MAUSAM, 51, 2 (April 2000), 193-214

Weather in India

HOT WEATHER SEASON (MARCH-MAY 1999)*

1. Introduction

Pre-monsoon thundershower activities were prominent in most parts of the country in the month of May. Season's rainfall was excess (percentage departure from normal rainfall is + 20% or more) in 15, normal (percentage departure from normal rainfall is between - 19% to + 19%) in 10, deficient (percentage departure from normal rainfall is between - 20% to - 59%) in 9 and scanty (percentage departure from normal rainfall is between - 60% to - 99%) in 1 meteorological sub-divisions. Season's rainfall was excess in Orissa, Bihar State, west Rajasthan, Saurashtra & Kutch, Konkan & Goa , Marathwada, Vidarbha, Telangana, Rayalaseema, Karnataka, Kerala and Lakshadweep; normal in Andaman & Nicobar Islands, Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, West Bengal & Sikkim, east Uttar Pradesh, Haryana, coastal Andhra Pradesh and Tamilnadu; deficient in Hills of west Uttar Pradesh, Punjab, Himachal Pradesh, Jammu & Kashmir, east Rajasthan, Madhya Pradesh, Gujarat region and Madhya Maharashtra and scanty in plains of west Uttar Pradesh.

Actual rainfall and its departure for each month and season as a whole are given in Table 1 and sub-divisional rainfall departures for the season March-May are shown in Fig. 1.

2. Chief features

(*i*) Very severe cyclonic storm over the Arabian sea (16-22 May 1999).

(*ii*) Very good pre-monsoon rainfall activity over most parts of the country in the month of May.

(*iii*) Heat wave conditions prevailed over many parts of the country.

(*iv*) Early onset of southwest monsoon over Kerala on 25 May 1999 as against normal date of 1 June.

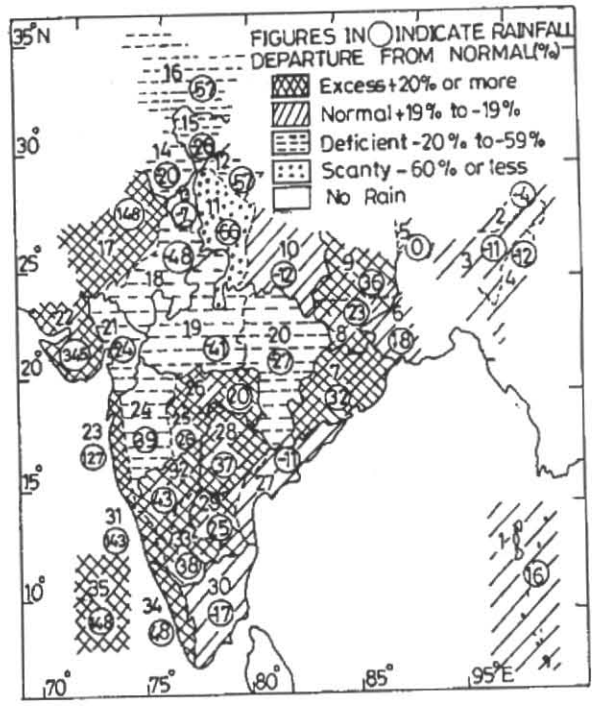

Fig. 1. Sub-divisionwise seasonal rainfall departure (%) for the period March-May 1999

3. Monthly features

3.1. *March*

3.1.1. *Weather and associated synoptic features*

Details of weather system formed during the month are given in Table 2.

Rain or snow occurred on either at most places (75% or more stations from the meteorological sub-divisions reporting rainfall more than 2.5 mms) or at many places (rainfall occurred over 51% to 75% stations from the meteorological sub-divisions; each station reporting rainfall at least 2.5mms) on 4 days in Jammu & Kashmir and on 2 days in Himachal Pradesh. Rain or thundershowers also occurred either at most places or at many places on 1 to 2 days in Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura and Sub-Himalayan West Bengal & Sikkim. Rain or

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TABLE 1

Monthly and seasonal rainfall (mm) for each month and season (March-May 1999)

S. No.	Meteorological sub-division	March			April			May			Season		
		Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)
1.	A. & N. Islands	26	40	-36	293	89	231	267	377	-29	585	506	16
2.	Arunachal Pradesh	25	105	-76	200	212	-6	394	328	20	619	645	-4
3.	Assam & Meghalaya	39	90	-56	174	213	-18	435	423	3	648	726	-11
4.	Naga., Mani., Mizo. & Tripura	38	74	-48	17	141	-88	346	241	43	401	455	-12
5.	SHWB & Sikkim	7	52	-86	138	109	26	291	276	6	436	437	0
6.	Gangetic West Bengal	1	27	-96	11	44	-76	197	105	88	208	176	18
7.	Orissa	1	24	-96	3	33	-91	154	64	142	158	120	32
8.	Bihar Plateau	0	18	-99	1	21	-96	110	52	113	111	91	23
9.	Bihar Plains	0	11	-100	4	14	-72	90	44	105	94	69	36
10.	East U.P.	0	9	-100	0	6	-98	28	16	72	28	32	-12
11.	Plains of West U.P.	0	13	-98	0	6	-100	10	11	-10	10	31	-66
12.	Hills of West U.P.	3	60	-95	3	34	-91	59	56	5	64	150	-57
13.	Haryana	1	14	-93	0	7	-100	29	12	143	30	32	-7
14.	Punjab	6	26	-78	0	11	-100	35	13	161	41	51	-20
15.	Himachal Pradesh	24	81	-70	2	44	-96	102	48	113	128	171	-26
16.	Jammu & Kashmir	75	136	-45	16	97	-83	37	66	-44	129	299	-57
17.	West Rajasthan	1	5	-84	0	2	-100	36	8	374	37	15	148
18.	East Rajashtan	0	5	-100	0	2	-100	9	9	-3	9	16	-48
19.	West Madhya Pradesh	0	7	-100	0	4	-99	11	9	31	11	19	-41
20.	East Madhya Pradesh	0	18	-100	0	14	-100	34	15	123	34	46	-27
21.	Gujarat Region	0	2	-100	0	1	-100	8	7	8	8	11	-24
22.	Sauarashtra & Kutch	0	4	-100	0	1	-100	39	4	891	39	9	345
23.	Konkan & Goa	0	0	-100	0	5	-100	109	42	157	109	48	127
24.	Madhya Maharashtra	0	4	-100	0	12	-100	28	29	-5	28	45	-39
25.	Marathwada	0	7	-100	0	10	-100	46	20	133	46	36	26
26.	Vidarbha	0	14	-99	0	12	-100	46	13	258	46	39	20
27.	Coastal A. P.	0	12	-98	4	25	-85	79	57	40	83	94	-11
28.	Telangana	2	11	-82	1	19	-96	74	26	187	77	56	37
29.	Rayalaseema	0	6	-98	7	20	-64	90	52	74	98	78	25
30.	Tamil Nadu	1	20	-97	55	49	12	56	69	-18	112	136	-17
31.	Coastal Karnataka	2	5	-61	6	33	-81	453	152	199	461	189	143
32.	N. I. Karnataka	1	6	-83	7	27	-73	115	53	118	124	87	43
33.	S. I. Karnataka	2	8	-69	55	45	23	156	102	53	214	154	38
34.	Kerala	22	40	-44	124	113	9	471	263	79	617	417	48
35.	Lakshadweep	18	8	132	21	35	-41	417	141	196	456	184	148

thundershowers also occurred either at a few places (rainfall occurred over 26% to 49% stations from the meteorological sub-divisions; each station reporting rainfall at least 2.5mms) or at isolated places (rainfall occurred over less than 25% stations from the meteorological sub-divisions; each station reporting rainfall at least 2.5mms) on many days in Kerala and on few days in northeast, northwest and peninsular India. Heavy rain (rainfall amount more than 6.5cms and less than 12.5cms over one or two stations in the sub-division) has occurred on 1 day in Assam & Meghalaya.

3.1.2. *Month's rainfall*

Month's rainfall was excess in 1; deficient in 5 and scanty in 19 meteorological sub-divisions. There was no rain in 10 meteorological sub-divisions. Rainfall was excess in Lakshadweep and deficient in Andaman & Nicobar Islands, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Jammu & Kashmir and Kerala and scanty in Arunachal Pradesh, West Bengal & Sikkim, Orissa, Bihar Plateau, west Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, west Rajasthan, Vidarbha, Andhra Pradesh, Tamilnadu and Karnataka. There was no rain in Bihar Plains, east Uttar Pradesh, east Rajasthan, Madhya Pradesh, Gujrat State, Konkan & Goa, Madhya Maharashtra and Marathwada. Principal amounts of rainfall are given in Table 5.

3.1.3. *Temperature*

Severe heat wave conditions (departure from normal is +5°C or more for the regions where the normal maximum temperature is more than 40°C and departure from normal is +7°C or more for the regions where the normal maximum temperature is 40°C or less) prevailed on 1 to 4 days in Assam & Meghalaya, Bihar Plateau, hills of west Uttar Pradesh, Kashmir and Rajasthan and in some parts of Orissa. Day temperatures were appreciably (departure from normal is +3°C to +4°C for the regions where the normal maximum temperature is 40°C or less) to markedly (departure from normal is +5°C to +6°C for the regions where the normal maximum temperature is 40°C or less) above normal on most of the days in Arunachal Pradesh and hills of west Uttar Pradesh; on many days in Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, West Bengal & Sikkim, Bihar, plains of west Uttar Pradesh, Haryana, Himachal Pradesh, Rajasthan, Madhya Pradesh, Saurashtra & Kutch and Vidarbha and on few days over rest of the country. Month's highest temperature of 44°C was recorded at Dholpur in Rajasthan on 31 march.

Night temperature were appreciably (departure from normal minimum temperature is in between -3°C to -4°C) to markedly (departure from normal minimum temperature is in between -5°C to -6°C) below normal on 8 days in Punjab; on 3 to 5 days in Nagaland, Manipur, Mizoram & Tripura, Bihar Plains, plains of west Uttar Pradesh, Jammu, Gujrat Region, Konkan & Goa, Marathwada and Tamilnadu and on 1 to 2 days in Arunachal Pradesh, Sub-Himalayan West Bengal & Sikkim, east Uttar Pradesh, Himachal Pradesh, west Rajasthan, west Madhya Pradesh, Saurashtra & Kutch and Madhya Maharashtra.

3.1.4. *Disastrous weather events and damages*

According to press reports, 7 people died in Orissa due to heat wave. Due to lightning, 14 people died in Kerala and there was damage to crops and electric lines.

3.2. *April*

3.2.1. *Weather and associated synoptic features*

Details of weather systems formed during the month are given in Table 3.

Rain or thundershowers have occurred either at most places or at many places on 13 days in Andaman & Nicobar Islands; on 5 to 9 days in Arunachal Pradesh, Assam & Meghalaya and Sub-Himalayan West Bengal & Sikkim and on 1 to 2 days in Nagaland, Manipur, Mizoram & Tripura, Tamilnadu, south interior Karnataka and Kerala. Rain or thundershowers have also occurred either at few places or at isolated places on most of the days in Tamilnadu and Kerala; on many days in Andaman & Nicobar Islands, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Sub-Himalayan West Bengal & Sikkim, Orissa and south interior Karnataka and on few days over the rest of the country outside plains of west Uttar Pradesh, Haryana, Punjab, Rajasthan, Madhya Pradesh, Gujrat State and Maharashtra & Goa States. Heavy to very heavy rainfall (rainfall amount more than 12.5cms over one or two stations in the sub-divisions) occurred on 4 days in Andaman & Nicobar Islands and Kerala and on 1 to 2 days in Arunachal Pradesh, Assam & Meghalaya, Sub-Himalayan West Bengal & Sikkim and Tamilnadu.

3.2.2. *Month's rainfall*

Rainfall was excess in 3, normal in 4, deficient in 1 and scanty in 15 meteorological sub-divisions. There was no rain in the remaining 12 meteorological sub-divisions.

Rainfall was excess in Andaman & Nicobar Islands, Sub-Himalayan West Bengal & Sikkim and south interior Karnataka; normal in Arunachal Pradesh, Assam &

TABLE 2

Details of the weather system during March 1999

S No.	System	Duration	Place of first location	Direction of movement	Place of dissipation	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A)	*Western disturbances*					
1.	Upper air system	1-5	North Pakistan and Parts of Jammu & Kashmir	Eastnortheasterly	Jammu & Kashmir, Himachal Pradesh & neighbourhood	Moved away eastnortheastwards
2.	Low pressure area	4-9	North Pakistan and adjoining parts of Jammu & Kashmir	Do	Southern Parts of Jammu & Kashmir, Punjab and neighbourhood	Associated induced cyclonic circulation lay over south Pakistan & adjoining parts of west Rajasthan and extended upto 4.5 km a.s.l. on 4. It lay over south Rajasthan on 5 and merged with the low pressure area.
3.	Upper air system	8-10	Jammu & Kashmir and neighbourhood	Northeasterly	Northern parts of Jammu & Kashmir	The western disturbance lay as a trough of low pressure area over southern parts of Jammu & Kashmir, Punjab and neighbourhood on 7 and became less marked on 9
4.	Do	10-12	North Pakistan	Do	Jammu & Kashmir & neighbourhood	Moved away northeastwards
5.	Do	12-14	North Pakistan and adjoining Jammu & Kashmir	Do	Do	Do
6.	Do	14-16	North Pakistan and neighbourhood	Do	North Pakistan and adjoining Jammu & Kashmir	Do

TABLE 2 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
7.	Upper air system	16-19	North Pakistan	Northeastwards	Jammu & Kashmir and neighbourhood	Associated induced cyclonic circulation lay over south Pakistan and extended upto 3.1 kms a.s.l. The western disturbance lay as a low pressure area on 17 and 18,it lay as a upper air cyclonic circulation.
8.	Do	19-23	North Pakistan and neighbourhood	Do	Eastern parts of Jammu & Kashmir and neighbourhood	Moved away
9.	Do	23-25	North Pakistan and adjoining Jammu & Kashmir	Do	Northern parts of Jammu & Kashmir and neighbourhood	Moved away
10.	Do	26-27	Jammu & Kashmir	Do		Moved away across Jammu & Kashmir
(B)	*Induced cyclonic circulations*					
1.	Lower levels	2-4	West Rajasthan & neighbourhood	Stationary	*In situ*	
2.	Mid tropospheric levels	11-13	Southern parts of Rajasthan	Eastnortheasterly	Southeast Rajasthan & northwest Madhya Pradesh	
3.	Lower tropospheric levels	16-17	South Pakistan	Do	South Pakistan & adjoining parts of west Rajasthan	Merged with the western disturbance over central Pakistan and adjoining Rajasthan, Punjab and Jammu & Kashmir
4.	Lower levels	20-21	Central Rajasthan and adjoining area	Northnortheasterly	North Rajasthan and neighbourhood	
5.	Do	23-26	South Pakistan & adjoining parts of west Rajasthan	Eastnortheasterly	Plains west Uttar Pradesh and adjoining Haryana and neighbourhood	
(C)	*Embedded cyclonic circulations*					
1.	Lower tropospheric levels	29-31	North Bangladesh & adjoining Sub-Himalayan West Bengal & Sikkim and Bihar	Stationary	*In situ*	

TABLE 2 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(D)	*Other cyclonic circulations*					
1.	Mid tropospheric levels	3-4	Northeast Arabian sea & adjoining parts of Saurastra & Kutch	Stationary	*In situ*	
2.	Lower levels	10-11	South Rajasthan & adjoining parts of northwest Madhya Pradesh	Do	Do	
3.	Lower tropospheric levels	13-15	Lakshadweep- Maldives area off Kerala coast	Do	Do	
4.	Lower levels	14-17	Sub-Himalayan west Bengal & Sikkim & neighbourhood	Do	Do	
5.	Do	18-21	Do	Southwesterly	Bihar plateau and adjoining Gangetic West Bengal	
6.	Do	25-26	Gangetic West Bengal & neighbourhood	Stationary	*In situ*	
7.	Do	30 Mar-02 Apr	Punjab & adjoining parts of Pakistan	Northnortheasterly	North Pakistan & neighbourhood	Moved away across Jammu & Kashmir
(E)	*Troughs in easterlies*					
1.	Lower levels	1-3	Madhya Maharastra to coastal Karnataka roughly along Long. 74° E	Stationary	*In situ*	
2.	Do	4-6	Roughly along Long. 75° E to the south of Lat. 20°N	Southwesterly	Marathwada to south Tamil Nadu through interior Karnataka	
(F)	*Troughs in westerlies*					
1.	Mid & upper tropospheric levels	7-9	Long. 68° E, north of Lat. 15° N	Easterly	Long. 70° E, north of Lat. 15° N	

TABLE 2 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(G)	*East-west trough*					
1.	Lower levels	26-31	Bihar plains to north Assam	Quasi-stationary	East Bihar to Manipur	
(H)	*Other troughs*					
1.	Lower levels	1-2	Bihar plateau to Telangana region through southeast Madhya Pradesh	Stationary	*In situ*	
2.	Do	7-9	Long. 89° E, north of Lat. 20° N	Northnortheasterly	Assam Meghalaya and adjoining Bangladesh and Sub-Himalayan West Bengal & Sikkim	Lay as a weak cyclonic circulation on 8
3.	Do	10-14	Telangana to south Tamil Nadu across interior Karnataka	Westerly	Southeast Madhya Pradesh to Kerala coast through Telangana and interior Karnataka	
4.	Do	16-29	Madhya Maharashtra to Lakshadweep across Karnataka coast	Quasi-stationary	South interior Karnataka to south Tamil Nadu	It was seen over different areas of Bihar, Orissa and peninsular India
5.	Do	24-25	Long. 90° E, north of Lat. 20° N	Stationary	*In situ*	
6.	Lower tropospheric levels	27-29	Bihar plains to northwest Bay	Do	Do	
7.	Lower levels	29-31	Bihar plateau to south Tamil Nadu across Telangana	Quasi-stationary	Bihar plateau to south Madhya Maharashtra	

TABLE 3
Details of the weather systems during April 1999

S. No.	System	Duration	Place of first location	Direction of movement	Place of dissipation	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A)	*Low pressure area*					
1.	Low pressure area	1-4	North Rajasthan and neighbourhood	Eastnortheasterly	Plains of west Uttar Pradesh and neighbourhood	Associated cyclonic circulation extended upto 1.5 km a.s.l. The low pressure area lay as a cyclonic circulation over north Rajasthan and adjoining parts of Haryana and Punjab on 2
2.	Do	4-6	Southeast Bay & neighbourhood	Westerly	Southwest Bay	It was first observed as a trough over the same area on 3 Associated cyclonic circulation extended upto mid tropospheric levels which became less marked on 8
3.	Do	22-26	Southern parts of west central Bay off south Andhra coast	Southwesterly	Tamil Nadu coast and neighbourhood	It was first seen as an upper air cyclonic circulation over southwest and west-central Bay on 16 Associated cyclonic circulation extended upto mid tropospheric levels tilting southwards with height
(B)	*Western disturbance*					
1.	Upper air system	20-24	North Pakistan and neighbourhood	Northeasterly	North Pakistan and adjoining Jammu & Kashmir	Moved away northeastwards
2.	Do	24-28	Do	Do	Jammu & Kashmir	Do
3.	Do	28 Apr-3 May	Do	Do	Jammu & Kashmir and adjoining Himachal Pradesh and hills of west Uttar Pradesh	Do

TABLE 3 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(C)	*Induced cyclonic circulation*					
1.	Lower levels	8-11	Bihar and neighbourhood	Northwesterly	East Uttar Pradesh	
2.	Lower tropospheric levels	29 Apr - 1May	Southwest Rajasthan and neighbourhood	Do	Himachal Pradesh and neighbourhood	Moved away across Himachal Pradesh
(D)	*Other cyclonic circulations*					
1.	Mid tropospheric levels	3-5	North Pakistan and adjoining Jammu & Kashmir	Stationary	*In situ*	Moved away across northeastwards
2.	Lower levels	8-9	Northwest Rajasthan and neighbourhood	Northwesterly	Punjab and adjoining Jammu & Kashmir	Moved away across Punjab and adjoining Jammu & Kashmir
3.	Do	10-15	Do	Northerly	Punjab and adjoining parts of Pakistan	Moved away across Jammu & Kashmir
4.	Do	11-16	Andaman Sea	Northnorthwesterly	East-central Bay to north Andaman Sea	It was more marked from 12 to 14. It lay as a trough on 15 in the lower levels from east-central Bay to north Andaman Sea which became less marked on 16
5.	Lower tropospheric levels	14-16	Gangetic West Bengal and neighbourhood	Stationary	*In situ*	A trough extending upto 1.5 km a.s.l. ran from Sub-Himalayan West Bengal and Sikkim to north Bay and became less marked on 18
6.	Lower levels	24 Apr - 1 May	North Bangla Desh and neighbourhood	Do	Do	

TABLE 3 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(E)	*Troughs in the westerlies*					
1.	Mid and Upper tropospheric levels	2-4	Long. 68° E, north of Lat. 20° N	Easterly	Long. 74° E, north of Lat. 20° N	
(F)	*East-west troughs*					
1.	Lower levels	5-6	Bihar plains to Arunachal Pradesh	Stationary	*In situ*	
2.	Do	7-16	Bihar plains to north Assam	Southeasterly	Bihar to Nagaland	
(G)	*Other troughs*					
1.	Mid tropospheric level	1-3	Sub-Himalayan West Bengal & Sikkim to north Bay	Stationary	*In situ*	
2.	Lower levels	6-16	Marathwada to south Tamil Nadu	Quasi-Stationary	East Madhya Pradesh to north Tamil Nadu	It was seen from different parts of central India to peninsular India
3.	Do	18-21	Telangana to Tamil Nadu	Northwesterly	North interior Karnataka to interior Tamil Nadu	
4.	Do	23 Apr - 7 May	Andaman Sea	Westerly	South interior Karnataka, Rayalaseema and adjoining Tamil Nadu coast	It tilted southwards with height on 6
5.	Do	24-26	Orissa to south Tamil Nadu and neighbourhood	Northwesterly	Southeast Madhya Pradesh to south Tamil Nadu coast across Telangana	
6.	Do	27 Apr - 4 May	Orissa to north Tamil Nadu	Quasi-Stationary	Southeast Madhya Pradesh to south Tamil Nadu	

TABLE 4
Details of the weather systems during May 1999

S. No.	System	Duration	Place of first location	Direction of movement	Place of dissipation	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A)	*Cyclonic storm*					
1.	Very severe cyclonic storm	16-22	Lakshadweep and adjoining Karnataka - north Kerala coast	Initially northwesterly then northerly and then northeasterly	Northwest Rajasthan and neighbourhood	A well marked low pressure area formed over Lakshadweep area and adjoining Karnataka-north Kerala coast on 16 th. It concentrated into a deep depression and lay centred at 1200 UTC of 16 th near Lat. 12.5° N / Long. 72.0 °E, about 300 kms westsouthwest of Mangalore. It further intensified into a cyclonic storms with estimated central pressure of 998 hPa and lay centred at 0300 UTC of 17 th near Lat. 14.5° N / Long. 70.5 °E, about 350 kms westsouthwest of Panjim. It moved in a northwesterly direction and intensified into a severe cyclonic storm and lay centred at 1200 UTC of 17 th near Lat. 15.0° N / Long. 69.5°E, about 670 kms southsouthwest Veraval. It further moved in a northnorthwesterly direction and intensified into a very severe cyclonic storm with estimated central pressure of 976 hPa and was centred at 0300 UTC of 18 th near Lat. 17.0° N / Long. 68.0 °E, about 500 kms southwest of Veraval. It moved in a northerly direction and at 1200 UTC of 18 th, it lay near Lat.18.5°N/ Long. 68.0 °E, about 360 kms southwest of Veraval. It continued to moved in a northerly direction and at 0300 UTC of 19th, it lay near Lat. 21.0° N / Long. 68.0 °E, about 190 kms southwest of Okha and at 1200 UTC of 19 th, near Lat.21.5°N/ Long. 68.0 °E, about 150 kms southwest of Okha.

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
						It crossed Pakistan coast close to international border in the afternoon of 20th. It recurved towards northeast after crossing coast, weakened slowly and entered India in west Rajasthan as a deep depression on 20th. It further weakened into a depression and into a well marked low pressure area over northwest Rajasthan and neighbourhood on 23rd
(B)	*Low pressure area*					
1.	Embedded low pressure area	11-13	Lakshadweep area and adjoining north Kerala coast	Quasi-Stationary	Lakshadweep and adjoining Kerala coast	It was first seen as a trough on sea level chart from Karnataka to south Kerala coast on 8 th. Associated cyclonic circulation extended upto mid tropospheric levels over the same region and became less marked on 14 th.
2.	Well marked low pressure area	27-30	Northwest Bay and neighbourhood	Northwesterly	West Bengal and adjoining Bihar Plateau	It was first seen as a cyclonic circulation over northwest Bay and neighbourhood on 19th. Associated cyclonic circulation extended upto mid tropospheric levels which became less marked on 31st A trough from this system to west-central Bay was observed on 27th
(C)	*Western disturbances*					
1.	Upper air system	3-6	Northern parts of Pakistan and adjoining west parts of Jammu & Kashmir	Eastnortheasterly	Eastern parts of Jammu & Kashmir	Moved away northeastwards
2.	Do	8-12	Punjab and neighbourhood	Do	Jammu & Kashmir and neighbourhood	
3.	Do	10-16	North Pakistan	Do	Do	A trough from this system was seen to east Uttar Pradesh on 11th

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(D)	*Induced cyclonic circulation*					
1.	Lower levels	1-6	Northwest Rajasthan and neighbourhood	Eastnortheasterly	Central Pakistan and adjoining Punjab and west Rajasthan	
2.	Lower tropospheric level	13-15	Northwest Rajasthan and neighbourhood	Easterly	Northwest Rajasthan and neighbourhood	
(E)	*Embedded cyclonic circulation*					
1.	Mid tropospheric levels	6-12	Bihar plains and adjoining Sub-Himalayan West Bengal & Sikkim	Southwesterly	Vidarbha and neighbourhood	An east-west trough from this system was observed from east Uttar Pradesh to Assam and Meghalaya on 6th, from Bihar plains to Arunachal Pradesh on 8th Another trough from this system ran to south Tamil Nadu on 9th and from northeast Madhya Pradesh on 11th
(F)	*Other cyclonic circulations*					
1.	Lower levels	1-6	East Uttar Pradesh and neighbourhood	Quasi-Stationary	East Uttar Pradesh to Assam and Meghalaya	It lay as a trough from 2 to 6 from plains of west Uttar Pradesh to Bihar plains through Uttar Pradesh
2.	Mid tropospheric Levels	7-11	Lakshadweep area off Kerala coast	Stationary	*In situ*	Merged with the embedded low pressure on 11th
3.	Do	7-9	North Andaman sea and adjoining central Bay	Do	Do	
4.	Do	12-15	West-central Bay off Andhra coast	Do	Do	
5.	Do	12-15	Bangladesh and adjoining parts of Sub-Himalayan West Bengal and Sikkim	Do	Do	

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
6.	Lower levels	21-22	Punjab and neighbourhood	Stationary	*In situ*	
7.	Do	25-26	Northwest Rajasthan and neighbourhood	Do	Do	
8.	Mid tropospheric levels	26-28	Gujarat Region and neighbourhood	Northwesterly	Saurashtra & Kutch and northeast Arabian Sea	
(G)	*Trough in westerlies*					
1.	Mid and upper troposphere	23-25	Long. 70°E, north of Lat. 20°N	Stationary	*In situ*	
(H)	*Other troughs*					
1.	Lower levels	5-6	Southeast Madhya Pradesh to Tamil Nadu across Telangana and Rayalaseema	Do	Do	
2.	Do	15-22	West Rajasthan to northwest Madhya Pradesh	Easterly	West Uttar Pradesh to north Bay across Bihar Plateau	
3.	Do	17-19	North Andaman Sea and adjoining northeast Bay	Stationary	*In situ*	
4.	Sea level chart	20-25	South Maharashtra coast to south Kerala coast	Do	Do	It became more marked on 24 th

TABLE 5

Principal amounts of rainfall (cm) for the months of March, April and May 1999

Date	March	April	May
(1)	(2)	(3)	(4)
1	Nil	Car Nicobar 1	Kolar Gold Field 8, North Lakhimpur 5, Hut Bay & Gangtok 2 each, Gulmarg1
2	Nil	Hut Bay, Dibrugarh & Batote 1 each	Mayabandar 6, Baghdogra, Khammam & Mandya 3 each, Tezpur 2, Midnapur 1
3	Nil	Hut Bay 4, Anantnag & Punalur 1 each	Mayabandar 6, Dibrugarh 3, Jalpaiguri & Midnapur 2 each
4	Nil	Dibrugarh & Gangtok 1each	Gangtok 9, Nagapattinam 5, Imphal 3, Mayabandar, Tezpur & Mysore 2 each, Jamshedpur, Quazigund, Jagdalpur & Arogyavaram 1 each
5	Banihal 1	Car Nicobar 5, Dibrugarh & Punalur 3 each, Pamban 1	Cooch Behar 5, Chikmagalur 4, Shillong 3, Keonjargarh & Bhagalpur 2 each, Purulia, Jamshedpur & Punalur 1 each
6	Konni 5, Punalur 1	Karaikudi, Adirampattinam & Palayamkottai 2 each	Vaikom 11, Mysore & Punalur 7 each, Imphal 6, Shillong 5, Madurai 3, Jagdalpur 2, Pahalgam, Ramagundam, Kurnool, Karwar & Minicoy 1 each
7	Banihal 3, Manali 2, Cochi 1	Konni 12, Punalur 2	Gangtok and Dharmpuri 5 each, Panambur, Mysore & Cochi 4 each, Guwahati 2
8	Banihal 6, Udhampur 3, Amritsar & Bhuntar 2 each, Car Nicobar 1	Vedaranniyam 3, Car Nicobar & Minicoy 2 each, Cochi 1	Kannur 11, Mangalore 5, Hut Bay, Agartala & Kolhapur 3 each, Chikmaglur and Amini Divi 2 each, Kupwara & Belgaum 1 each
9	Dundi & Batote 4 each, Gohar & Quazigund 3 each, Kondul 1	Cooch Behar 4, Car Nicobar, Krishnanagar & Narsapur 2 each, Kailashahar & Pahalgam 1 each	Gannavaram 5, Baghdogra 4, Shillong, Purnea, Kolhapur, Medak & Amini Divi 3 each, Calcutta (ALP), Theog & Punalur 2 each, Mayabandar & Gorakhpur 1 each
10	Dundi 1	Quilandy 5, Krishnanagar 2, Mayabandar, Dibrugarh & Kupwara 1 each	Siliguri 7, Amini Divi 4, Contai, Balasore, Kumarsain, Arogyavaram, Mangalore & Bangalore 3 each, Jamshedpur 2, Kondul, Imphal, Malda & Gulmarg 1 each

TABLE 5 (*Contd.*)

(1)	(2)	(3)	(4)
11	Nil	Kondul & Madapura 4 each	Tadepallegudem & Amini Divi 9 each, Arogyavaram & Ponnani 5 each, Shillong 3, Balasore, Bhiwani, Solan & Honavar 2 each, Mayabandar, Darjeeling, Makteshwar, Sagan, Tiruchirapalli and Bellary 1 each
12	Thiruvananthapuram 2	Car Nicobar 7, Kodaikanal 5, Quazigund & Hassan 1 each	Contai 6, Malda 3, Nancowrie, Hyderabad, Gadag & Amini Divi 2 each
13	Cochi 1	Kondul 10, Chikmagalur 5, Alapuzha 3, Uthagamandalam 2	Kailashahar & Balurghat 4 each, Cuttack, Udhampur, Tuni and Kunnamunlam 3 each, Hut Bay, Berhampore, Delhi Ridge, Nadaun, Vellore & Amini Divi 2 each, Shillong, Moradabad & Mandya 1 each
14	Nil	Hut Bay 4, Salem 2, Jalpaiguri, Kolar Gold Field & Cochi 1 each	Baghdogra 12, Tiruchirapalli 7, Shillong 5, Hut Bay 4, Agartala, Bhubaneshwar & Mandya 3 each, Patna, Varanasi & Amini Divi 2 each, Mandi, Pendra & Chandrapur 1 each
15	Uthagamandalam & Chengannur 2 each	Gangtok 7, Hut Bay & North Lakhimpur 2 each	Berhampore 14, Mathunga 9, Bapatla 8, Thiruvanatha-puram(AP) & Amini Divi 7 each, Hassan 5, Gadag 4, Passighat & Mangalore 3, Hut Bay, Agartala , Gaya, Thiruchirapalli, 2 each, Gangtok, Jamshedpur, & Nandyal 1 each
16	Alapuzha 2, Tuticorin & Amini Divi 1 each	Gangtok 3, Mayabandar 2	Cuttack & Amini Divi 5 each, Port Blair, Agartala & Purulia 4 each, Thiruvananthapuram 3, Bihubar, Ranchi, Karwar, Belgaum & Madikeri 2 each, Pune 1
17	Minicoy 3, Car Nicobar 1	Nil	Akola, Belgaum 5, Satara & Kodaikanal 4 each, Mumbai 3, Aurangabad & Kottayam 2 each, Baghdogra, Sambalpur & Amini Divi 1 each
18	Kozhikode 3, Tatsio & Kupwara 2 each, Thiruvananthapuram 1	Mayabandar 3, Nedumangad 2	Jogindernagar 3, Port Blair, Digha, Balasore, Nagpur & Nandyal 2 each, Panjim, Nasik & Bangalore 1 each
19	Karimganj 4, Silchar & Matizuri 3 each	Kochi 5, Nancowrie, Kailashahar & Kodaikanal 1 each	Cuttack & Ahmednagar 5 each, Patna & Kolar Gold Fields 4 each, Thiruvananthapuram 3, Varanasi, Pandoh, Nandyal & Amini Divi 2 each, Dibrugarh, Alibagh & Honavar 1 each

TABLE 5 (*Contd.*)

(1)	(2)	(3)	(4)
20	Nil	Madurai 2, Koadul 1	Bhagalpur 10, Okha and Kunnamkulam 9 each, Hut Bay 7, Agartala, Balurghat and Digha 5 each, Passighat, Paradip, Visakhapatnam & Karwar 4 each, Panjim & Amini Divi 3 each, Beki Road Bridge 2, Bahraich, Nandyal, Uthagamandalam & Raichur 1 each
21	Banihal & Batote 1 each	Tondi 3, Nagapattinam 2	Naliya 37, Kundulu 17, Bhuj & Mangalore 11 each, Panjim 8, Amini Divi 6, Pantnagar & Madurai 4 each, Hut Bay, Kailashahar, Kasol, Churu, Cuddapah & Bijapur 3 each, Kheri, Udhampur, Ahmednagar, Osmanabad & Bangalore 2 each, Dholai, Bhagalpur, Jhansi, Narnaul, Ajmer, Gwalior, Jagdalpur & Ramagundam 1 each
22	Nil	Port Blair 4, Pondicherry 3, Minicoy 1	Jaisalmer & Ratnagiri 13 each, Khavda 12, Bhuj 10, Honavar 9, Betul 8, Nancowrie & Piravom 7 each, Idar 6, Buldhana 5, Tezpur & Kolar Gold Field 4 each, Darjeeling, Diamond Harbour & Puri, Kasauli 2 each, Imphal, Ambala, Samrala, Satna, Kakinada, Tirupathi, Kodaikanal & Bijapur 1 each
23	Nil	Chennai & Haripad 5 each, Car Nicobar & Shimoga 3 each	Margherita 9, Passighat 8, Honavar 7, Bikaner 6, Nancowrie, Mumbai (CLB) & Mannarkad 5 each, Imphal, Sirsa & Khajuraho 3 each, Jalpaiguri, Mana & Vadodara 2 each
24	Kupwara	Thiruvananthapuram 7, Dibrugarh 6, Cooch Behar 5, Hut Bay 3, Medikeri 2, Kanyakumari 1	Jalpaiguri 31, Cuttack 13, Manas NHX-ing, Balachaur & Kasauli 11 each, Car Nicobar & Piravom 8 each, Calcutta (ALP) & Tuni 5 each, Samalkha, Rajgarh & Medak 4 each, Kathua & Panjim 3 each, Passighat & Minicoy 2 each, Chottabekra Aurangabad, Nandyal, Karaikal, Mangalore, Gulbarga & Medikeri 1 each
25	Anantnag & Pahalgam 2 each	Coimbatore 5, Mayabandar,North Lakhimpur & Hassan 3 each, Thiruvananthapuram 1	Bhalapur 23, Cochi 9, Hut Bay & Mangalore 7 each, Kahu, & Panjim 4 each, Chottabekra, Khammam, Kanyakumari, Medikeri & Amini Divi 3 each, Passighat, Gorakhpur & Nindadvolu 2 each, Gangtok, Keonjargarh, Kalka, Nawashahar, Pahalgam, Yeotmal & Bijapur 1 each

TABLE 5 (*Contd.*)

(1)	(2)	(3)	(4)
26	Banihal & Quazigund 1 each	Alapuzha 14, Gangtok 12, Mayabandar 6, Cochi 5, Bangalore 4, Tezpur 3, Uthagamandalam 2, Hyderabad 1	Bahampong 14, Mangalore 11, Bidar & Punnalur 8 each, Mayabandar 7, Bokajan 4, Gangtok, Buldhana & Nandyal 3 each, Agartala, Calcutta (ALP) & Bangalore (AP) 2 each, Jharsuguda, Panjim, Pune (AP), Aurangabad, Baptala & Nizamabad 1 each
27	Agartala 5, Imphal & Gangtok 3 each, Tezpur 2, Kondul & Calcutta (AP) 1 each	Gangtok 12, Bangalore 3, Hut Bay & North Lakhimpur 2 each	Paradip & Kottayam 7 each, Cooch Behar 5, Mayabandar, Digha, Hyderabad & Salem 3 each, Osmanabad & Amini Divi 2 each, Goa, Gaya, Sholapur, Nagpur & Mangalore 1 each
28	Dibrugarh & Kailashahar 3 each Port Blair 2	Tadong 3, Tezpur & Punalur 2 each, Hut Bay 1	North Lakhimpur, Digha, Balasore & Bijapur 5 each, Mancompu 4, Jalpaiguri 3, Jamshedpur, Panjim & Agumbe 2 each, Port Blair, Jagdalpur & Anantpur 1 each
29	Nil	Hut Bay & Tadong 9 each, Dibrugarh & Krishnagiri 3 each , Punalur 2	Jalpaiguri & Calcutta (ALP) 8 each, Chowdowaghat 5, Cuttack & Jamshedpur 3 each, Miao, Honavar, Agumbe & Thiruvananthapuram 2 each, Mayabandar, Agartala, Bhagalpur, Gorakhpur, Nagapattinam & Minicoy 1 each
30	Car Nicobar	Mayabandar & Neyyantinkara 6 each, Cooch Behar 3, Silchar 1	Agartala 10, Goalpara 9, Aluva 8, Mangalore 5, Coimbatore 4, Mayabandar 3, Seppa, Darjeeling & Krishnanagar 2 each, Amini Divi 1
31	Nil		Golaghat 9, Miao 7, Cooch Behar 6, Imphal & Punalur 5 each , Honavar 3, Car Nocobar & Dahanu 2 each, Shimla & Jammu 1 each

Meghalaya, Tamilnadu and Kerala and deficient in Lakshadweep. It was scanty over Nagaland, Manipur, Mizoram & Tripura, Gangetic West Bengal, Orissa, Bihar, east Uttar Pradesh, hills of west Uttar Pradesh, Himachal Pradesh, Jammu & Kashmir, west Madhya Pradesh, Andhra Pradesh and coastal & north interior Karnataka. There was no rain over plains of west Uttar Pradesh, Haryana, Punjab, Rajasthan east Madhya Pradesh, Gujarat State, Maharashtra & Goa States. The principal amounts of rainfall (cm) are given in Table 5.

3.2.3. *Temperature*

Severe heat wave conditions prevailed on 1 to 4 days in Arunachal Pradesh, Assam & Meghalaya, Jammu and Rajasthan and heat wave conditions (temperature from normal is +3°C to +4°C more for the regions where the normal maximum temperature is more than 40°C) also prevailed on 1 to 2 days in West Bengal, interior Orissa, Bihar, plains of west Uttar Pradesh, Gujarat State, west Madhya Pradesh, Vidarbha and Andhra Pradesh. Day temperatures were exceptionally high, some times between +7°C and +12°C above normal on 11 to 13 days in hills of west Uttar Pradesh and Kashmir. Day temperatures were appreciably to markedly above normal on many days in many parts of the country outside northeast India, Konkan & Goa, Madhya Maharashtra, coastal Andhra Pradesh, Tamilnadu, Kerala and Karnataka. Month's highest temperature of 47.8°C was recorded at Hissar in Haryana on 30 April.

3.2.4. *Disastrous weather events and damages*

Heat wave which was at times severe took a toll of 118 lives in the country (50 in Bihar, 38 in Orissa, 13 in Andhra Pradesh, 8 in West Bengal, 5 in Gujarat, 2in Vidarbha and 2 in Madhya Pradesh). Hailstorm and lightning took a toll of 11 lives (6 in Tamilnadu and 5 in Kerala) and caused wide spread damage to standing crops estimating a loss of more than 10 crores of rupees in Karnataka and Kerala. Severe drought in northeast India also caused damage to Rabi and paddy crops. Due to norwesters, 4 people died in Assam.

3.3. *May*

Details of weather systems formed during the month are given in Table 4.

3.3.1. *Very severe cyclonic storm (16-22 May1999)*

A well-marked low pressure area formed over Lakshdweep area and adjoining Karnataka-north Kerala coast on 16. It concentrated into a "deep depression" and lay centred at 1200 UTC 0f 16 near Lat. 12.5° N/Long. 72.0° E, about 300 kms westsouthwest of Mangalore. It further intensified into a cyclonic storm with estimated central pressure of 998 hPa and lay centred at 0300 UTC of 17 near Lat. 14.5° N/Long. 70.5° E, about 350 kms westsouthwest of Panjim. It moved in a northwesterly direction and intensified into a severe cyclonic storm and lay centred at 1200 UTC of 17 near Lat. 15.0° N/ Long. 69.5° E, about 670 kms southsouthwest of Veraval. It further moved in a northnorthwesterly direction and intensified into a very severe cyclonic storm with estimated central pressure of 976 hPa and was centred at 0300 UTC of 18 near Lat. 17.0° N/Long. 68.0° E, about 500 kms southwest of Veraval. It then moved in a northerly direction and at 1200 UTC of 18, it lay near Lat. 18.5° N/Long. 68.0° E, about 360 kms southwest of Veraval. It continued to move in a northerly direction and at 0300 UTC of 19, it lay near Lat.21.0°N/Long.68.0°E, about 190 kms southwest of Okha and at 1200 UTC of 19, near Lat. 21.5°N/Long. 68.0°E, about 150 kms southwest of Okha. It crossed Pakistan coast close to international border in the afternoon of 20. It recurved towards northeast after crossing coast, weakened slowly and entered India in west Rajasthan as a deep depression on 20. It further weakened into a depression and into a well marked low pressure area over northwest Rajasthan and neighbourhood on 23. The track of very severe cyclonic storm is given in Fig.2.

Maximum intensity reported by INSAT cloud imagery was T 5.5 (102 kts) from 1200 UTC of 18 to 0000 UTC of 20. The "eye" was clearly seen. The lowest estimated central pressure was 946 hPa at 0000 UTC of 20. From the available reports the storm surge upto 2.5 mtrs. Above the normal astronomical tide was experienced over various ports along Saurashtra coast at the time of storm crossing the coast.

Widespread heavy rain occurred in Konkan and Gujrat coast from 18 to 20 May. Heavy to very heavy rain also occurred over Saurashtra & Kutch, Konkan & Goa and west Rajasthan on 21 and 22.

According to press reports, 453 persons lost their lives in Saurashtra Region. Out of 835 boats out in sea, 755 boats returned and 80 boats were missing, while another 35 boats were found totally damaged. As per the damage report published in the newspapers, total death of human life in Kutch coast is about 450. 2600 huts, 631 Pukka house and 627 Kutcha houses were completely damaged causing the total loss of Rs. 100 crores.

3.3.2. *Weather and associated synoptic features*

Southwest monsoon was vigorous on 2 days in Gangetic West Bengal and on 1 day in Nagaland, Manipur, Mizoram & Tripura and was active on 5 days in

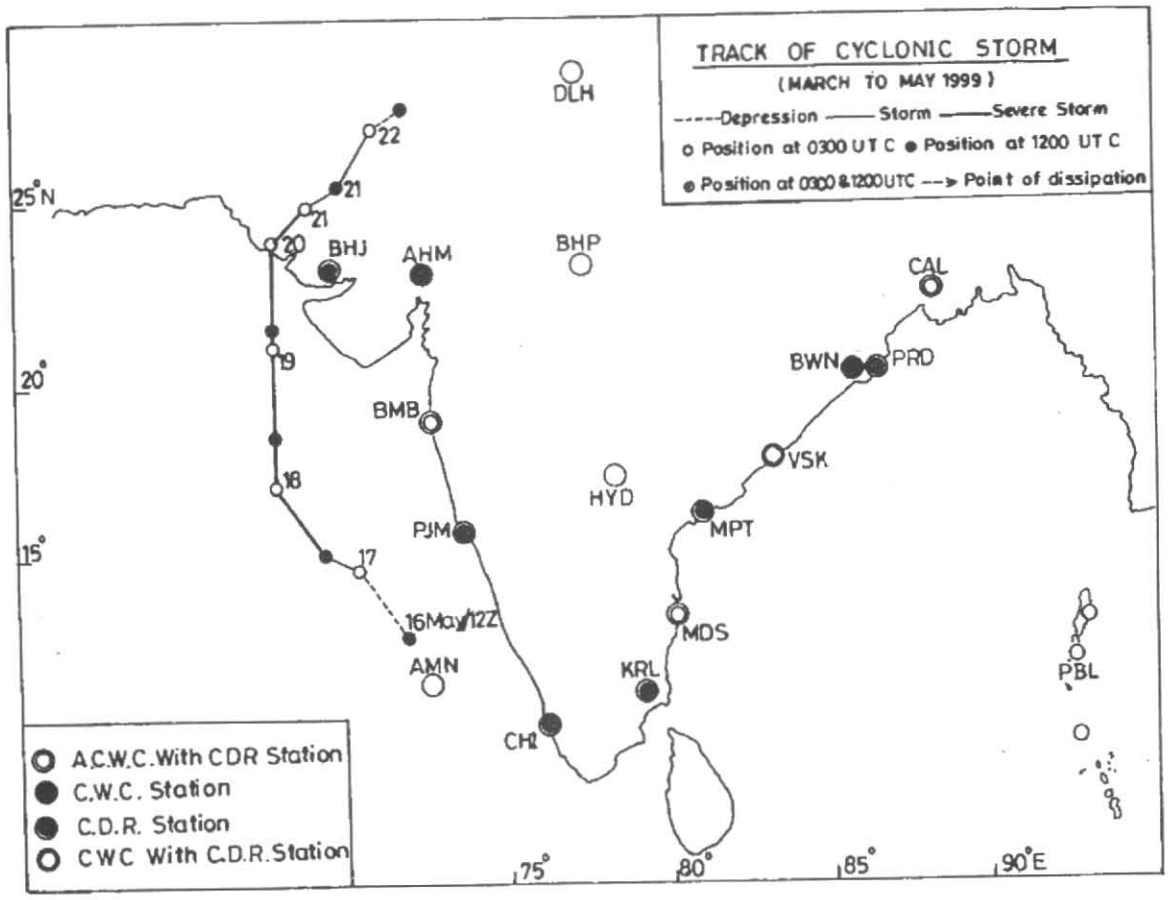

Fig. 2. Track of very severe cyclonic storm (March to May 1999)

Kerala and on 1 to 2 days in Assam & Meghalaya, Sub-Himalayan West Bengal & Sikkim and Orissa. Heavy to very heavy rainfall have also occurred on 8 to 11 days in Assam & Meghalaya, coastal Karnataka and Kerala; on 4 to 6 days in Arunachal Pradesh, Sub-Himalayan West Bengal & Sikkim and south interior Karnataka and on 1 to 3 days in Andaman & Nicobar Islands, Nagaland, Manipur, Mizoram & Tripura, Gangetic, West Bengal, Orissa, Bihar Plains, Punjab, Himachal Pradesh, west Rajasthan, Saurashtra & Kutch, Konkan & Goa, Tamilnadu, north interior Karnataka and Lakshadweep.

3.3.3. *Advance of southwest monsoon*

The southwest monsoon advanced over Andaman Sea and adjoining parts of southeast Bay of Bengal on 20 May. It further advanced into some parts of Commorin area and most parts of Bay of Bengal on 24. The southwest monsoon set in over Kerala on 25 May, one week in advance against its normal date. On the same day, it set in over some parts of south Arabian Sea, Maldives and Commorin area, parts of Tamilnadu and some more parts of Bay of Bengal. On 26, it further advanced into rest of Arabian Sea, parts of coastal and interior Karnataka and parts of northeastern states.

3.3.4. *Month's rainfall*

Rainfall during May was excess in 25, normal in 8 and deficient in 2 meteorological sub-divisions. The principal amounts of rainfall are given in Table 5.

Rainfall was excess in Arunachal Pradesh, Nagaland, Manipur, Mizoram & Tripura, Gangetic West Bengal, Orissa, Bihar, east Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, west Rajasthan, Madhya Pradesh, Saurashtra & Kutch, Konkan & Goa, Marathwada, Vidarbha, Andhra Pradesh, Karnataka, Kerala and Lakshadweep; normal in Assam & Meghalaya, Sub-Himalayan West Bengal & Sikkim, west Uttar Pradesh, east Rajasthan, Gujarat region, Madhya Maharashtra and Tamilnadu and deficient in Andaman & Nicobar Islands and Jammu & Kashmir.

3.3.5. *Temperature*

Severe heat wave conditions prevailed on 1 day in Arunachal Pradesh. Heat wave conditions also prevailed on 4 to 5 days in plains of west Uttar Pradesh, and Vidarbha and on 1 to 2 days in Jammu, Rajasthan and Marathwada. Day temperatures were appreciably to markedly above normal in north and central India and interior Karnataka in the first week of the month. It was appreciably to markedly below normal in Orissa, Bihar, west Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, Madhya Maharashtra , Marathwada, Vidarbha and interior Karnataka on many days in the second half of the month.

Month's highest temperature of 47 °C was recorded at Sambalpur and Bolangir in Orissa on 7 May.

3.3.6. *Disastrous weather events and damages*

Apart from the damages caused by the very severe cyclonic storm in the Arabian Sea, according to press reports, 53 people died (39 in Orissa, 13 in Madhya Pradesh and 1 in Vidarbha) due to heat wave. Heavy rain and floods took a toll of 76 people in different parts of the country. Large crops were inundated, standing crops were destroyed and houses were damaged. In West Bengal, norwesters took a toll of 4 people.