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Fluctuations of monsoon activity

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ABSTRACT. In order to study the evolution of flow patterns associated with 'strong' and 'break' monsoon we have studied six cases each of such epochs during the period 1965 to 1973. As we are interested in the departure of the flow patterns from the normal, we have subtracted long term climatological pentad means from the daily data and constructed anomaly wind, height and thickness charts at standard levels.

The charts show several contrasting features during the epochs as well as prior to the epochs. A few days prior to the beginning of the strong monsoon epoch (usually in association with a depression), an east-west anomaly trough is seen extending from SE Asia to peninsular India in the lower and middle tropospheres. The trough over peninsular India shifts northwards with the advance of the epoch. Westward movement of a cyclonic anomaly from across Southeast Asia is also seen. In the upper troposphere a warm anomaly ridge is seen to the northwest of India.

Prior to the beginning of breaks, however, an anomaly ridge is seen extending from peninsular India to Malaysia in the lower and middle tropospheres. This feature also shows some northward shift with the advance of the epoch. In the upper troposphere, an anomaly trough is seen to the northwest of India.

1. Introduction

It is well known that during the monsoon season there are spells of active and weak or break monsoon. A thorough understanding of the morphology and dynamics of the large-scale flows during and prior to these epochs is a pre-requisite to medium and extended range prediction in these parts. There have been several studies (Ramamurthi *et al.* 1965; Raman *et al.* 1965; Ramaswamy 1965; Ramamurthy 1969) contrasting the flow patterns during active and break monsoon epochs. Here it is proposed to study the anomalous flow features prior to and during strong and break monsoon situations.

2. Data and analysis

2.1. *Spells*

The periods of strong monsoon (over the central parts of the country) and break chosen are :

(*i*) *Strong Monsoon*

Year	*Period*	*'O' date*	*Date of formation of depression*
1967	17 Jul to 6 Aug	27 Jul	26 Jul
1968	25 Jul to 14 Aug	4 Aug	3 Aug
1969	21 Jul to 10 Aug	31 Jul	28 Jul
1970	9 Aug to 1 Sep	19 Aug	17 Aug
1971	17 Aug to 6 Sep	27 Aug	30 Aug
1973	27 Jun to 17 Jul	7 Jul	5 Jul

(*ii*) *Break in Monsoon*

Year	*Period*	*'O' date*	*First day of break*
1965	4-15 Aug	7 Aug	4 Aug
1966	2-11 Jul	3 Jul	2 Jul
1970	12-18 Jul	15 Jul	12 Jul
1971	30 Jul-7 Aug	6 Aug	30 Jul
1972	18-31 Jul	27 Jul	18 Jul
1973	24 Jul-1 Aug	28 Jul	24 Jul

2. 2 *Anomaly charts*

As the stationary component of the monsoon is pronounced and as our aim is to study the

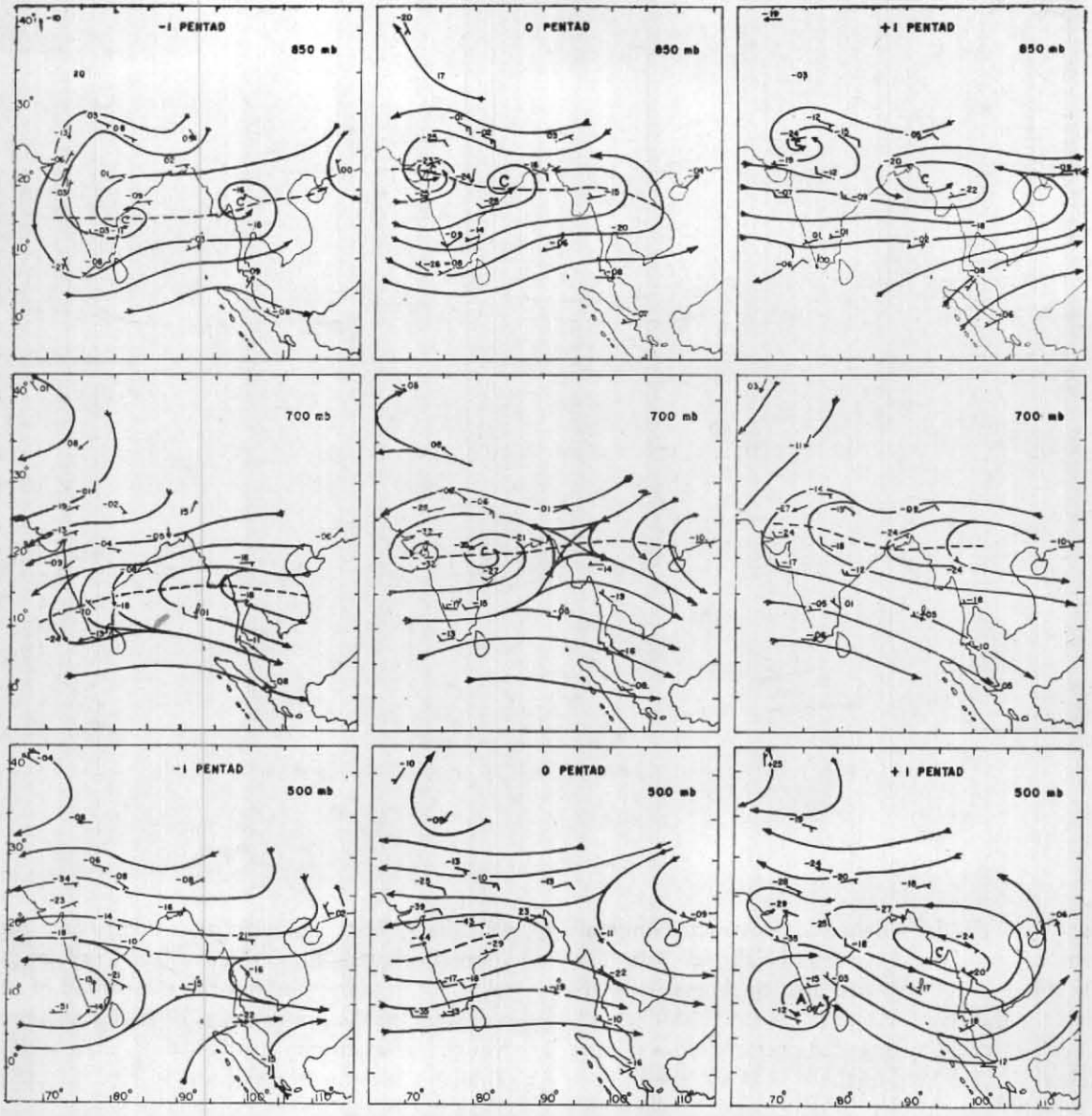

Fig. 1 (a). Composite pentad anomaly charts — Strong monsoon

fluctuations of the super-posed transient disturbances, we have removed the long-term climatological mean monsoon from the observations and studied the anomaly fields. This procedure is adopted for the surface pressure data and surface pressure departure charts are in use in India Meteorological Department for a long time. We have constructed similar anomaly charts for the contour height, wind and thermal fields at all standard levels both on a daily as well as on a pentad basis.

At present only monthly mean values of the upper air parameters are available. We have plotted the monthly mean values of contour height, u and v components of wind for Indian and neighbouring stations and interpolated the means for the pentads from smooth graphs. From computations of means from actual daily data for about 7 years for three samples pentads, we have verified that the pentad means extracted from the graphs are fairly accurate. We have subtracted these pentad

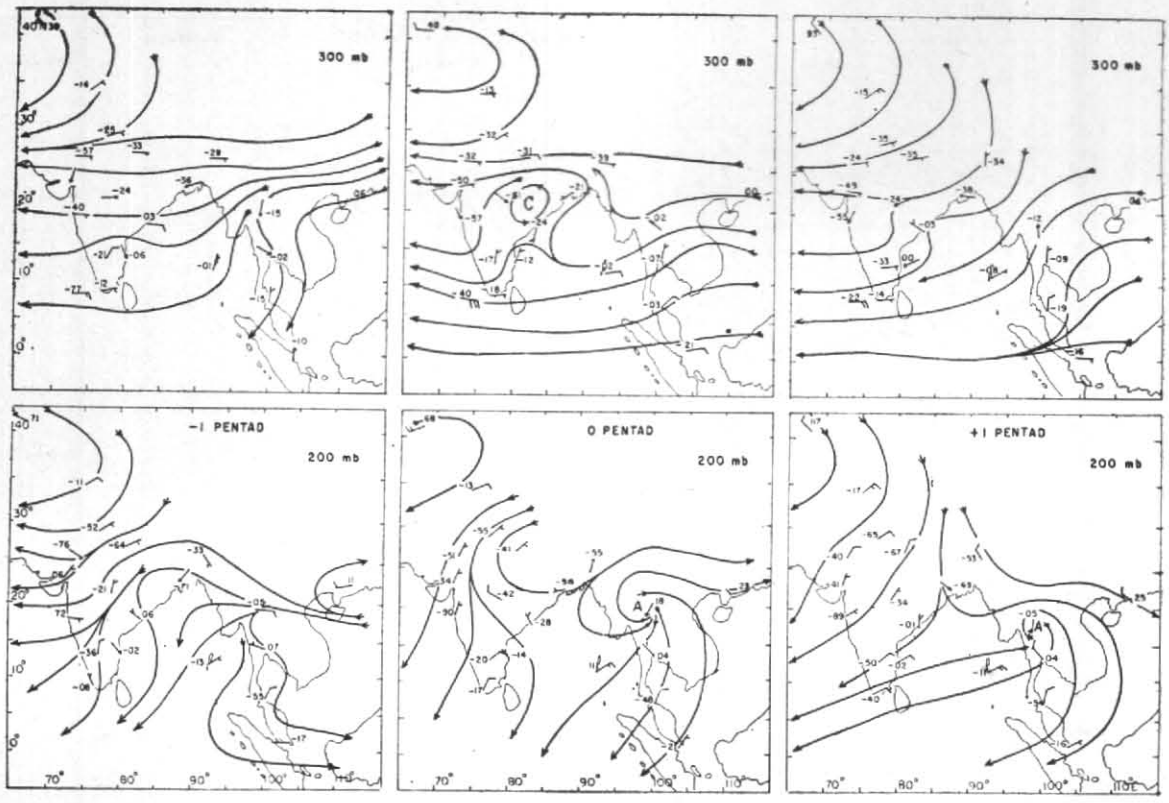

Fig. 1 (b). Composite pentad anomaly charts — Strong monsoon

means from the daily data and constructed anomaly charts of wind and contour height at 850, 700, 500, 300 and 200 mb and also thickness anomaly charts for the layers 200-500, 500-850, 200-700 mb. Typical cases of strong and weak monsoon were studied with the help of these anomaly charts both on a daily basis as well as on a pentad basis. We have also prepared composite pentad anomaly charts with the peak of epochs as the central or 'O' pentad. Composite daily anomaly charts were also constructed with :

(*i*) the day of peak activity of the epoch as the 'O' date

(*ii*) the date of formation of depression as the 'O' date

(*iii*) with the first day of the 'break' as the 'O' date.

3. *Results*

In order to first get a rough picture of the evolution of the patterns prior to and during the epochs we shall first examine the composite pentad anomaly charts—Figs. 1 (a & b) and 2 (a & b). It is seen that in the pentad prior to the pentad of strong monsoon (in the central parts of India) an anomaly trough is extending from south Peninsula to Thailand and further east at 850 mb, 700 mb and 500 mb. With the advance of the epoch, the anomaly trough slowly shifts nothwards over India. This is something like a mini-advance of the monsoon. In the upper troposphere we see a warm ridge to the northwest of India prior to and during the strong monsoon epoch, so that there is generally more northerly component of wind over northwest and central India at these levels.

In the pentad prior to the 'break' monsoon, however, we see a well marked anomaly ridge which extends from south Peninsula to Andaman sea and thence to Malaysia at 850, 700 and 500 mb. With the advance of the 'break' this ridge also shows some northward shift over India. In the upper troposphere we see a trough to the northwest of India so that more southerly component of wind is

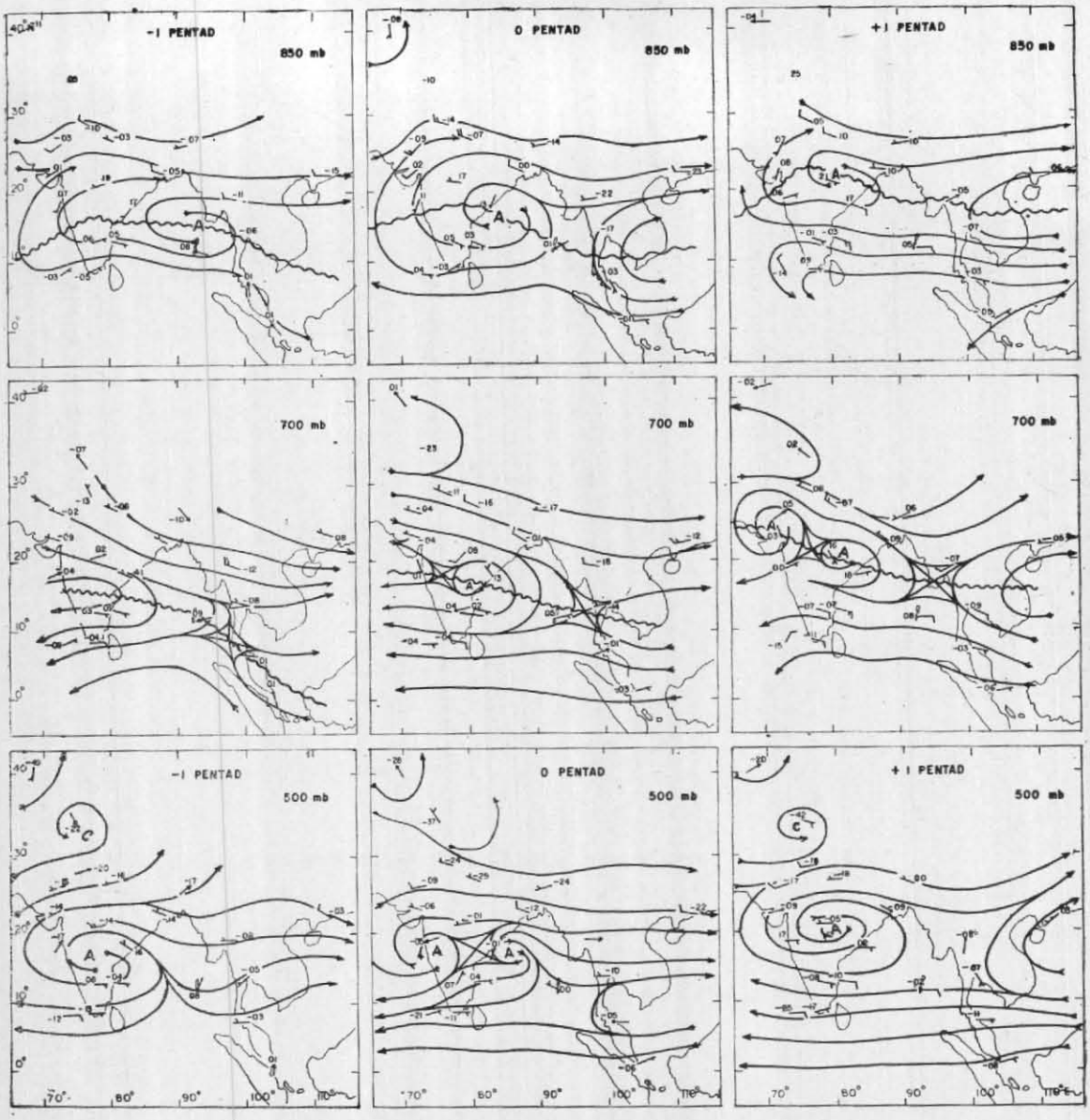

Fig. 2 (a). Composite pentad anomaly charts — Break monsoon

seen over northwest and central India. Temperatures are also below normal to the northwest of India.

Thickness and shear anomaly charts for the layer 200-700 mb show that prior to and during the strong monsoon epoch, the region to the northwest of India is warm compared to eastern parts of Tibet, whereas prior to and during 'break' monsoon, the region to the northwest of India is 'cold' compared to Tibetan region.

Composite daily anomaly charts with the peak of 'active' or 'break' monsoon as the 'O' date (Figs. 3, 4 and 5) show similar features. It is observed that a few days before the peak of active monsoon the anomaly trough is marked over Southeast Asia in the lower and middle tropospheres and the anomaly trough over India is seen at a lower latitude, *i.e.*, over Peninsula. In the upper troposphere a ridge is seen to the northwest of India.

A few days before the peak of 'break' on the

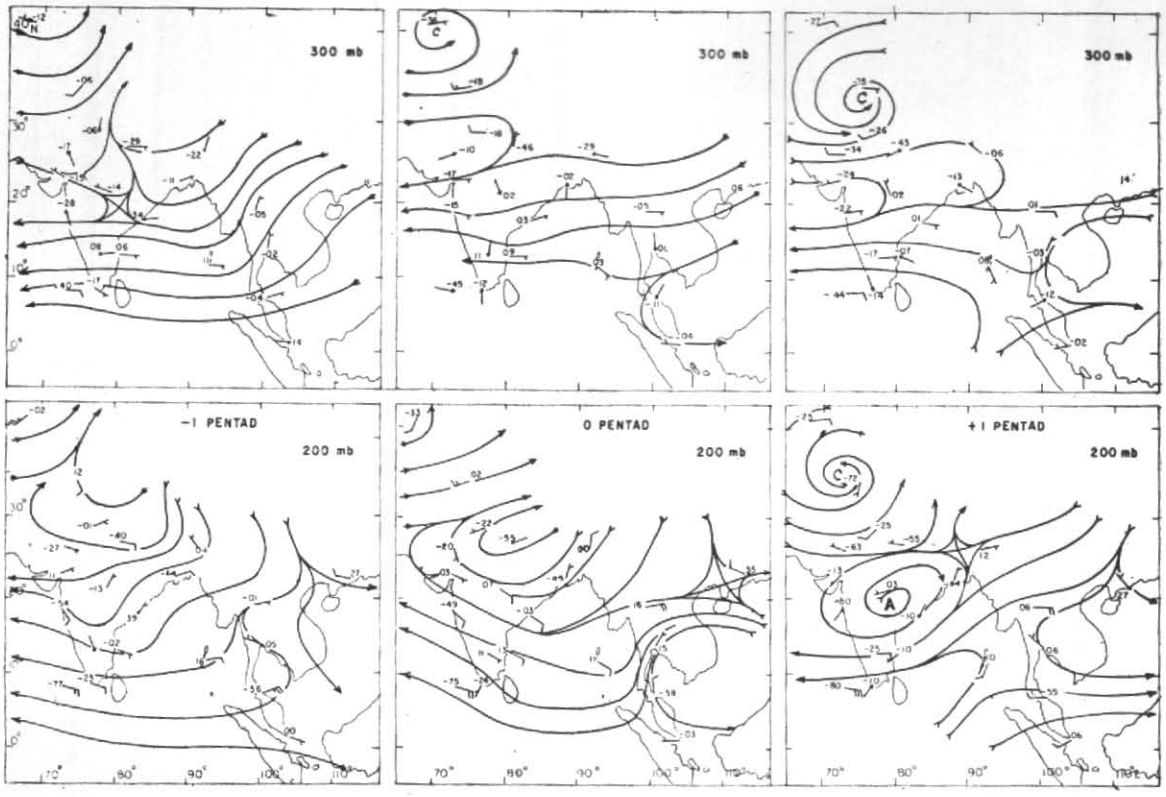

Fig. 2 (b). Composite pentad anomaly charts — Break monsoon

other hand, the trough over Southeast Asia has already shifted to north of 20°N and we have an anomaly ridge running from Peninsular India to Malaysia in the lower and middle troposphere. In the upper troposphere, a trough is seen to the northwest of India.

We shall now examine the composite charts with the date of formation of a depression in the Bay of Bengal as the 'O' date (Figs. 6, 7 and 8). This is a composite of 11 cases of depression formation occurring in the above epochs. One or *two* days before the formation of depressions, the anomaly trough over Southeast Asia is well marked and a cyclonic anomaly moves from Southeast Asia into Bay of Bengal. During this time, in the upper troposphere, there is a ridge to the northwest of India and curiously there is a trough extending from east Tibet to Bengal. The flow over north Bay of Bengal is divergent.

We shall now examine composite daily anomaly charts with the first day of the 'break' as the 'O' date (Figs. 9, 10 and 11). Two or three days before the beginning of 'break' the monsoon trough over Southeast Asia has already shifted to the north and we have an anomaly ridge extending from Peninsula to Malaysia or Gulf of Siam in the lower and middle troposphere. In the upper troposphere a cold low is seen to the northwest of India.

We have used the salient features of these charts for developing statistical predictors for forecasting weekly rainfall anomalies over central India.

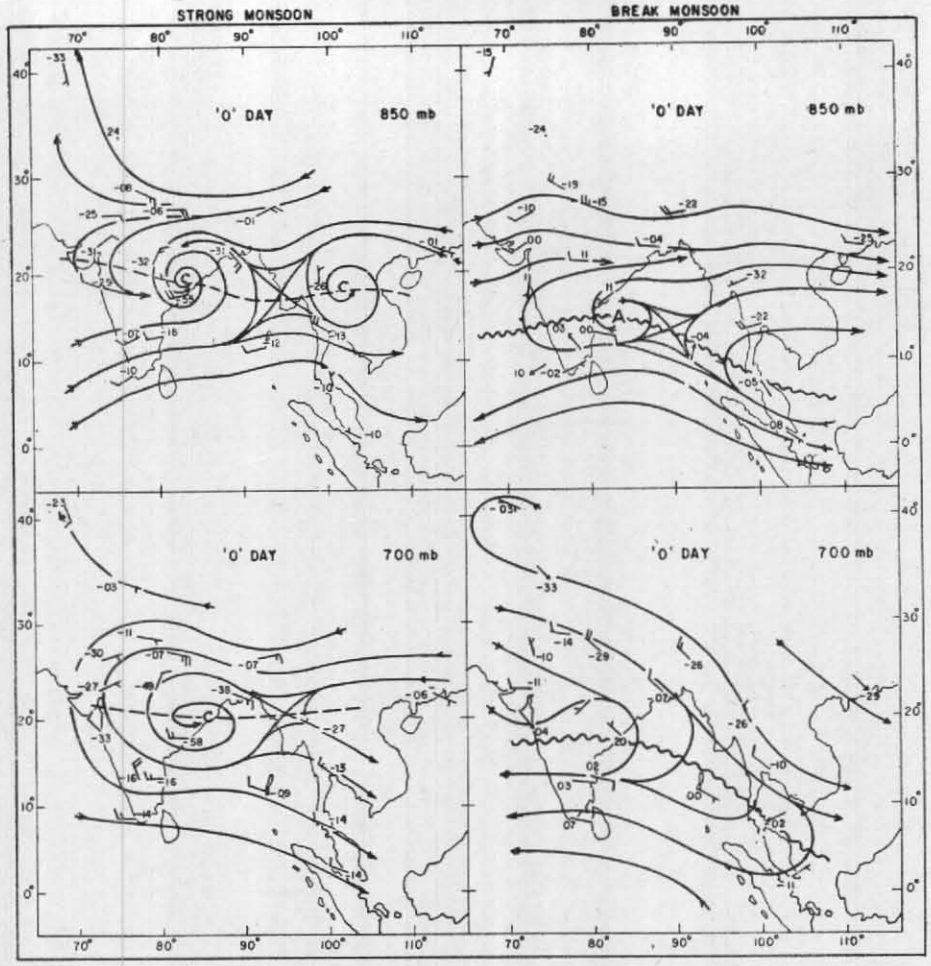

Fig. 3 (a). Composite daily anomaly charts (with date of peak activity as '0' date)

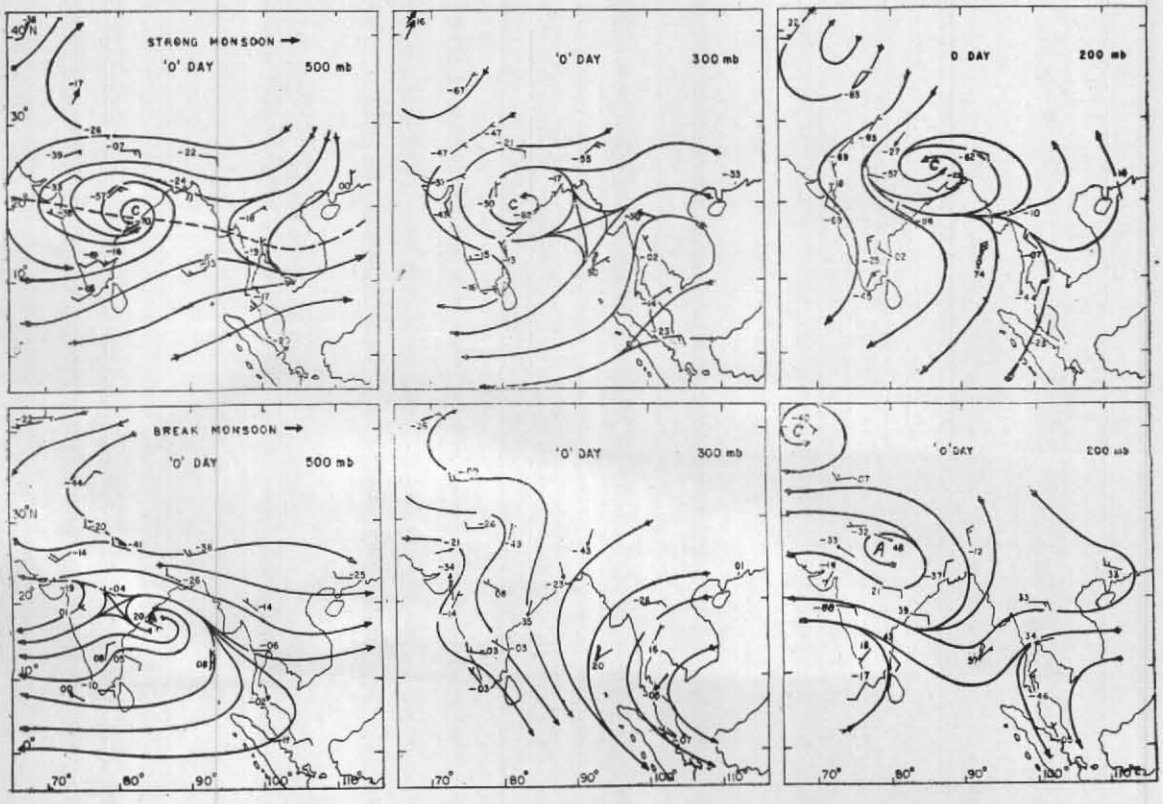

Fig. 3 (b). Composite daily anomaly charts (with date of peak activity as '0' date)

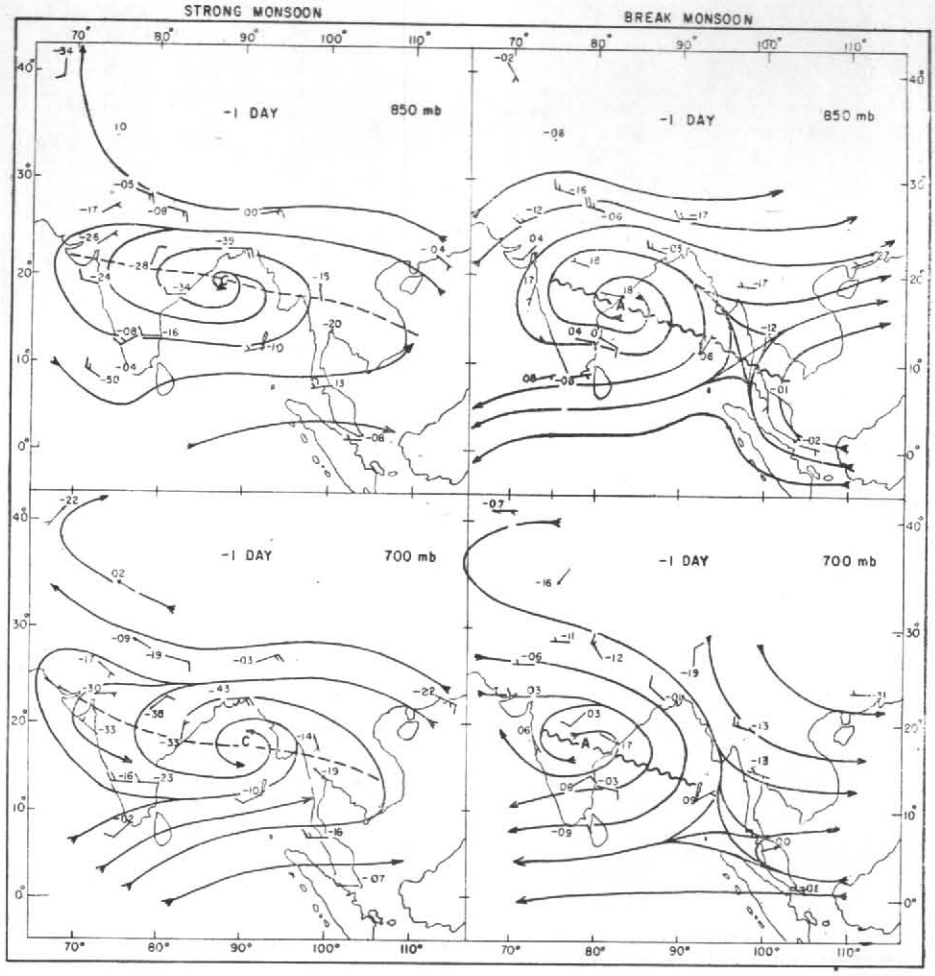

Fig. 4 (a). Composite daily anomaly charts (with date of peak activity as 'O' date)

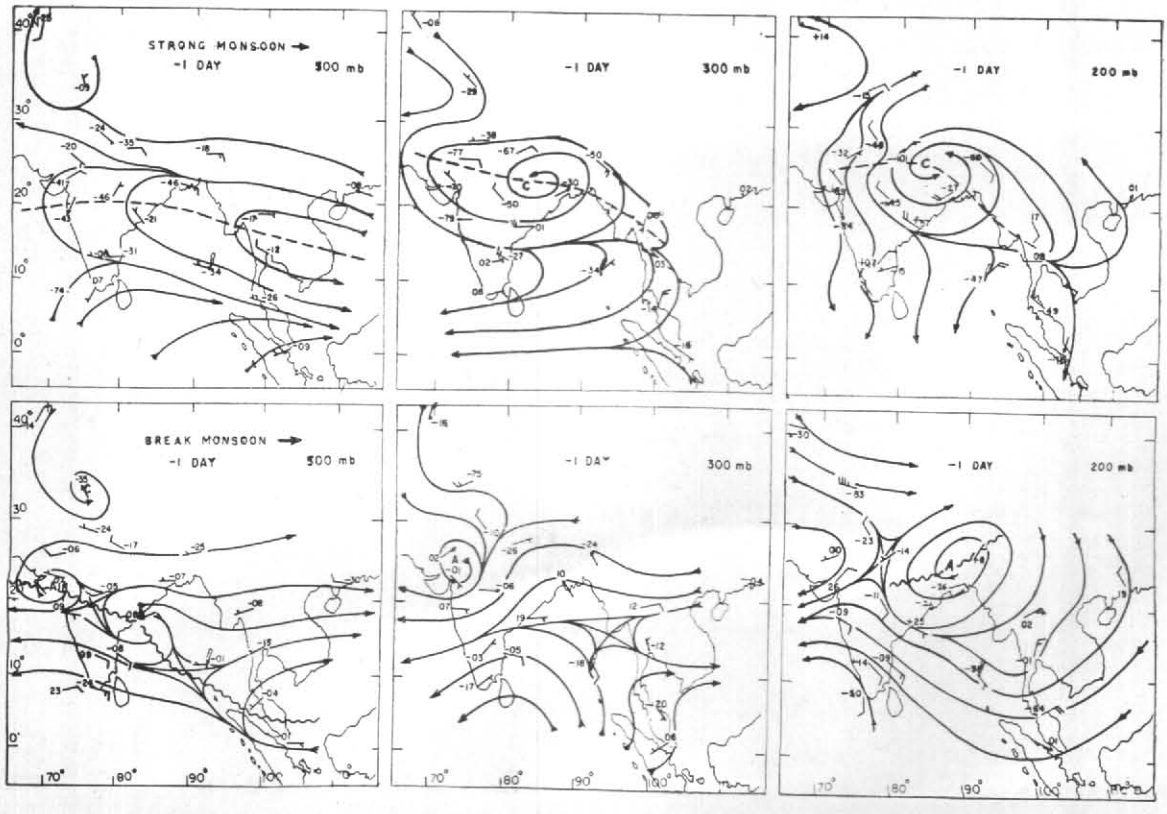

Fig. 4 (b). Composite daily anomaly charts (with date of peak activity as 'O' date)

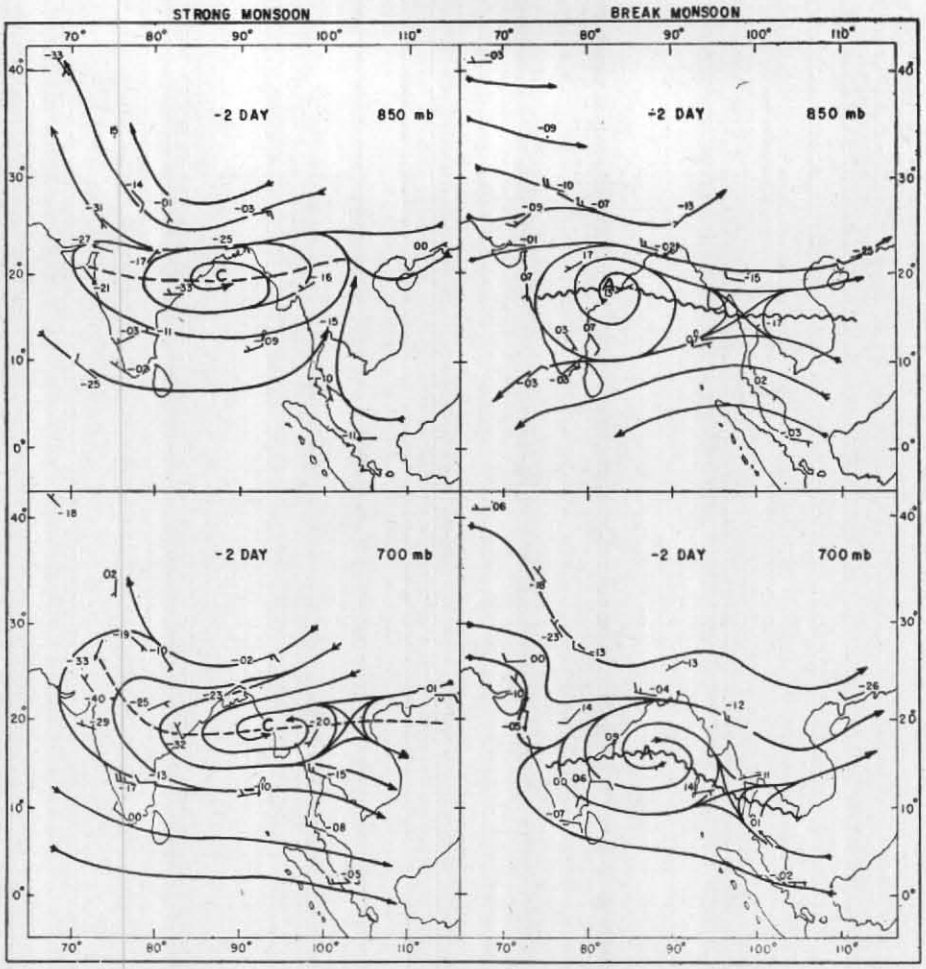

Fig. 5 (a). Composite daily anomaly charts (with date of peak activity as 'O' date)

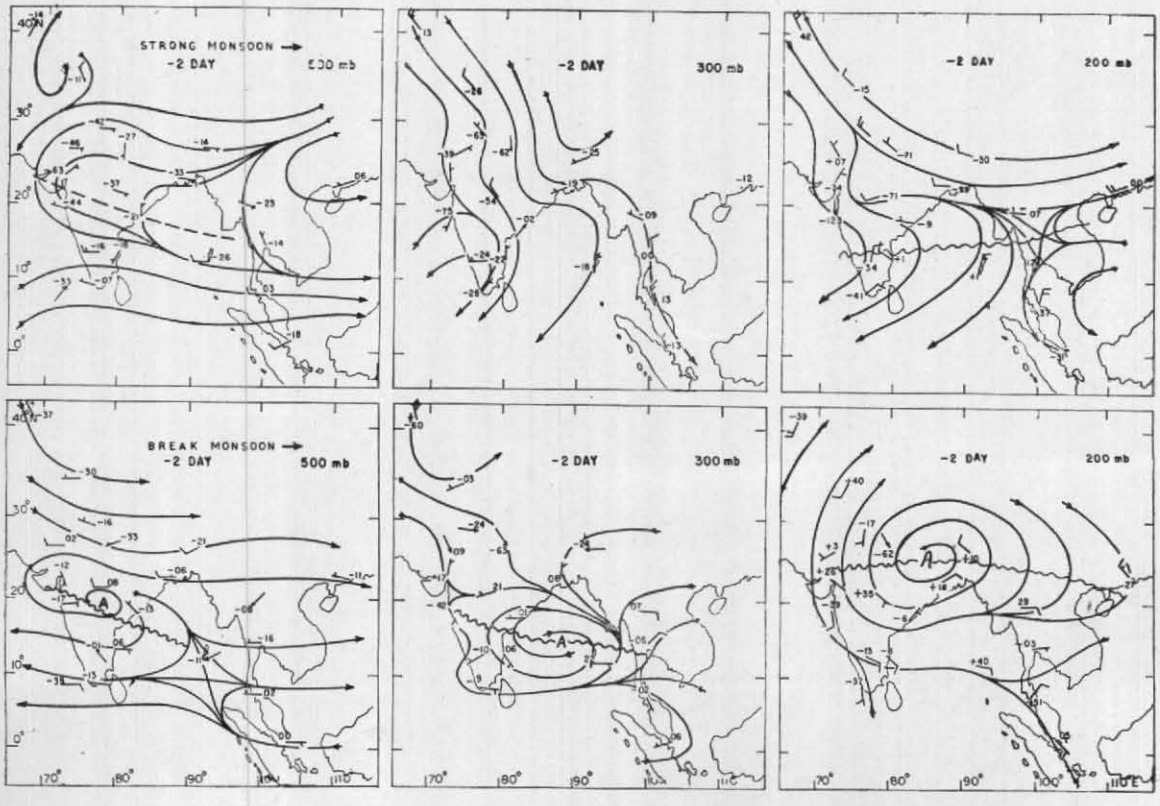

Fig. 5 (b). Composite daily anomaly charts (with date of peak activity as 'O' date)

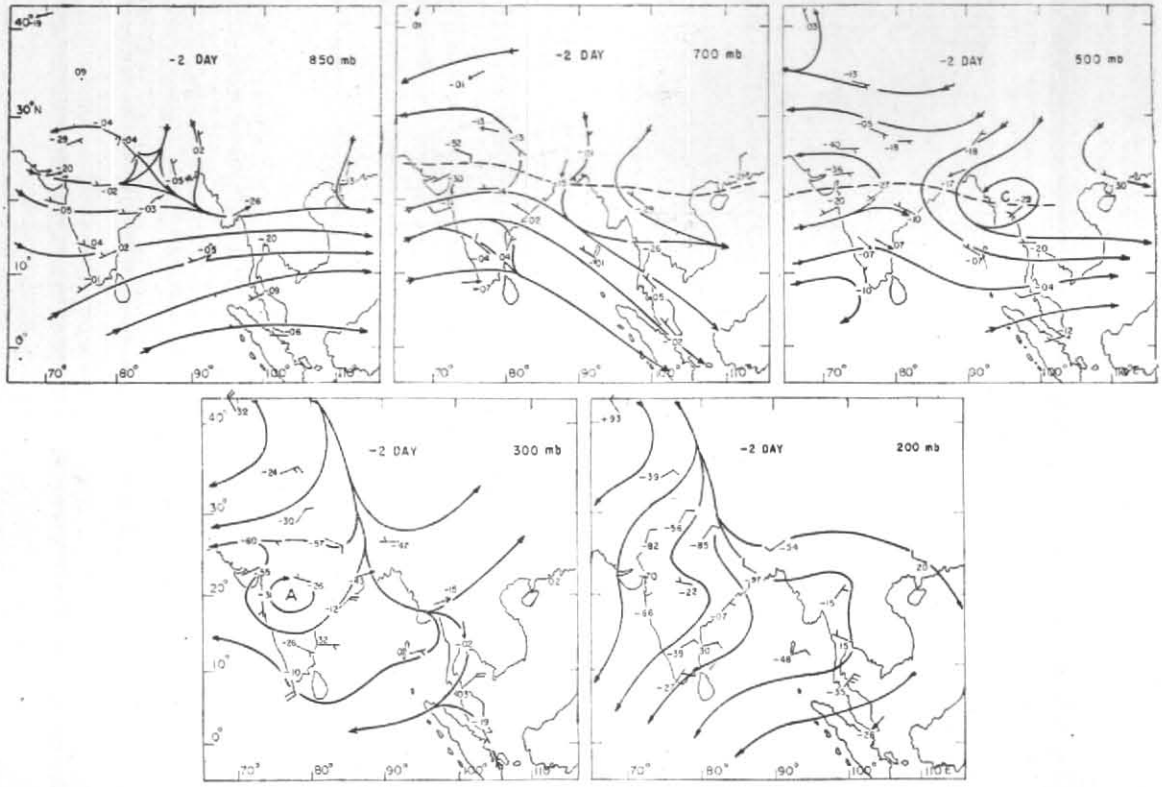

Fig. 6. Composite daily anomaly charts — Depression (with date of formation of depression as 'O' date)

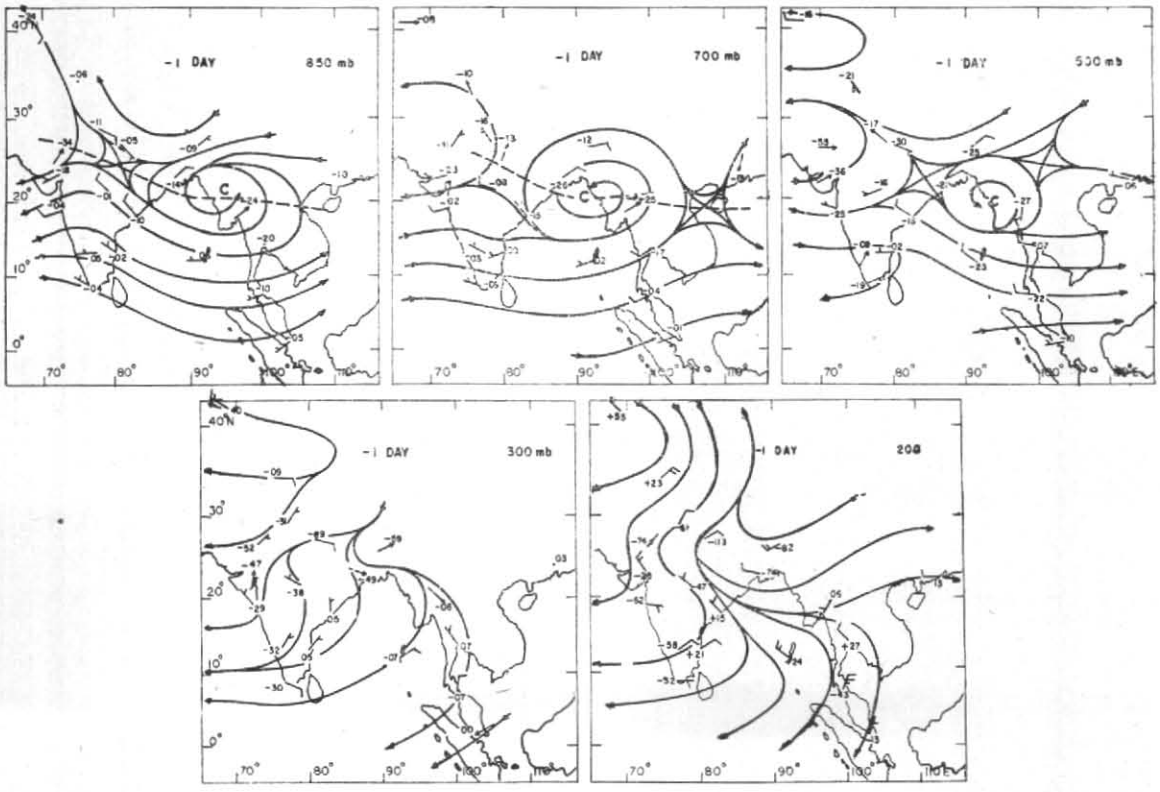

Fig. 7. Composite daily anomaly charts — Depression (with date of formation of depression as 'O' date)

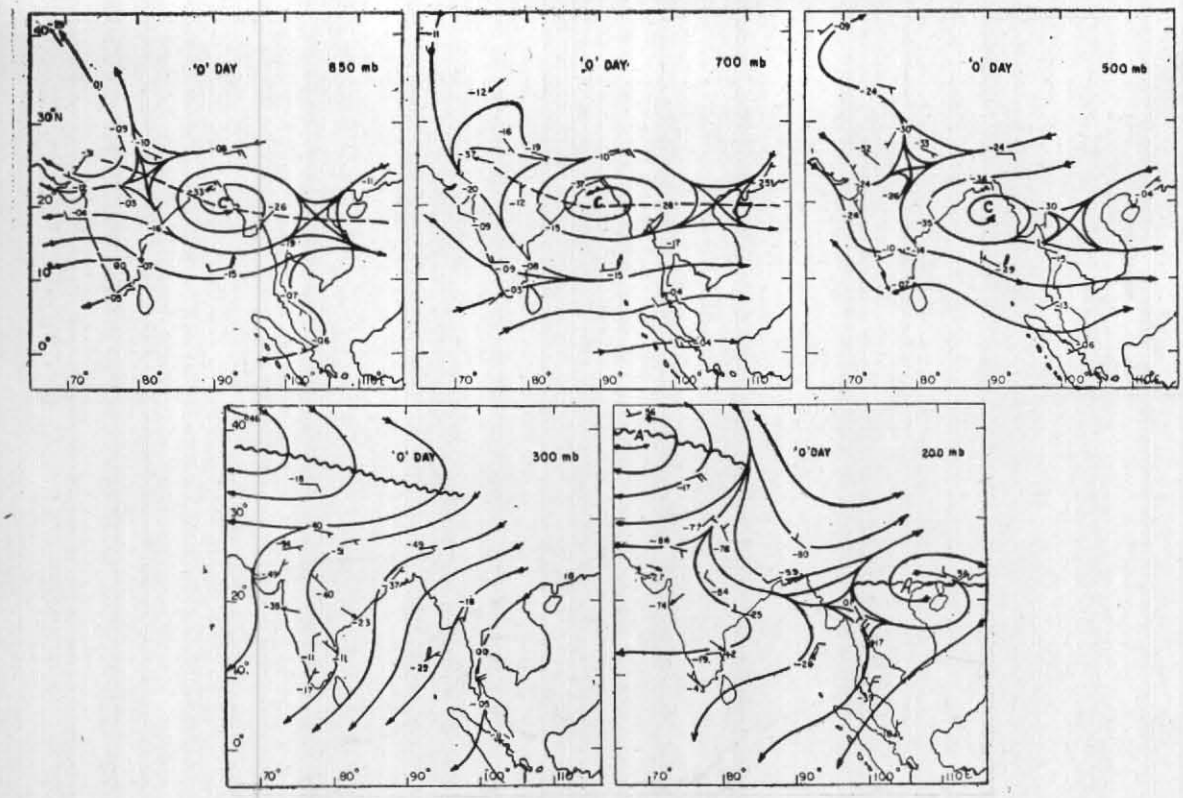

Fig. 8. Composite daily anomaly charts — Depression (with date of formation of depression as '0' date)

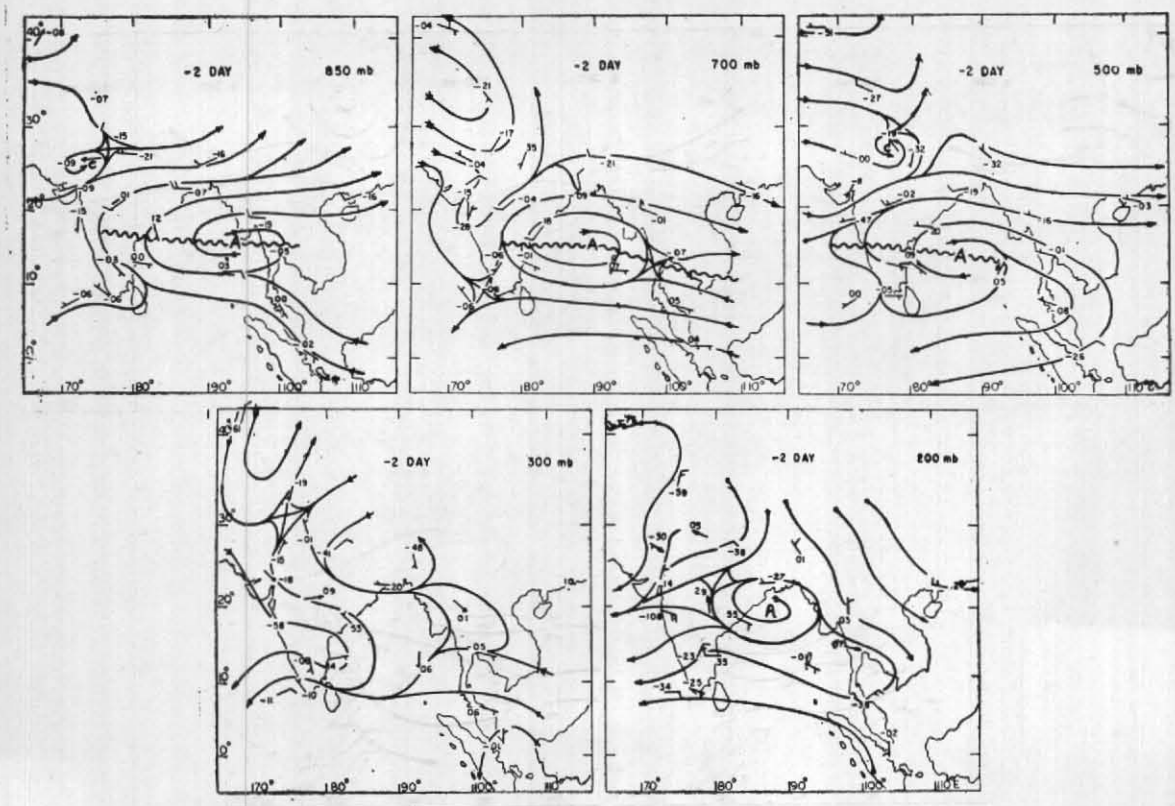

Fig. 9. Composite daily anomaly charts — Break monsoon (with date of beginning of the break as '0' date)

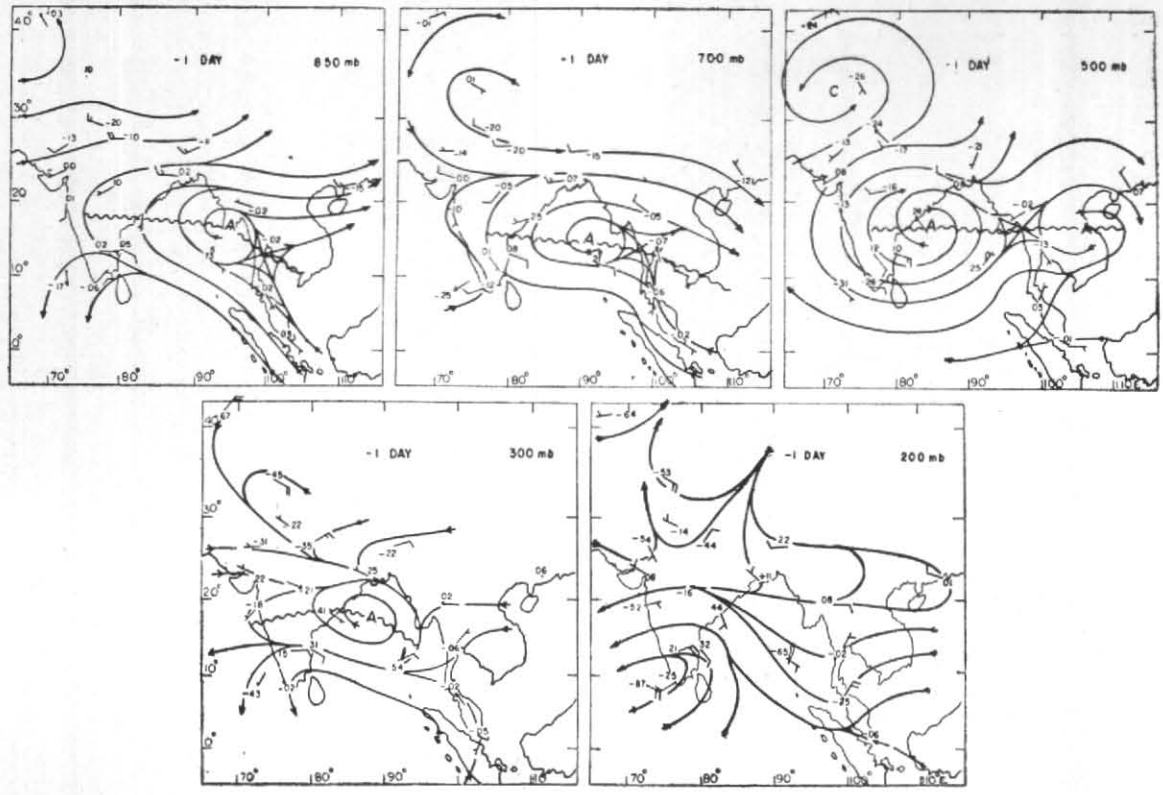

Fig. 10. Composite daily anomaly charts — Break monsoon (with date of beginning of the break as 'O' date)

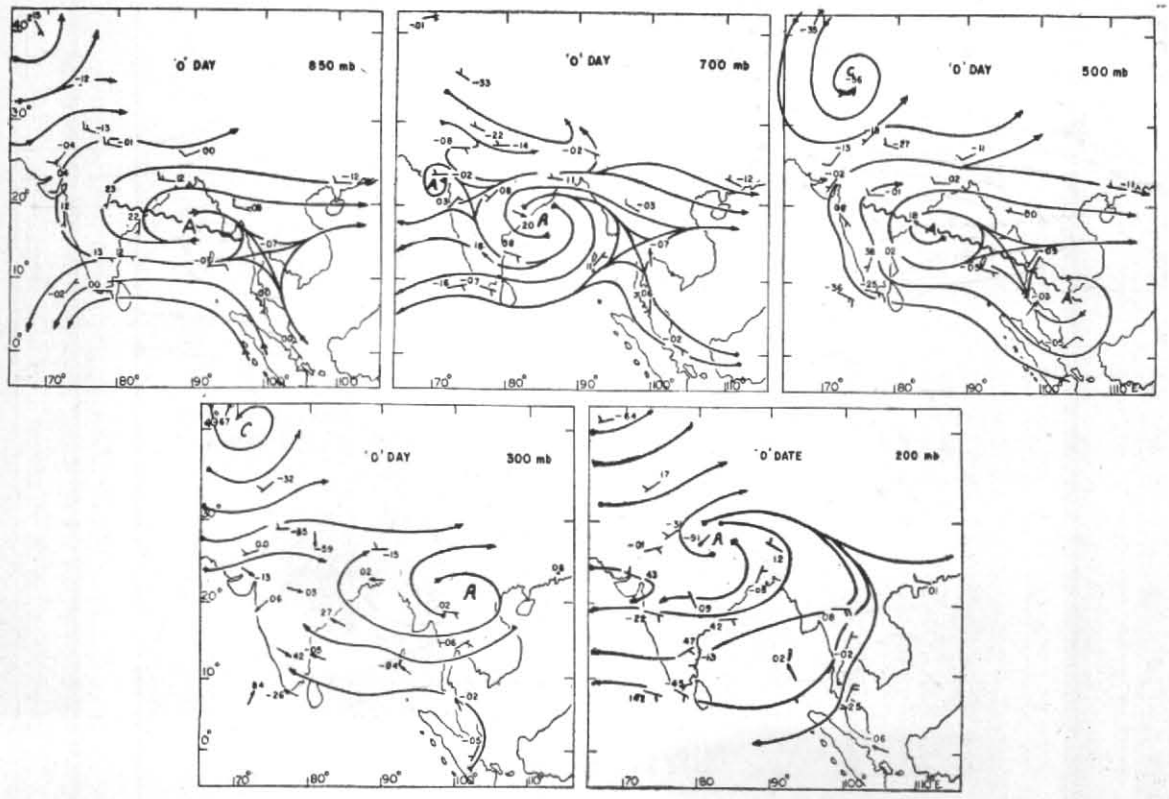

Fig. 11. Composite daily anomaly charts — Break monsoon (with date of beginning of the break as 'O' date)

4. Conclusions

An examination of the anomalous flow features prior to and during strong and break monsoon situations reveals the following features:

(*i*) A couple of days prior to the beginning of break monsoon an anomaly ridge extends from Peninsular India to Malaysia in the lower and middle troposphere. In the upper troposphere an anomaly trough (with below normal temperature) is seen to the northwest of India.

(*ii*) A couple of days prior to the beginning of strong monsoon (in association with depressions) a marked anomaly trough extends from Peninsular India to Thailand in the lower and middle tropospheres. In the upper troposphere an anomaly ridge (with above normal temperatures) is seen to the northwest of India.

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DISCUSSION

(Paper presented by George Alexander)

P. R. PISHAROTY : In the India Meteorological Department it is customary to prepare charts of "pressure departures from normal". This paper suggests that we should regularly plot on the operational charts, the vector wind departures from normal, especially since the geostrophic law need not be obeyed in the lower latitudes. Perhaps this was being done at Poona under the direction of Dr. Alexander, while he was the Dy. Director General Forecasting.

AUTHOR : This was done at Poona during 1976 monsoon season.