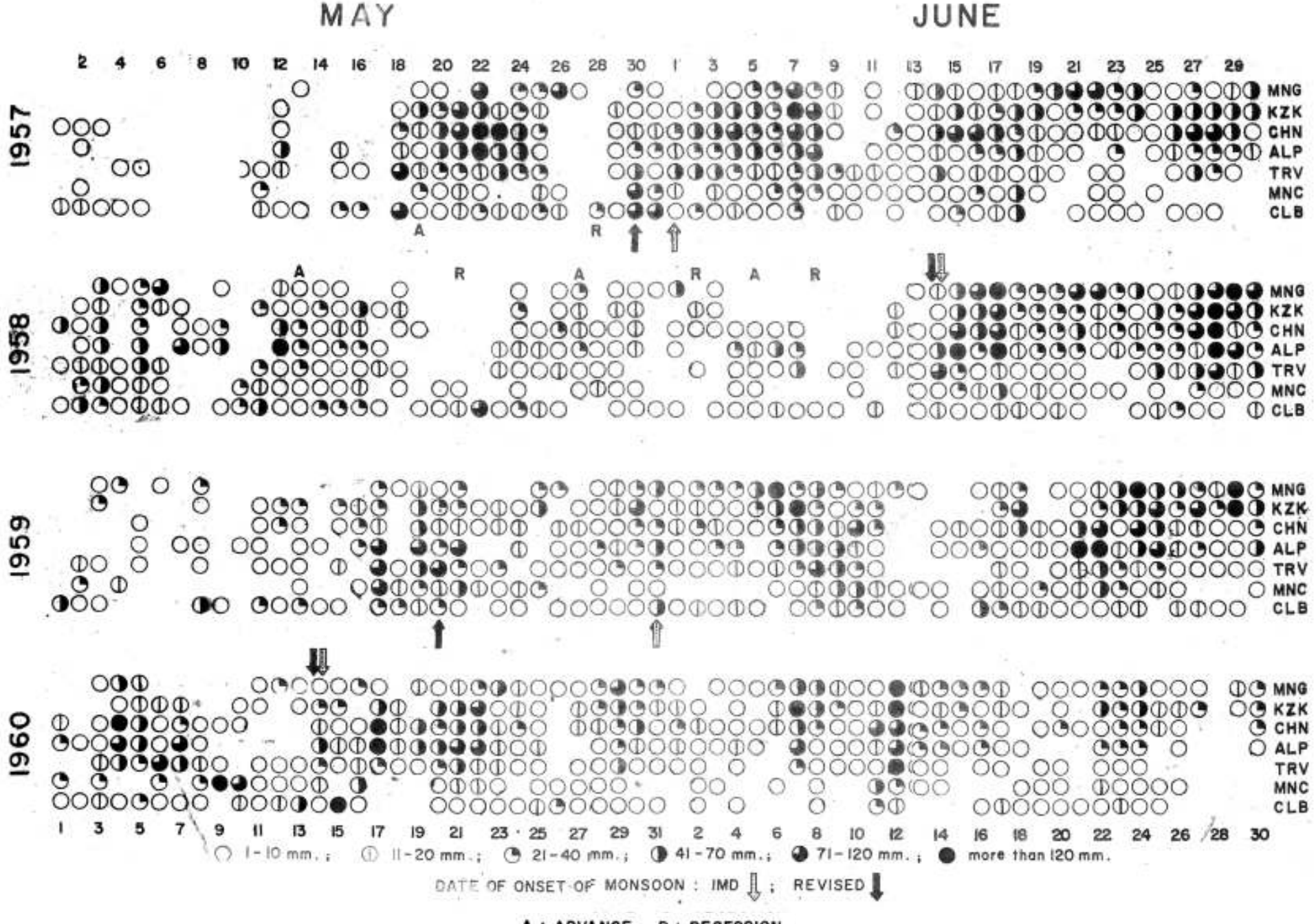
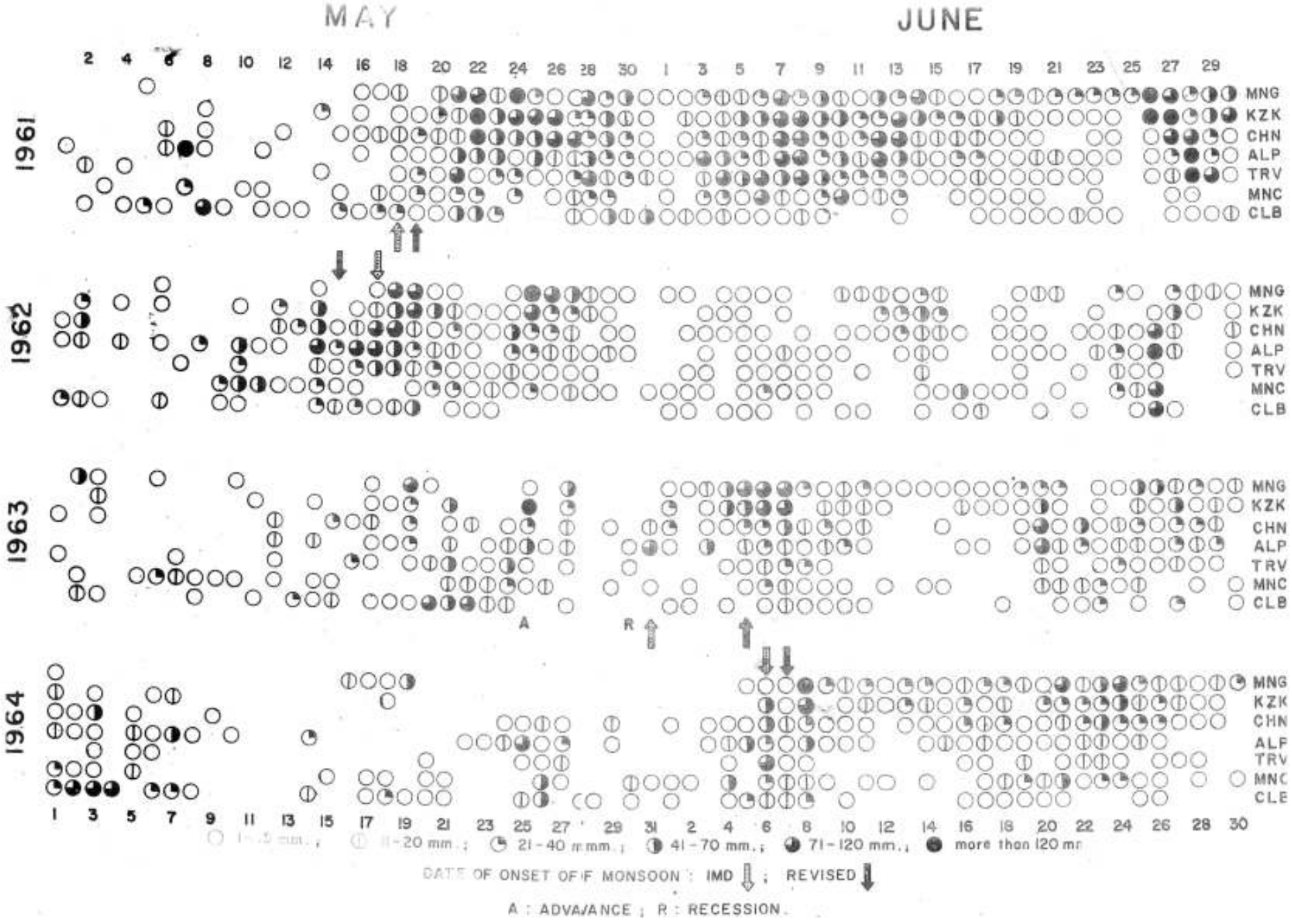


A : ADVANCE ; R : RECESSION.

DAILY RAINFALL



DAILY RAINFALL