

FORECASTING THE ONSET OF MONSOON OVER KERALA WITH THE HELP OF SATELLITE CLOUD PICTURES*

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ABSTRACT

Since the launching of the Operational Weather Satellites carrying the APT (Automatic Picture Transmission) system in the beginning of 1966, the actual cloud photographs over India and the adjoining sea areas are being regularly received through the APT Ground Station at Bombay. Utilising these cloud pictures, the cloud-cover and its progress over south Arabian Sea and the adjoining equatorial region during May and June were examined for the years 1967 and 1968 with a view to study the advance of the southwest monsoon into Kerala. The results of this study have been published in the Forecasting Manual of the India Meteorological Department. The study revealed that there is a progression of cloud maximum northward from the equatorial region and the mean clouding over the Arabian Sea in the latitude of Kerala (7.5° N to 10° N) reaches 2—3 oktas about a week prior to the onset of the monsoon over Kerala. This result, though based on two years' data, appears to be useful from the point of view of medium range forecasting of the onset of monsoon over Kerala. As the network of surface and upper air observatories is sparse and ships' observations generally few over south Arabian Sea and the adjoining equatorial region and as the available methods of forecasting the onset of the monsoon over Kerala using the conventional data have not been quite successful, the clouds covering vast areas of the south Arabian Sea and the adjoining equatorial region as revealed by the Satellite Photographs seem to be a fairly reliable tool for this purpose. Hence a study of the Satellite Cloud Pictures over the Arabian Sea for three more years, viz., 1966, 1969 and 1970 has been made and the results are presented in this paper. The results confirm the earlier findings. In the opinion of the authors, a study of the satellite cloud pictures as outlined in this paper can serve as a reasonably reliable guide for forecasting the onset of monsoon over Kerala about a week ahead.

INTRODUCTION

THE southwest monsoon which gives India most of its rainfall, sets in first along the Kerala coast towards the end of May and advances northwards. The normal date of onset of the monsoon over Kerala is 31 May, but on individual years, the date of onset can vary within a margin of about 10 days on either side. We may therefore expect the monsoon to set in over Kerala generally on any day during the last week of May or first week of June. On account of this variation, the public as well as the meteorologists are keenly interested to know from the beginning of May when the monsoon is likely to set in. Medium range forecasting of meteorological phenomena are still in the experimental stage. However, a number of workers have studied the various features associated with the onset of the monsoon. Yin (1949), Malurkar (1950), Yeh *et al.* (1959), Rai Sircar and Patil (1962), Koteswaram and Bhaskara Rao (1963) Pant (1964), Ramamurthy and Keshavamurthy, (1964), Ananthakrishnan and Ramakrishnan (1965, 1966), Flohn (1965), Ramamurthy and Jambunathan (1965) Ramaswamy (1965) and Thiruvengadathan (1966) have made significant contributions in this respect and the results of their study have been summarised in Part IV - 18.2 (October 1968) of the Forecasting Manual

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of the India Meteorological Department. Ananthakrishnan *et al.* (1968) also examined in detail the behaviour of the various meteorological parameters at the time of and prior to the onset of the monsoon over Kerala and the results of their study are summarised below:

"From the forecasting point of view, the following may be taken as the synoptic indications in the months of May/June for the imminent onset of the monsoon over Kerala :

- i. Any disturbance in the Arabian Sea/Bay of Bengal. The most common initial form of the disturbance is a trough of low pressure in south-east Arabian Sea.
- ii. Reports from ships and island stations in the south Arabian Sea, of heavy convection, squally weather and rough seas or swell from south-west with moderate to strong winds from some southerly or westerly direction.
- iii. The strengthening and deepening of lower tropospheric west winds over extreme south Peninsula and Ceylon and strengthening of upper tropospheric easterlies to 40 kts for a few days at 14 to 16 kms. At the time of onset, the easterlies reach a maximum speed of about 60 kts.
- iv. The tendency of the strong westerlies of the upper troposphere over north India to break up or to shift northwards.
- v. Persistent moderate to heavy clouding in the south Arabian Sea shown by Satellite pictures and its tendency to shift northwards.

Of these, the parameters mentioned in (i) to (iv) have been examined exhaustively, while parameter (v) *viz.*, the Satellite cloud pictures over the Arabian Sea had been examined only for two years (1967 and 1968). Since the publication of these findings, Satellite cloud data over India and adjoining sea areas for two more years (1969 and 1970) have become available. The present study has been made using these Satellite pictures to verify the conclusion under item (v) mentioned above. In addition to the APT cloud pictures for 1969 and 1970, the NEPHANALYSIS for 1966 published by ESSA (Washington) has also been utilised for this study and the results are discussed below.

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DISCUSSION

Krishna Rao (1966) made a study of the onset of the monsoon over India during 1962 using data from Channel 2 of TIROS IV Meteorological Satellites and concluded that "the centres of low outgoing long wave radiation values associated with the cloudiness of ITC moved northward with time. With the advancement of cloudiness northwards, the monsoon set in over the Indian sub-continent." Ramamurthy and Jambunathan (1967) studied the clouding in the Indian Sea areas shown by Satellite pictures at the time of onset of monsoon in the Year 1966 and found that the onset of the monsoon in Arabian Sea and Bay of Bengal is mainly associated with developments taking place to the north of the equator and their *extension* northwards into the Indian area. Anderson (1968) made a study of the

five-day averages of cloud brightness centred seven days apart during May and June 1968 and showed the northward progression of cloudiness over the Indian Seas in association with the advance of the monsoon.

In the present study, the daily cloud amount (in oktas) in every two and a half degrees square was estimated over the Arabian Sea and the adjoining equatorial region from Lat 5° S to 20° N and Long 60° E to 80° E from the Satellite pictures for 1969 and 1970 and from the NEPHANALYSIS for 1966 for the period 1 May to about 10 June. If a two and a half degree square was completely covered with clouds, the cloud amount in that square was taken as 8; if it was half covered, it was taken as 4 and so on. Then the cloud amounts over the two and a half degree squares were averaged for the longitudinal belt 60° E to 80° E, across every 2½° latitude. The time-latitude sections of the mean cloudiness for the years 1966 to 1970 are shown in Figs. 1(a) to 5(a). Cloud analyses for 1967 and 1968 have been reproduced from the Forecasting Manual Report referred to earlier as these were also done in the same manner as described above. In the lower half of these diagrams, the daily total rainfall for the four coastal stations of Kerala, viz., Trivandrum, Alleppey, Cochin and Calicut, has been depicted. The first arrow shows the date when 2 okta mean cloudiness developed over Trivandrum latitude and persisted. The second arrow refers to the date of onset of monsoon over Kerala. For these five years, the upper winds at 200 mb (12.0 kms asl) across the country along the mean meridian 75° E have also been depicted by means of iostachs drawn at 20 kts interval, for the period 1 May to 10 June, in Figs. 1(b) to 5(b). This has been done to examine the behaviour of the upper tropospheric westerlies and Sub-tropical ridge prior to and at the time of the onset of the monsoon over Kerala. The salient features as revealed by these diagrams are discussed below year by year. In addition, the upper winds over Trivandrum from the beginning of May were also examined for these five years to see whether they showed any systematic changes prior to the onset of the monsoon, which could be of prognostic value. The results of this examination are also discussed.

1966

Fig. 1 (a): In this year, the monsoon set in over Kerala on 2 June. The mean cloudiness of 4–6 okta extending from equator to the latitude of Kerala in the first week of May was in association with a cyclonic storm in the Bay of Bengal which

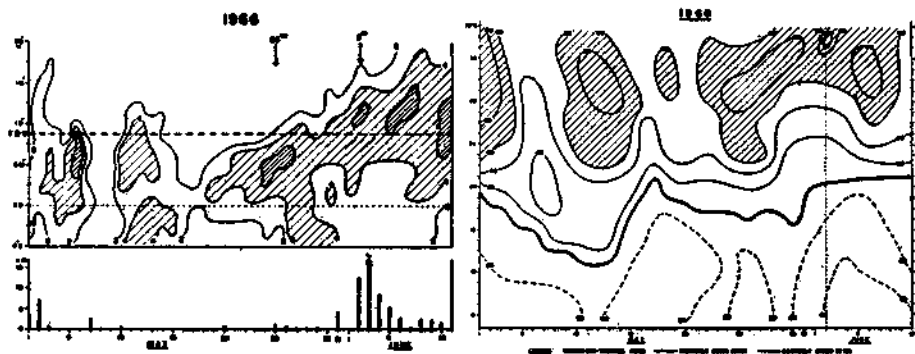


Fig.1 a. Mean cloudiness (OKTA) over Arabian Sea and Kerala rainfall; and
 b. Upper winds (1200 GMT) at 200 mb along longitude 75° E.

moved into south Peninsula on 1 May, weakened into a depression and moved north-northwestwards to south Maharashtra State by 4th. This system gave some

rainfall over Kerala on the first three days. Another spell of 2—4 okta cloudiness extended between Lat 2° N and 12° N from 9 to 14 May. This cloudiness was mainly confined to southwest and adjoining southeast Arabian Sea and as such there was no rainfall over Kerala during this period. An examination of the weather charts for these days showed no synoptic system in the Arabian Sea. Ships in this area reported westerlies of 10—15 kts with rain at some places. Cloudiness decreased in these areas during the subsequent three days. Mean cloudiness of 2 okta and more again developed in the near-equatorial region of the Northern Hemisphere on 18 May and progressively extended northwards to the latitude of Trivandrum by 25 May i.e. 8 days before the onset of monsoon over Kerala. It may be noted that persistent cloudiness of 2 okta and more in the near-equatorial region and its systematic progression northwards has taken place after about the middle of May.

Fig. 1(b): The upper tropospheric westerlies of 60 kts and more continued to prevail in the latitude of Delhi even after the onset of the monsoon. The Sub-tropical ridge did not show any progressive northward shift. It was oriented along Lat 18° N from 18 to 30 May and then shifted slightly north to about Lat 20° N only two days before the onset of the monsoon.

In this year, the westerlies over Trivandrum at 0.9 kms asl, which were 15—20 kts from 1 May strengthened to 25 kts from 25 to 30 May. Then they weakened to 15—20 kts and remained so thereafter. The winds at 3.0 kms asl which were easterlies upto 23 May became northerlies and then westerlies from 31st. The easterlies between 14 and 16 kms asl became 40 kts 14 days before the onset of the monsoon and strengthened to 60 kts 10 days before the onset and remained so thereafter.

1967

Fig. 2(a): The mean cloudiness of 2 okta and more which persisted in the latitude of Trivandrum from 10 to 18 May was in association with an upper air cyclonic

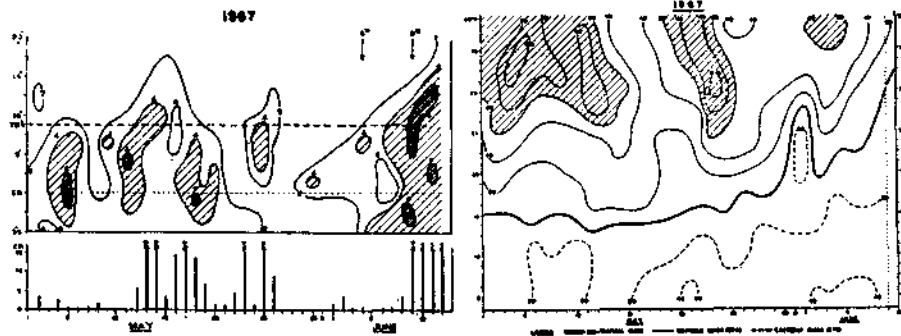


Fig.2 a. Mean cloudiness (OKTA) over Arabian Sea and Kerala rainfall; and
b. Upper winds (1200 GMT) at 200 mb along longitude 75° E.

circulation (extending to the middle troposphere) which moved from Cape Comorin to coastal Mysore along the west coast and then recurved eastnortheastwards across the south Peninsula during this period. This system caused a fairly continuous spell of rainfall over Kerala from 12 to 19 May. Seasonal thundershower activity continued over Kerala upto 26 May. The rainfall which commenced from 12 May has been declared to be associated with a temporary advance of monsoon over Kerala. After a break of about a fortnight, the monsoon revived over Kerala

on 9 June. The cloudiness also decreased to less than 2 okta near Trivandrum latitude after 26 May. Cloudiness of 2 okta and more re-appeared over near-equatorial region on 28 May and progressively extended northwards reaching Trivandrum latitude on 4 June i.e. 5 days before the revival of the monsoon.

Fig. 2 (b): The upper tropospheric westerlies of 60 kts and more prevailed north of Lat 24° N from 1 to 14 May and again from 19 to 25 May. Thereafter they weakened to about 40 kts except for a few days in the beginning of June when Srinagar reported about 60 kts. On 9 June, when the monsoon revived, the westerlies had weakened further to 20 kts even upto Srinagar. The Sub-tropical ridge was persisting around Lat 15° N to 16° N upto about 24 May and then gradually shifted northwards to Lat 20° N by 3 June and then rapidly to about Lat 28° N at the time of the revival of the monsoon.

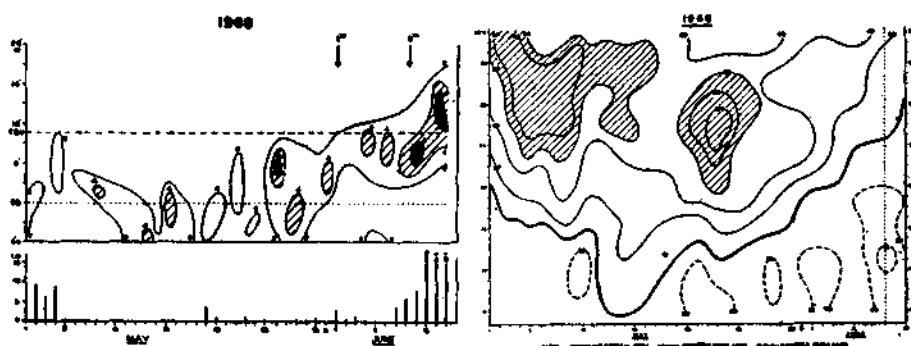


Fig. 3a. Mean cloudiness (OKTA) over Arabian Sea and Kerala rainfall; and
b. Upper winds (1200 GMT) at 200 mb along longitude 75° E.

The winds over Trivandrum at 0.9 kms asl were westerlies of the order of 20 kts from 15 to 23 May and again from 2 June onwards. There was no significant strengthening of the winds at or near about the revival of the monsoon. Winds at 3.0 kms asl were Northeast/East 20—25 kts upto 13 May. They suddenly became westerlies during the period of temporary onset. They again changed over to easterlies from 20 May and remained so till 5 June. On 6 June, i.e., 3 days prior to the revival of the monsoon, they became westerlies. The easterlies at 14—16 kms asl attained 40 kts and more from 18 to 23 May and weakened thereafter. They again strengthened to 40 kts or more from 27 May i.e. 13 days before the revival of the monsoon. They strengthened to 60 kts during 18 to 21 May and again from 3 June i.e. 6 days before the revival.

1968

Fig. 3 (a): The monsoon set in over Kerala on 8 June. Mean cloudiness of 2 okta and more progressively extended northwards and reached Trivandrum latitude on 1 June 7 i.e. 6 days before the onset of the monsoon, and persisted thereafter.

Fig. 3 (b): The upper tropospheric westerlies of 60 kts and more which were prevailing north of latitude 23° N upto 26 May weakened to about 20 kts right upto Srinagar at the time of onset of monsoon. The Sub-tropical ridge which was near

Lat 20° N in the beginning of May gradually shifted southwards and came as far south as Trivandrum by the middle of May. Then it progressively shifted northwards to Lat 24° N at the time of the onset of the monsoon.

The westerlies at 0.9 kms asl over Trivandrum were 20 kts from 28 May i.e. about 11 days prior to the onset and remained so at the time of onset. The winds at 3.0 kms asl which were easterlies till 3 June became westerlies from 5 June, i.e. 3 days before the onset of the monsoon. The upper tropospheric easterlies at 14—16 kms asl attained 40 kts 8 days before the onset and persisted thereafter. They trengthened to 60 kts 2 days after the onset of the monsoon.

1969

Fig. 4 (a): The monsoon set in over Kerala on 17 May. This was in association with the formation of a cyclonic storm in the west central Bay of Bengal and its movement towards the Andhra coast. The storm weakened by 20 May. The rainfall over Kerala also practically ceased from 20 May. The monsoon revived over Kerala on 25 May. Mean cloudiness of 2 okta and more developed over Trivandrum latitude on 15 May and persisted in that latitude till 22 without

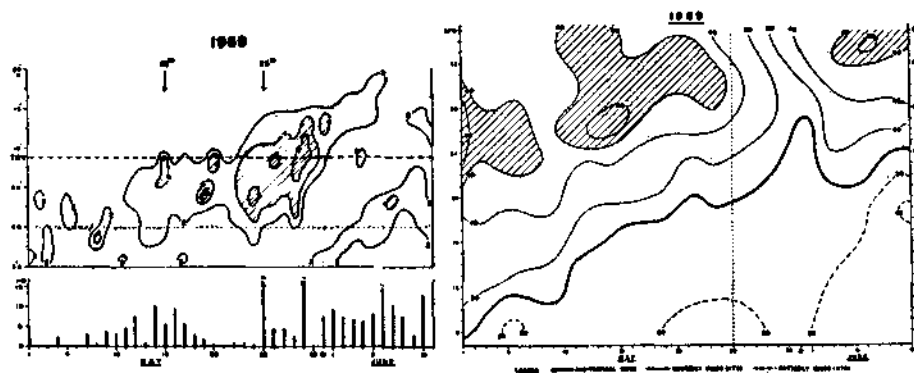


Fig.4 a. Mean cloudiness (OKTA) over Arabian Sea and Kerala rainfall; and
b. Upper winds (1200 GMT) at 200 mb along longitude 75° E.

any northward progression. The northward progression however commenced only after 22 May. The decrease of rainfall after 19 May and the non-progression of 2 okta cloudiness northwards from Trivandrum latitude during the period 15 to 22 May would suggest that the rainfall during this spell was a temporary feature associated with the cyclonic storm and may be regarded as a temporary advance of the monsoon. The date of revival of the monsoon viz., 25 May may be regarded as the date of regular onset of the monsoon in view of the persistent rainfall over Kerala and the heavy cloudiness and its progression northwards thereafter. In that case, it will be seen that the date of appearance of 2 okta cloudiness over Trivandrum latitude was 10 days before the regular onset of the monsoon.

Fig. 4 (b): The upper tropospheric westerlies of 60 kts shifted progressively northwards from latitude 22° N to 28° N from 1 to 24 May. The weakened to about 20 kts during the subsequent one week but again strengthened to 60—80 kts near Srinagar latitude, even after the onset of the monsoon. The Sub-tropical ridge which was close to Trivandrum in the beginning of May, progressively shifted northwards to Jodhpur latitude (26° N) at the end of May but again shifted southwards

to Lat 20° N by 3 June. Then it again showed a tendency to shift slightly northwards after 5 June.

The westerlies at 0.9 kms asl over Trivandrum strengthened to 25 kts or more only at about the time of the regular onset of the monsoon. Prior to that date, the wind speed fluctuated. At 3.0 kms asl, winds which were easterlies, became westerlies from 16 May. The upper tropospheric easterlies at 14–16 kms asl reached 40 kts 4 days before the temporary onset and 12 days before the regular onset. They strengthened to 60 kts 5 days before the regular onset.

1970

Fig. 5 (a): The monsoon set in over Kerala on 26 May. Cloudiness of 2 okta and more developed over Trivandrum latitude on 19 May i.e. 7 days before the onset of the monsoon, persisted thereafter and also progressively extended northwards.

Fig. 5 (b): The upper tropospheric westerlies of 60 kts which were prevailing near Lat 23° N in the beginning of May shifted to Lat 28° N by 7 May and persisted near that latitude till the onset of the monsoon. The Sub-tropical ridge which was near Lat 12° N in the beginning of May gradually shifted northwards

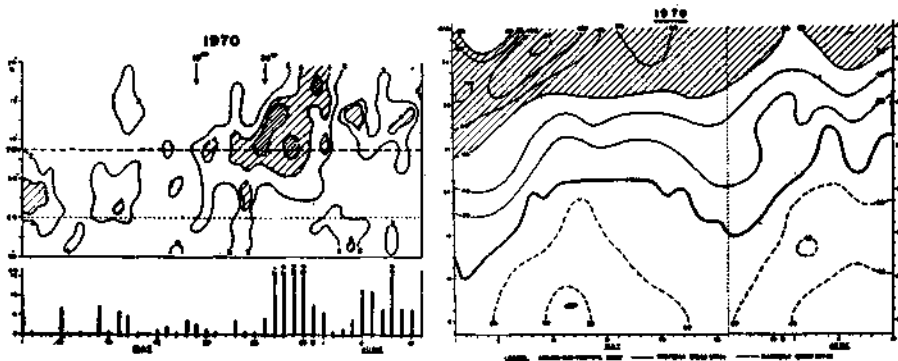


Fig.5 a. Mean cloudiness (OKTA) over Arabian Sea and Kerala rainfall; and
b. Upper winds (1200 GMT) at 200 mb along longitude 75° E.

to Lat 21° N by 11 May and remained there till 19 May. Then it shifted again progressively southwards to Lat 16° N by 26 May. It is interesting to note that in this year, the Sub-tropical ridge which had moved as far north as Lat 21° N started shifting southwards about a week prior to the onset of the monsoon reaching the southern-most position (Lat 16° N) at the time of the onset. From 27 May, it gradually shifted again northwards.

The westerlies at 0.9 kms asl over Trivandrum strengthened to 25 kts or more 5 days after the onset of the monsoon. At 3.0 kms asl, the winds were variable from 1 May to 22 May and became westerlies from 23 May i.e. 3 days prior to the onset of the monsoon and strengthened to 20–25 kts from the date of the onset. In the upper troposphere (14–16 kms asl), the easterlies of 40 kts appeared first over Trivandrum on 5 May i.e. 21 days before the onset, and remained so upto 19 May. They weakened thereafter. They became again 40 kts 2 days after the onset. Their strengthening to 60 kts took place on 29 May i.e. 3 days after the onset.

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The points discussed above have been summarised in Table 1.

TABLE 1

S. No.	Parameters	Year and date of onset of the monsoon				
		1966	1967	1968	1969	1970
		2 June	9 June	8 June	25 May	26 May
1	Number of days before the onset of monsoon when upper tropospheric westerlies over North India weakened to less than 60 kts	No weakening	14	12	1	No weakening
2	Whether the Sub-tropical ridge shifted northwards before the onset of the monsoon	No	Yes	Yes	Yes	No. It shifted southwards.
3a	Whether the low westerlies over Trivandrum strengthened to 25 kts or more at the time of onset	No	No	No	Yes	No
	b Whether the low level westerlies over Trivandrum strengthened to 25 kts or more prior to the onset, and if so, how many days before.	Yes. 8 days	No	No	No	No
	c Whether the low level westerlies over Trivandrum extended to 3.0 kms asl at the time of onset or earlier. If earlier, the number of days before the date of onset of the monsoon	2	3	3	9	3
4a	Number of days before the onset of monsoon when upper tropospheric easterlies over Trivandrum strengthened to 40 kts	14	13	8	12	21
	b Number of days before the onset of monsoon when upper tropospheric easterlies over Trivandrum strengthened to 60 kts	10	6	No	5	No
5	Number of days before the onset of monsoon when mean cloudiness of 2 okta and more has appeared over the Arabian Sea across the latitude of Trivandrum	8	5	7	10	7

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