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THE INDIAN INSTITUTE OF TROPICAL METEOROLOGY

A STUDY OF THE ANOMALOUS THERMAL AND WIND PATTERNS DURING EARLY SUMMER SEASON OF 1979 OVER THE AFRO-ASIAN REGION IN RELATION TO THE LARGE-SCALE PERFORMANCE OF THE MONSOON OVER INDIA.

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March 1981

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ABSTRACT

Anomalous features in the upper tropospheric temperature (cold anomaly) and wind field (westerly anomaly) over the Asian region during the early summer months of May and June in the Monex year of 1979 were found to persist in July and August. Surface pressure over India during the monsoon season of 1979 were also observed to be above normal Abnormality was also found in the tracks of the monsoon depressions of the season. All these features are discussed in relation to the failure of the monsoon over large parts of India during the year.

1. Introduction

Summer monsoon of SE Asia is a thermally driven, large scale circulation. Radiational heating in the troposphere being its main forcing. This forcing begins to operate from the pre-monsoon season at different levels. Earlier study by Verma and Sikka (1977) showed double maxima over Asiatic monsoon region in the annual temperature wave in the

troposphere - one at 850 mb (the lowest level considered) and the other at about 300 mb. It was suggested by the authors that whereas the lower tropospheric heating is sensible in nature, the secondary maximum at 300 mb may be caused by the condensational heating resulting from the summer monsoon rainfall regime. Verma (1979) studied the upper tropospheric thermal anomalies over north India during the premonsoon months and found that they persist during the months of July and August. He also suggested that the temperature anomaly field may have some influence upon the large-scale activity of the ensuing monsoon rainfall. As the upper tropospheric data during the field phase of Monex-79 became available, it was found that in May 1979 the upper troposphere was much cooler than the normal over major parts of India. This cold anomaly prompted us to keep a watch on this feature and study its possible effect on the summer monsoon. The result of this investigation is presented in the present article.

2. Data and Procedure

Mean monthly values of temperature at 200 mb level, for the months of May and June 1979, were computed from the daily charts prepared at the Summer Monex Operational Centre (SMOC), Bombay, at about 40 radiosonde stations, spread over an area extending from equator to 45°N and from 20°E to 155°E. These include 15 Indian and 25 extra-Indian stations. In addition, to fill the gap in the Chinese region, grid point values at nine points (Intersections of 25°, 30°, 35°N and 100°, 110°, 120°E) were also picked up from the analysed

daily charts.

Due caution has been taken in adopting the normals for 200 mb temperatures for the purpose of calculating the anomalies. Most of the Indian radiosonde stations switched over to audio-modulated types during late sixties. Hence, short period normals (1967 to 1976) have been prepared and used for all Indian and some extra-Indian stations. These normals for extra-Indian stations are in good agreement with the normals prepared by WMO (1965) or as shown in the IIOE Atlas by Ramage and Raman (1972).

The position and strength of the sub-tropical westerly jet stream at 200 mb over India and neighbourhood were obtained as follows : Based on the analysed streamlines - isotachs charts, the position (latitude) and strength of the maximum isotach at longitudes of 40, 50, 60, 70, 80, 100, 110 and 120°E were picked up. The position and strength of this maximum wind were averaged for 40, 50 and 60°E to represent condition along 50°E, 70 and 80°E to represent conditions at 75°E and 100, 110, 120°E to represent conditions at 110°E. The daily values of the latitude and the strength of the 200 mb maximum wind thus determined, were averaged to find out the representative mean monthly values of the parameters at 50, 75 and 110°E, In addition, monthly mean values of observed 200 mb wind at about 8 stations (over north India, Japan and West Asia), obtained from monthly climatic data for the world, have been also used to delineate the position of

the westerly jet. These observed wind showed very good agreement with the computed wind based on grid point data by the procedure described above.

3. Upper tropospheric anomalies in May and June of 1979

3.1 Temperature anomalies

Figure 1 shows the temperature anomalies in ^{o}C at 200 mb level during May and June of 1979 over the Afro-Asian region. Upper tropospheric temperatures were observed to be markedly below normal by about $4^{o}C$ during the months of May and June 1979, over North Indian region (north of about $18^{o}N$). Comparison of temperature anomalies of May with those of June 1979 indicates that negative temperature anomaly region has extended to almost whole of southeast Asia as the season advanced. Thus, anomalously cold upper troposphere over Afro-Asian region was a significant feature of the early summer season of 1979.

The negative thermal anomalies have been observed to persist during July and August also over Indian region as shown in Figure 2.

3.2 Anomaly in sub-tropical westerlies

The mean position and strength of the westerly jet at 200 mb level during the months of May and June of 1979 are also shown in Figure 1. Table 1 shows the position and strength of subtropical westerly wind maxima at different longitudes at 200 mb for the months of May and June of 1979 along with the

normals taken from the IIOE Atlas by Ramage and Raman (1972). The jet was much stronger (by about 20 knots) than the normal. There seems to be slight southward (about 2°) shift in the jet. Actually, the upper tropospheric flow over north India, during the entire monsoon period of June to September, remained anomalously westerly.

Table 1 : Subtropical westerly wind maxima at 200 mb

Month		Position and Strength at different Longitudes		
		50°E	75°E	110°E
May	Normal	30°N/65K	35°N/55K	37°N/65K
	1979	28°N/90K	32°N/80K	35°N/100K
June	Normal	36°N/65K	38°N/50K	37°N/60K
	1979	34°N/75K	38°N/75K	34°N/80K

4. Large-scale behaviour of Monsoon 1979 over India

4.1 Anomaly in the surface pressure

Daily surface pressure departures from normal at 2.5° latitude-longitude intervals were obtained from the analysed charts and the chart was categorised into above normal/below normal type, if more than 70% of the grid points over India were above normal/below normal. Otherwise the chart was categorised as 'normal-type'. Frequency distribution of different chart-types, as worked out for each month, is shown in Table 2.

Table 2 : Frequency distribution of surface pressure departure.

Month	No. of days of different types			Total
	Below normal	Normal	Above normal	
May 1979	8	6	17	31
June 1979	9	4	17	30
July 1979	5	5	21	31
August 1979	12	5	14	31
September 1979	8	3	19	30
Total	42	23	88	153
Percentage of the total no. of days	28	14	58	

During more than half of the period of May to September 1979, the surface pressure departure over the country was above normal. By examining the daily chart-types, it was noticed that this aspect of the surface pressure was cumulative effect of three very well marked spells of (i) 16 May - 10 June, (ii) 9 July - 31 July and (iii) 16 August - 22 September when surface pressure departures were observed to be predominantly positive. By and large, these spells were marked by weak monsoon conditions over the country, as large-scale positive surface pressure departure would tend to suppress large-scale convection.

4.2 Monsoon depressions/storms during June-September 1979

During summer monsoon season (June-September), de-

pressions normally form over head Bay of Bengal and move inland in a west/northwesterly direction giving copious rains to the south of their tracks. Monsoon depressions, thus serve to distribute rainfall in the belt between 20-28°N depending upon their paths.

The tracks, dates and the intensities of monsoon depressions/storms, which formed during the monsoon season of 1979, are shown in figure 3. In all 10 depressions (seasonal normal 8) formed during this monsoon season - 3 over the Arabian sea and 7 over the Bay of Bengal. The depressions which formed over the Bay of Bengal during this monsoon season, showed abnormal behaviour. They were either short-lived (those which formed on 7 July, 23 September and 29 September), moved northwards (those which formed on 28 June and 12 August) or moved south of the normal track (which formed on 6 August) resulting respectively in, localised rain, weak/break monsoon conditions over large parts of the country (by shifting the seasonal trough to the foot of the Himalayas within a few days of their formation), or restricting rainfall activity to the south of Central India. A remarkable feature of the depression movement during the season has been their avoiding the Gangetic plains west of 85°E and north of 24°N.

The two long lived depressions which formed over the Arabian Sea show almost indentical tracks, though they formed 3-months apart. The first, which formed on 16 June advanced the monsoon upto northern parts of the Peninsula.

The second, which formed on 18 September, had a history from south Andaman sea, and caused widespread rain while passing as a 'low' over southern and western parts of the Peninsula.

4.3 Summer Monsoon Rainfall Activity over India from June to September 1979.

The abnormal tracks and the shorter life duration of depressions as well as relatively large interval (nearly a month) between the two westward moving depressions in July and August during which interval the monsoon circulation remained rather weak, were responsible for the below normal rainfall activity in the peak monsoon months over large parts of the country. A spell of good rainfall over central parts of the country occurred in the first fortnight of August. During this period also the rainfall was below normal to the north of the tracks of the disturbances as is usually the case. Thereafter the monsoon weakened over the country and could not recover its intensity till the middle of September.

The withdrawal of the monsoon possibly set in over NW India in this weak phase as the rainfall remained scanty over these parts of the country from the third week of August till the third week of September. As the monsoon disturbances in September (except the one which formed over west Bengal on 29 September) did not affect the Indian region to the north of 20°N, the northern and central parts of the country remained deprived of rainfall in September also. In fact the monsoon rainfall over large parts of the country was below normal in

the season except for three spells; one in the onset phase in the second half of June, second in the second week of July and the third in the first fotnight of August. From this description it appears that certain persistent large-scale features acted throughout the season which did not favour the intensification of monsoon system.

The rainfall activity over India, during the monsoon season of 1979 is depicted in Figure 4. The percentage rainfall departures from normals are shown subdivisionwise. Note that over large areas of central and north India, the seasonal rainfall deficiency is more than one third of the normal. Season's rainfall departure for the country as a whole works out to be about - 16 per cent.

5. Conclusions

The study reveals the following features :

(1) The upper troposphere over south-east Asia was characterised by (i) large negative thermal anomalies, and (ii) anomalous westerly winds during the early summer of 1979. These anomalies persisted through the summer monsoon season, particularly over India. The magnitude, as well as the spatial and temporal scales of these anomalies were remarkably large.

(2) Surface pressure departure over India was above normal for more than half of the period of May to September of 1979. This occurred mainly during three spells of about

20 days each. This feature seems to have inhibited the large-scale convection during the monsoon season, thus affecting the rainfall distribution.

(3) Although ten depressions formed over Indian seas during the monsoon season of 1979, most of them either short-lived/moved northwards or followed south of the normal tracks. This abnormal behaviour of the season's most of the depressions deprived large parts of the central/northwest India of their depressional rains.

(4) The rainfall departure for the whole of India for the monsoon season has worked out to be about - 16 per cent which makes it one of the largest deficit rainfall years in the last 100 years of recorded data.

The study also supports the hypothesis put forward by Verma (1979) that the upper tropospheric thermal anomalies over north India, during the premonsoon months, persist during the subsequent monsoon period and that the large negative (positive) anomalies are generally linked with the below normal (above normal) rainfall activity of the ensuing monsoon over India. This aspect of anomalous temperature distribution in the upper troposphere may have its usefulness in the long-range forecasting of the seasonal monsoon rainfall over India.

REFERENCES

Ramage, C.S. and Raman, C.R.V.	1972	Meteorological atlas of the International Indian Ocean Expedition, Vol. 2.
Verma, R.K.	1979	Long-range prediction of monsoon activity - a synoptic-diagnostic study. Symposium on Monsoon Prediction, 17-18 March 1979, IIT, New Delhi.
Verma, R.K. and Sikka, D.R.	1977	Annual oscillation in the tropospheric temperature in the northern hemisphere with special reference to Asiatic summer monsoon. Joint IUTAM/IUGG International symposium on Monsoon Dynamics, 5-9 December 1977, IIT, New Delhi.
World Meteorological Organisation	1965	Short period averages for 1951-1960 and provisional average values for climat temp and climat temp ship stations. No. 170, TP 84.

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LEGEND OF FIGURES

Figure 1 : Temperature anomalies in ^{o}C at 200 mb during May and June of 1979 over the Afro-Asian region. Also shown is the position of the sub-tropical westerly jet by thick line with speeds indicated at 50^{o}, 75^{o} and $110^{o}E$ longitudes.

Figure 2 : Temperature anomalies in ^{o}C at 200 mb during July and August of 1979 over Indian region.

Figure 3 : Tracks, dates and the intensities of monsoon depressions/storms formed over Indian seas during the monsoon season of 1979.

Figure 4 : Rainfall activity over India, during the monsoon season of 1979. Percentage rainfall departures from the normals are shown subdivisionwise. Sub-divisions having negative departures are shaded.

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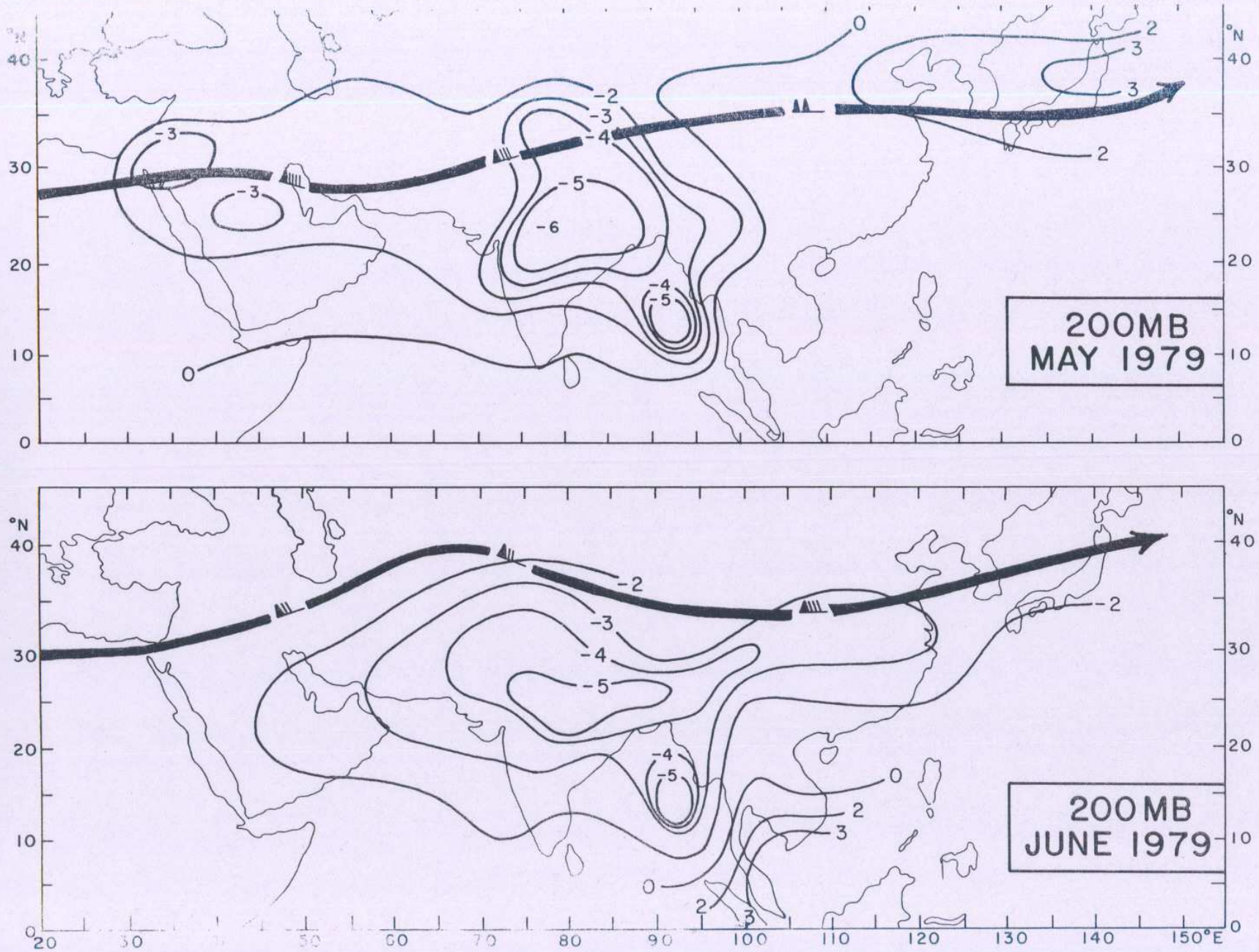
200MB
MAY 1979
200MB
JUNE 1979
°N
40
30
20
10
0
20
30
50
60
70
80
90
100
110
120
130
140
150°E

FIG. 1

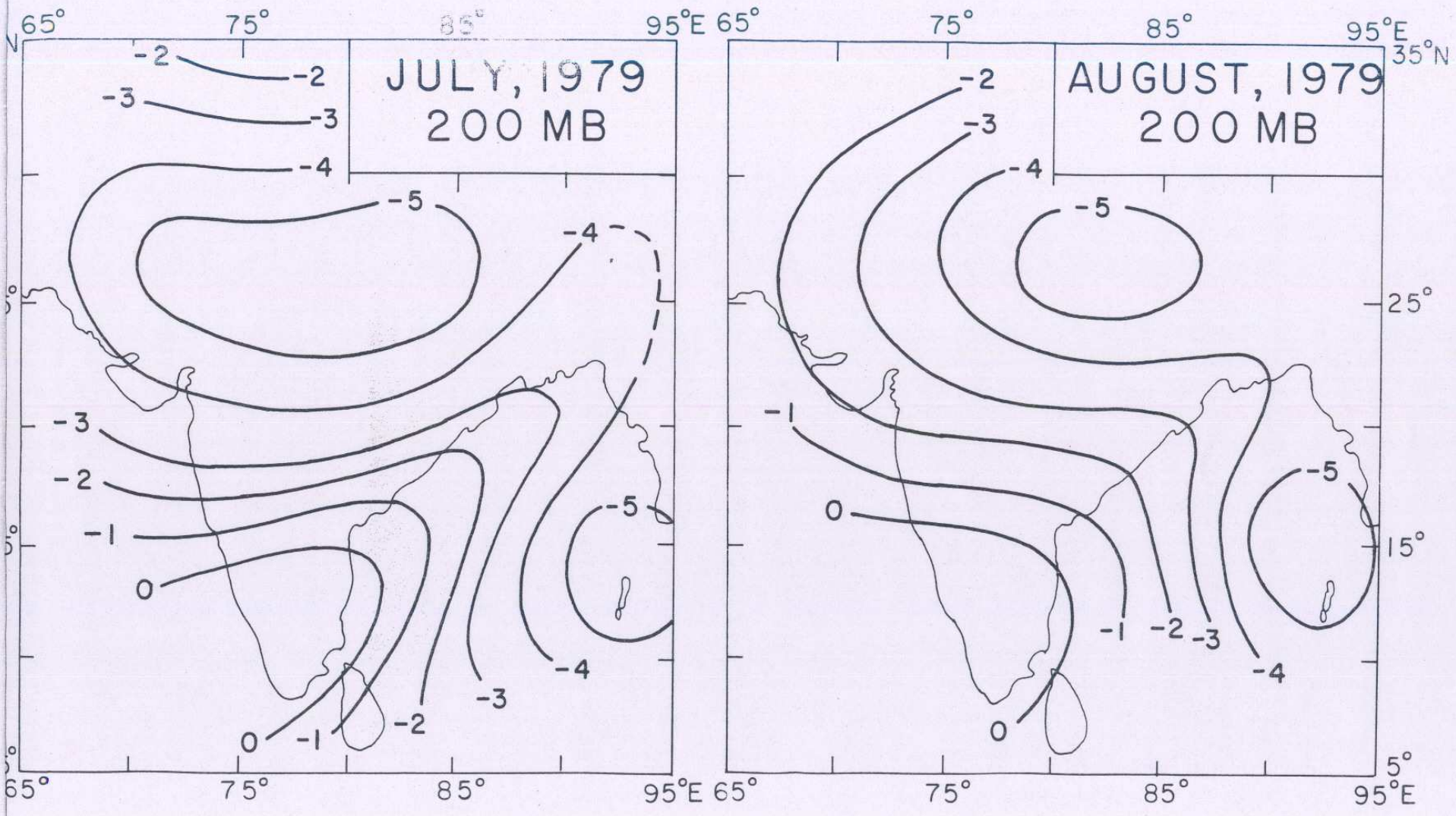
JULY, 1979
200 MB
AUGUST, 1979
200 MB
65°
75°
85°
95°E
35°N
25°
15°
5°
-2
-3
-4
-5
-1
0

FIG. 2.

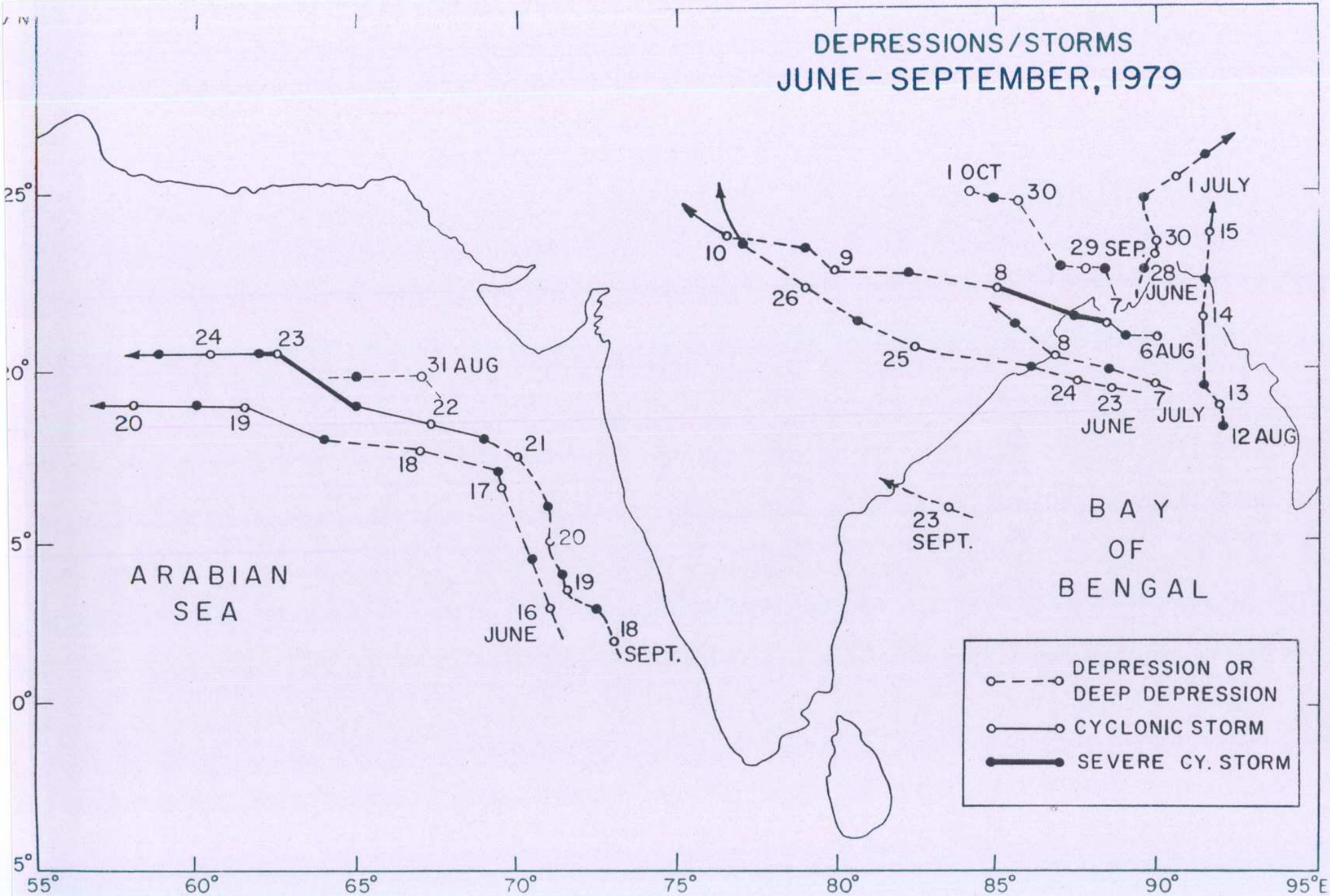
DEPRESSIONS/STORMS
JUNE-SEPTEMBER, 1979
ARABIAN SEA
BAY OF BENGAL
1 OCT
30
29 SEP.
30
1 JULY
15
28 JUNE
14
6 AUG
13
12 AUG
7 JULY
23 JUNE
24
25
26
10
9
8
7
8
23 SEPT.
31 AUG
24
23
22
21
20
19
18
17
20
19
16 JUNE
18 SEPT.
DEPRESSION OR DEEP DEPRESSION
CYCLONIC STORM
SEVERE CY. STORM
25°
20°
5°
0°
5°
55°
60°
65°
70°
75°
80°
85°
90°
95°E

FIG. 3

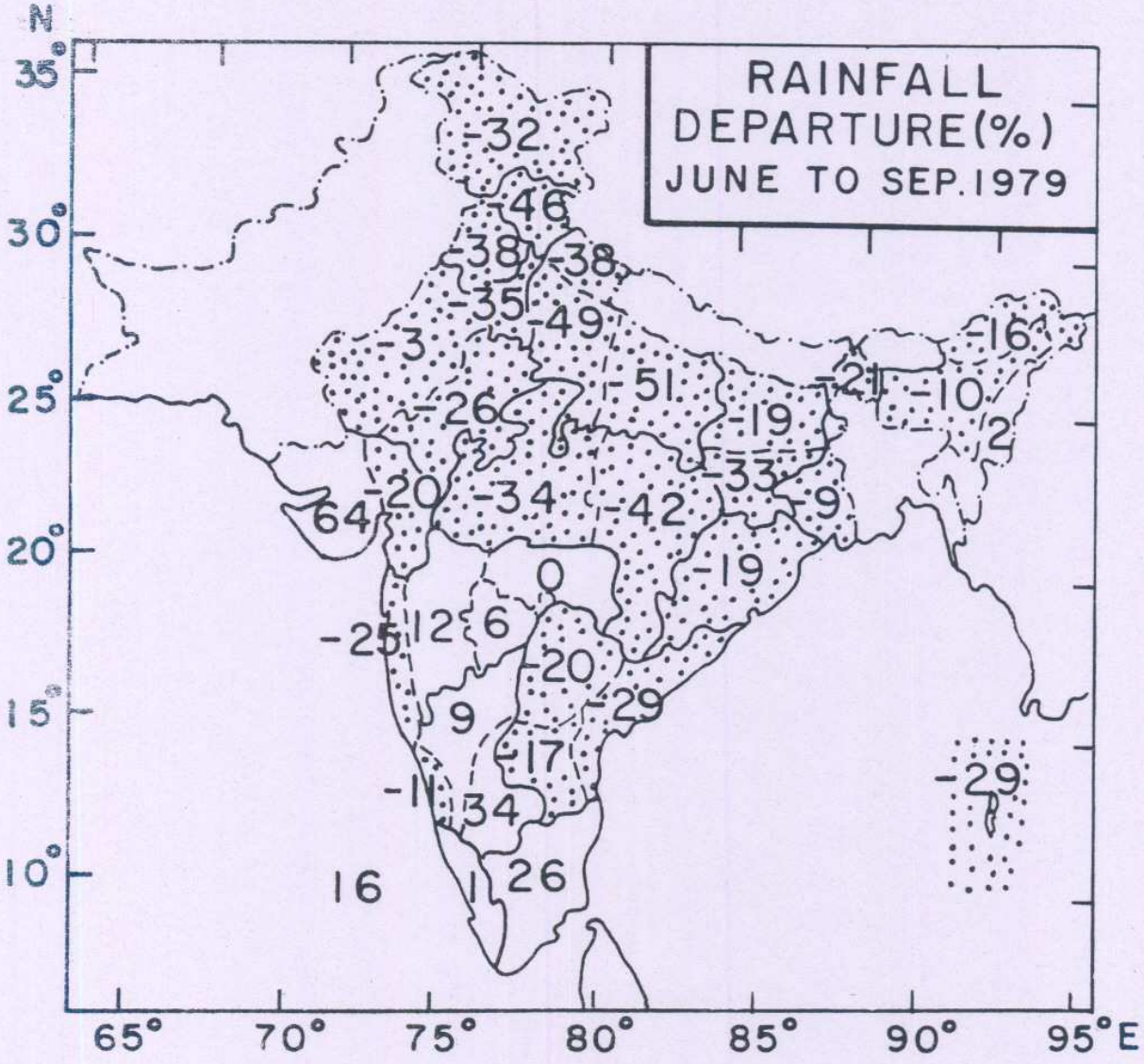
RAINFALL
DEPARTURE(%)
JUNE TO SEP. 1979
N
35°
30°
25°
20°
15°
10°
65°
70°
75°
80°
85°
90°
95°E
-32
46
38
-38
-35
-49
-3
-16
-51
-21
-10
-26
-19
2
-33
-20
-34
-42
-9
64
0
-19
-25
12
6
-20
-29
9
-17
-1
34
-29
16
126

FIG. 4