MAUSAM, 50, 2 (April 1999), 219-231

Weather in India

HOT WEATHER SEASON (MARCH-MAY 1998)*

1. Introduction

Season's rainfall was excess in 14, normal in 10 deficient in 9 and scanty in 1 meteorological sub-divisions. There was no rain in 1 meteorological sub-division.

Season's rainfall was excess in Nagaland, Manipur, Mizoram and Tripura, Gangetic West Bengal, Orissa, Bihar, Uttar Pradesh, Haryana, Chandigarh and Delhi, Punjab, Himachal Pradesh, west Rajasthan, east Madhya Pradesh and Vidarbha and normal in Arunachal Pradesh, Assam and Meghalaya, Sub-Himalayan West Bengal and Sikkim, Jammu and Kashmir, east Rajasthan, west Madhya Pradesh, Madhya Maharashtra, Rayalaseema and interior Karnataka. It was deficient in the remaining sub-divisions out side Gujarat state where there was no rain in Gujarat region and scanty in Saurashtra & Kutch. Seasonal rainfall departures are given in Fig. 1.

Actual rainfall and its departures for each month and season are given in Table 1.

2. Chief features

(*i*) Severe Cyclonic storm over the Bay of Bengal (17 May - 20 May).

(*ii*) Deep depression over the Arabian sea (28 - 29 May).

(*iii*) Severe heat wave conditions over north west and north India during May.

(*iv*) Advancement of the southwest monsoon advanced over south Andaman sea on 15 May.

3. Monthly features

3.1. *March*

3.1.1. *Weather and associated synoptic features*

During this month, 1 low pressure area, 5 induced low pressure areas, 8 western disturbances, 5 cyclonic circulations, 3 induced cyclonic circulations and 2 east-west troughs formed and affected the weather over north and northwest India. Details of these systems and other systems are given in Table 2.

Rain or snow occurred at most places on 2 days in Jammu and Kashmir and on 1 day in Himachal Pradesh. Rain or thundershowers occurred at most places or at many

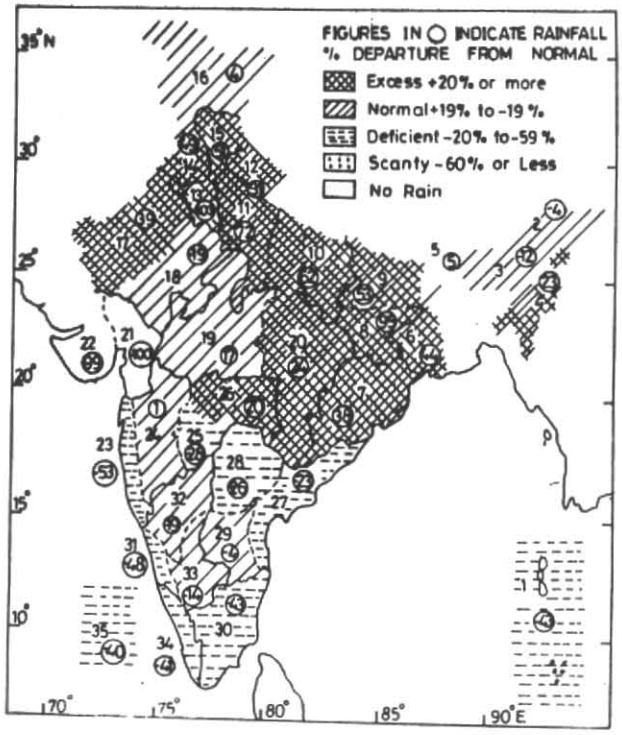

Fig. 1. Rainfall percentage departure from normal for the period 1 March - 31 May 1998

places on 4 to 6 days in Assam and Meghalaya, Nagaland, Manipur, Mizoram and Tripura, West Bengal, Orissa, Bihar Plateau, Himachal Pradesh and Jammu & Kashmir, on 3 days in Arunachal Pradesh, Haryana, Punjab and on 2 days in east Madhya Pradesh and Vidarbha. Rainfall occurred at a few places or at isolated places on 8 to 10 days in Assam and Meghalaya, plains of west Uttar Pradesh, Himachal Pradesh, Madhya Pradesh, Vidarbha, Telangana, south interior Karnataka and Kerala, on 11 to 17 days in Sub-Himalayan West Bengal and Sikkim, Orissa, Bihar, Hills of west Uttar Pradesh and coastal Andhra Pradesh, on 4 to 6 days in Arunachal Pradesh, Negaland, Manipur, Mizoram and Tripura, east Uttar Pradesh, Haryana, Punjab, Jammu & Kashmir, Rajasthan and on 1 to 3 days in Gangetic West Bengal, Madhya Maharashtra, Marathwada, Rayalaseema, Tamil Nadu and coastal & north interior Karnataka. Mainly dry weather prevailed over Andaman and Nicobar Islands, Gujarat State, Konkan & Goa and Lakshadweep during the month.

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TABLE 1

Monthly and seasonal rainfall (mm) for each month and season (March-May 1998)

S. No.	Meteorological Sub-divisions	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	0	40	-100	3	89	-96	285	377	-24	288	506	-43
2.	Arunachal Pradesh	194	104	85	90	212	-58	338	328	3	622	645	-4
3.	Assam and Meghalaya	144	90	61	191	206	-7	296	423	-30	632	719	-12
4.	Nag., Man. Miz. & Tri.	130	74	76	141	128	10	275	241	14	545	443	23
5.	S. H. W. B. & Sikkim	122	52	136	138	109	26	200	276	-27	460	437	5
6.	Gangetic W.B.	133	27	388	61	45	36	61	105	-42	255	176	44
7.	Orissa	67	22	205	39	32	22	57	64	-11	163	118	38
8.	Bihar Plateau	63	19	239	37	20	83	74	51	47	175	90	95
9.	Bihar Plains	29	11	161	24	15	61	51	42	21	104	68	53
10.	East U.P.	16	9	71	8	6	32	27	16	69	50	31	62
11.	Plains of west U. P.	24	13	85	13	6	105	16	11	40	53	31	72
12.	Hills of west U.P.	78	62	27	63	34	87	57	56	3	199	151	31
13.	Haryana, Chandi. & Delhi	37	14	168	16	7	143	13	12	6	65	32	103
14.	Punjab	33	26	27	38	11	235	5	14	-65	76	51	49
15.	Himachal Pradesh	138	81	71	75	44	71	47	48	-2	260	173	51
16.	Jammu & Kashmir	110	123	-10	117	93	26	54	55	-2	282	271	4
17.	West Rajasthan	7	5	60	11	2	371	2	7	-76	20	14	39
18.	East Rajasthan	6	5	18	5	2	130	2	9	-76	13	16	-19
19.	West M.P.	17	8	125	3	4	-4	3	9	-67	23	20	17
20.	East M.P.	27	18	55	17	14	26	13	15	-12	57	46	24
21.	Gujarat region	0	2	-100	0	1	-100	0	7	-100	0	10	-100
22.	Saurashtra & Kutch	0	4	-100	0	1	-100	0	4	-99	0	9	-99
23.	Konkan & Goa	0	0	-100	0	5	-100	23	42	-46	23	48	-53
24.	Madhya Maharashtra	1	4	-66	5	12	-62	40	29	36	46	45	1
25.	Marathwada	1	7	-88	3	10	-72	23	20	15	26	36	-28
26.	Vidarbha	26	15	72	10	12	-17	13	13	-5	48	40	20
27.	Coastal A. P.	18	13	45	35	25	39	20	57	-65	73	95	-23
28.	Telangana	2	11	-78	13	19	-31	26	26	1	42	56	-26
29.	Rayalaseema	2	6	-74	34	21	67	40	53	-24	76	79	-4
30.	Tamil Nadu	1	21	-98	13	51	-74	67	71	-5	81	142	-43
31.	Coastal Karnataka	1	5	-77	9	33	-72	89	152	-41	99	189	-48
32.	N. I. Karnataka	1	6	-83	11	27	-58	58	53	9	70	87	-19
33.	S. I. Karnataka	6	8	-18	63	45	41	61	99	-38	131	151	-14
34.	Kerala	11	40	-73	65	113	-43	171	263	-35	247	416	-41
35.	Lakshadweep	2	8	-77	40	35	16	67	141	-52	109	184	-40

TABLE 2

Details of the weather systems during March 1998

S. No.	System	Period	Place of first location	Direction of movement	Place of dissipation	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A) *Low pressure areas*						
1.	Low pressure	16-17	Kutch and adjoining parts of Saurashtra	Stationary	*In situ*	Associated cyclonic circulation extended upto 2.1 km a.s.l on 16. It was observed over Gujarat Region and adjoining Saurashtra & Kutch on 17, over southeast Rajasthan and adjoining parts of Gujarat Region on 18 and became less marked on 19. A trough from this system to Karnataka was observed on 18
(B) *Induced low pressure areas*						
1.	Lower tropospheric levels	5-6	Punjab and adjoining parts of east Rajasthan	Stationary	*In situ*	It was first observed as an induced cyclonic circulation over northwest Rajasthan and adjoining parts of Punjab. Associated cyclonic circulation extended upto 2.1 km a.s.l. A trough from the system to south Gujarat Region was observed in the lower levels on 5
2.	Do	11-12	Northwest Rajasthan	Eastnortheasterly	Haryana and neighbourhood	It was first observed as a cyclonic circulation over south Pakistan on 10. On 12, it was observed as an induced cyclonic circulation over Haryana and neighbourhood. It became less marked on 14. A trough from this system to Bihar Plateau was observed on 13 and became less marked on 14
3.	Do	23-24	Northwest Rajasthan and neighbourhood	Stationary	*In situ*	Associated cyclonic circulation extended upto lower levels. It merged with the another trough on 24
4.	Do	24-25	Northeast Madhya Pradesh and neighbourhood	Do	Do	Associated cyclonic circulation extended upto 0.9 km a.s.l. It lay over Gangetic West Bengal on 24 and became less marked on 26. Two trough from this cyclonic circulation from Bihar Plains to Arunachal Pradesh on 25 and became less marked on 26. The other trough from the system was observed from Gangetic West Bengal to south coastal Andhra Pradesh across Orissa from 25 to 27 and became less marked on 28. A trough from the system was observed in lower levels to north Assam on 24. Another trough from the system to coastal Karnataka was observed on 24
5.	Do	29-30	Northeast Madhya Pradesh and adjoining east Rajasthan	Stationary	*In situ*	It was first observed as an induced cyclonic circulation over southwest Rajasthan. A trough from the system to north Tamil Nadu was observed on 29 and 30. Associated cyclonic circulation in the lower levels over northeast Madhya Pradesh on 29 and became less marked on 30. A trough from this cyclonic circulation was observed on 29 and 30 to Sub-Himalayan West Bengal and Sikkim
(C) *Western disturbances*						
1.	Upper air system	2-6	West Afghanistan and neighbourhood	Northeasterly	Jammu & Kashmir and neighbourhood	Moved away northeastwards

TABLE 2 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.	Upper air system	7-10	North Pakistan and neighbourhood	Do	Do	Do
3.	Do	11-13	Afghanistan	Do	Do	Do
4.	Do	15-19	West parts of Pakistan	Do	Do	Do
5.	Do	19-23	North Pakistan and neighbourhood	Do	Do	Do
6.	Do	23-25	North Pakistan and adjoining Jammu & Kashmir	Do	Do	Do
7.	Do	27-30	North Pakistan and neighbourhood	Do	Do	Do
8.	Do	30 Mar-3 Apr	Central Afghanistan	Do	Do	Do
(D) *Induced cyclonic circulations*						
1.	Lower tropospheric levels	28 Feb-1 Mar	Haryana and neighbourhood	Northeasterly	Moved away northeastwards	
2.	Lower levels	9-12	West Rajasthan	Eastnortheasterly	East Rajasthan and adjoining parts of Northwest Madhya Pradesh	A trough from the system to north Madhya Maharashtra was observed on 9. It became less marked on 10. A westerly trough from the system to north interior Karnataka was observed on 11 and became less marked on 12
3.	Do	20-21	Northwest Rajasthan and neighbourhood	Stationary	*In situ*	
(E) *Embedded cyclonic circulations*						
1.	Lower levels	15-16	South Telangana and neighbourhood	Stationary	*In situ*	
(F) *Other cyclonic circulations*						
1.	Lower tropospheric levels	1-2	South Madhya Maharashtra	Stationary	*In situ*	
2.	Lower levels	2-3	South Tamil Nadu and neighbourhood	Do	Do	A trough easterlies from the system was observed to Sikkim across interior Karnataka on 2. It lay from Kerala to south Madhya Maharashtra on 3. It persisted there upto 5 and became less marked on 6
3.	Do	6-8	Northwest Madhya Pradesh	Easterly	East Madhya Pradesh and adjoining parts of Vidarbha	A westerly trough from the system was observed to coastal Karnataka in lower levels on 6. It was seen from the system to south Tamil Nadu on 7 and from coastal Orissa to south Tamil Nadu on 8 and became less marked on 9
4.	Do	14-15	South Pakistan and neighbourhood	Stationary	*In situ*	
5.	Lower levels	22-23	North Assam and neighbourhood	Do	Do	
(G) *Troughs in the easterlies*						
1.	Lower levels	19-22	Southeast Rajasthan to south Kerala coast	Westerly	Southwest Madhya Pradesh to south Konkan	
(H) *East-West troughs*						
1.	Lower levels	9-14	Sub-Himalayan West Bengal to North Assam	Stationary	*In situ*	
2.	Do	23-24	Bihar Plains to northeast Assam	Do	Do	
(I) *Troughs in westerlies*						
1.	Mid and upper tropospheric levels	4-7	Lat. 60° E, north of Long. 35°N	Eastnortheasterly	Lat. 72° E, north of Long. 30° N	
2.	Do	12-13	Lat. 64° E, north of Long. 24° N	Stationary	*In situ*	

TABLE 2 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
3.	Mid and upper tropospheric levels	16-17	Lat. 65° E, north of Long. 15° N	Do	Do	
4.	Do	30 Mar - 1 Apr	Lat. 85° E, north of Long. 15° N	Northeasterly	Lat. 88°E, north of Long. 22°N	Moved away northeastwards
(J) *Other troughs*						
1.	Lower levels	13-17	East Madhya Pradesh to south Tamil Nadu	Westerly	South Kerala to west Madhya Pradesh	
2.	Do	26-29	North interior Karnataka	Stationary	*In situ*	
3.	Lower tropospheric levels	27-29	South Madhya Maharashtra to south Kerala	Southerly	North interior Karnataka to south Kerala	
4.	Lower levels	31 Mar-3 Apr	Vidarbha to south Tamil Nadu	Southeasterly	South Konkan to Lakshadweep	
5.	Do	26-27	South Pakistan to Gulf of Cambay	Stationary	*In situ*	

3.1.2. *Month's rainfall*

Rainfall during the month of March was excess in 19, normal in 3 and scanty in 9 meteorological sub-divisions. There was no rain in the remaining 4 Meteorological subdivisions.

Rainfall was excess in Arunachal Pradesh, Assam & Meghalaya and Negaland, Manipur, Mizoram and Tripura, West Bengal, Orissa, Bihar, Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, west Rajasthan, Madhya Pradesh, Vidarbha and coastal Andhra Pradesh, normal in Jammu and Kashmir, each Rajasthan and south interior Karnataka and scanty in Madhya Maharashtra, Marathwada, Telangana, Rayalaseema, Tamil Nadu, coastal and north interior Karnataka, Kerala & Lakshadweep. There was no rain in Andaman and Nicobar Islands, Gujarat state and Konkan & Goa. Principal amounts of rainfall are given in Table 5.

3.1.3. *Month's temperature*

During the month of March, heat wave conditions prevailed on 3 days in Jammu and Kashmir, 1 day each in west Rajasthan, Konkan & Goa and north interior Karnataka.

Day temperatures were 3 to 4°C appreciably above normal on 3 to 5 days in Hills of west Uttar Pradesh, Jammu and Kashmir, Rajasthan, Saurashtra and Kutch, Rayalaseema, Tamil Nadu and Karnataka, on 1 to 2 days in Assam and Meghalaya, west Madhya Pradesh, Gujarat Region and Maharashtra during the second fortnight of the month. They were appreciably below normal on 12 days in Gangetic West Bengal and Bihar Plateau, on 5 to 9 days in Bihar Plains, east Uttar Pradesh, Plains of west Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, west Rajasthan, Madhya Pradesh and Vidarbha, on 2 to 4 days in Assam and Meghalaya, Negaland, Manipur, Mizoram and Tripura, Sub-Himalayan West Bengal and Sikkim, east Rajasthan and Gujarat state and on 1 day in hills of west Uttar Pradesh and Marathwada. The highest maximum temperature of 43°C in the plains was recorded at Cudappah on 24, 25, 26 and 27 March.

Severe cold wave conditions prevailed on 4 days over hills of west Uttar Pradesh, on 1 day in Himachal Pradesh and Bihar Plateau. Cold wave conditions also prevailed on 5 days in Himachal Pradesh, 2 days in Jammu and Kashmir, and 1 day in hills of West Uttar Pradesh.

Night temperatures were appreciably below normal on 7 to 10 days in Bihar, Hills of west Uttar Pradesh, Haryana, Punjab and west Madhya Pradesh, on 4 to 6 days in Assam and Meghalaya, Negaland, Manipur, Mizoram and Tripura, Sub-Himalayan West Bengal and Sikkim, Plains of Uttar Pradesh, Marathwada and Vidarbha and on 1 to 3 days in Gangetic West Bengal, Jammu and Kashmir, Rajasthan, east Madhya Pradesh, Gujarat State, Konkan and Goa, Madhya Maharashtra, coastal Andhra Pradesh and coastal Karnataka. They were generally above normal or appreciably above normal over most parts of the country during the month. The lowest minimum temperature 4° C in the Plains at Amritsar was recorded on 8th March and in the Hills -6°C at Manali on 7 March.

3.1.4. *Disastrous weather events and damages*

During the month of March, more than 200 people lost their lives and 500 people were feared trapped under the debris due to severe thunder squall that hit Balasore district in Orissa and Midnapore district in West Bengal on 24 afternoon. Over 10,000 cattles were also perished and properties worth several lakhs of rupees were damaged.

In Maharashtra 4 persons lost their lives due to lightning and 11 persons were injured and hundreds were rendered homeless due to unseasonal rain on 17 March.

TABLE 3

Details of the weather systems during April 1998

S.No	System	Period	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	4-8	North Afghanistan & neighbourhood	Northeasterly	Jammu & Kashmir and neighbourhood	
2.	Do	9-13	North Afghanistan & Pakistan	Do	Do	Moved away across west Himalayan
3.	Do	13-17	Central Pakistan & neighbourhood	Do	Jammu & Kashmir	
4.	Do	22-24	North Pakistan & adjoining Jammu & Kashmir	Do	Jammu & Kashmir and neighbourhood	
5.	Do	26-28	North Pakistan & neighbourhood	Do	Do	
6.	Do	29 Apr-2 May	Do	Do		
(B) *Induced cyclonic circulations*						
1.	Lower tropospheric levels	2-4	Northwest Rajasthan & neighbourhood	Eastnortheasterly	Northeast Rajasthan & neighbourhood	It was first observed as an induced cyclonic circulation over southwest Rajasthan on 31. Associated cyclonic circulation extends upto lower levels. Cyclonic circulation lay over Haryana & neighbourhood in the lower levels on 4 and less marked on 5 over Hills of west Uttar Pradesh and neighbourhood. A trough from this system to south Madhya Maharashtra on 2 to east Madhya Pradesh on 3 and less marked on 4
2.	Lower levels	5-6	Southeast Pakistan and adjoining southwest Rajasthan	Stationary	*In situ*	
3.	Do	7	Southeast Pakistan and adjoining west Rajasthan			
4.	Do	8	Northwest Rajasthan and adjoining Punjab, Haryana and neighbourhood			Associated cyclonic circulation on mid tropospheric levels
5.	Lower tropospheric levels	9-10	South Rajasthan and neighbourhood	Stationary	*In situ*	
6.	Lower levels	14-16	Hills of west Uttar Pradesh and adjoining Himachal Pradesh	Northeasterly	Moved away northeastwards	
(C) *Embedded cyclonic circulations*						
1.	Lower levels	22-26	North parts of Gangetic West Bengal and neighbourhood	Quasi-stationary	Bihar plains and neighbourhood on 23	
2.	Do	28-29	Telangana & adjoining parts of north interior Karnataka	Stationary	Do	Merged with the another trough
(D) *Other cyclonic circulations*						
1.	Lower levels	3-9	Soutneast Rajasthan and adjoining Pakistan	Easterly	Central Bihar and adjoining east Madhya Pradesh	
	Do	5-8	East Uttar Pradesh and adjoining Bihar plains	Do		At trough from this system to interior Karnataka through southeast Madhya Pradesh and Telangana on 5

TABLE 3 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Lower levels	10-14	East Uttar Pradesh and adjoining east Madhya Pradesh		Assam & Meghalaya	
	Do	12-16	West Madhya Pradesh and adjoining Vidarbha			
	Do	16-17	North Gujarat and neighbourhood	Stationary	*In situ*	
	Do	17-22	South Pakistan and neighbourhood	Northeasterly	Southern parts of Himachal Pradesh and adjoining Haryana	
	Do	28-29	Central Bihar and neighbourhood	Stationary	*In situ*	
	Do	29-30	North Rajasthan	Do	Merged with the above trough	
3.	Lower tropospheric levels	21-23	Southwest Rajasthan	Northeasterly	Northwest Rajasthan and neighbourhood	
	Do	24-27	South Pakistan	Do	Hills of west Uttar Pradesh	The trough from this system in lower levels to east Uttar Pradesh with an embedded cyclonic circulation over east Uttar Pradesh on 25, 26. Both became less marked on 27
	Do	29 Apr - 1 May	Southwest Rajasthan and adjoining Gujarat	Northeasterly	Northwest Rajasthan and neighbourhood	
(E) *Troughs in the westerlies*						
1.	Mid and upper troposphere	29-30	80° E, north of 15° N	Stationary	*In situ*	
2.	Do	4-5	Sub-Himalayan West Bengal & Sikkim to south Madhya Maharashtra through Bihar plateau and southeast Madhya Pradesh	Do	Do	
	Do	10-14	Central Uttar Pradesh to south Konkan and Goa through Vidarbha and south Madhya Maharashtra		Vidarbha to south Tamil Nadu across Madhya Maharashtra and interior Karnataka	
	Do	16-17	Southeast Uttar Pradesh to north Gujarat Region	Stationary	*In situ*	
	Do	16-23	Southwest Madhya Pradesh to south interior Karnataka	Easterly	Vidarbha to Lakshadweep	
	Do	23 Apr-12 May	East Madhya Pradesh to south Tamil Nadu			
3.	Do	6-8	90° E north of 10° N	Easterly	Moved away eastwards	
(F) *Other troughs*						
1.	Northsouth Lower levels	6-10	75° E south of 25 ° N upto Karnataka coast	Stationary	77° E, south of 20° N upto south Tamil Nadu on 9	
2.	Eastwest Lower levels	9-12	20° N from east Uttar Pradesh to Assam & Meghalaya		West Madhya Pradesh to Tripura across Bihar plateau and Gangetic West Bengal	
	Do	18-27	Northeast Uttar Pradesh to north Assam		Bihar plains to Nagaland	More marked on 24, 25, 26 and less marked on 27

TABLE 4

Details of the weather systems during May 1998

S.No	System	Period	Place of first location	Direction of movement	Place of dissipation	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A) *Cyclonic storm*						
1.	Severe cyclonic storm	17-20	Southern parts of central Bay and adjoining south Bay	Northnortheasterly	Assam & Meghalaya	It was first observed as a trough of low pressure area over southeast Bay on 16, it became well marked over southern parts of central Bay and adjoining parts of south Bay on 17. It concentrated into a depression in the same evening near 15.5° N/88.5° E and as a deep depression at 0900 UTC of 18 and it intensified into a cyclonic storm in the evening of 18 near 19.5° N/ 90.5° E. It further intensified into a severe cyclonic storm on 19 near 20.5°N/ 90.5° E in the morning of 20. It weakened into a depression and crossed Bangla Desh coast, 50 kms northeasterly of Cox's Bazar and further weakened into a depression in the evening of 20. Moving in a northerly direction, it further weakened into a low pressure area over Assam & Meghalaya
(B) *Western disturbances*						
1.	Upper air system	5-10	Pakistan & neighbourhood	Northeasterly	Jammu & Kashmir and neighbourhood	
2	Do	24-25	Jammu & Kashmir and neighbourhood	Do	Do	
(C) *Induced cyclonic circulations*						
1.	Lower tropospheric levels	8-12	North Punjab and neighbourhood	Northeasterly	Haryana and neighbourhood	
(D) *Embedded cyclonic circulation*						
1.	Lower tropospheric levels	1-3	Rayalaseema and adjoining south interior Karnataka		Central parts of Andhra Pradesh	
2.	Do	12-13	Marathwada and neighbourhood	Stationary	*In situ*	Merged with the trough on 11
(E) *Other cyclonic circulations*						
1.	Lower tropospheric levels	2-7	West Rajasthan and adjoining parts of Pakistan		Hills of west Uttar Pradesh	
2.	Do	11-12	East Uttar Pradesh and neighbourhood	Stationary	*In situ*	
3.	Do	12-13	South Rajasthan and neighbourhood		Southeast Rajasthan and adjoining parts of west Madhya Pradesh	A trough from this system to south interior Karnataka on 13. The cyclonic circulation merged with the trough of 12
4.	Do	17-19	West Punjab and adjoining Pakistan		Punjab and adjoining parts of Haryana	A trough from this system to west Madhya Pradesh on 17, 18
5.	Do	31 May-1 June	North Pakistan and neighbourhood	Stationary	*In situ*	
6.	Do	1-2	East Uttar Pradesh and adjoining parts of Bihar	Do	Do	A trough from this system to north Assam on 1. From Bihar plains to north Assam on 2,3

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
7.	Lower tropospheric levels	4-8	Bihar plains to adjoining east Uttar Pradesh	Westerly	East Uttar Pradesh and neighbourhood	A trough from this system to north Assam on 4, to northeast Assam on 5, 6, 7. Less marked on 8
8.	Do	7-12	Southwest Rajasthan and neighbourhood	Southeasterly	Southwest Madhya Pradesh and neighbourhood over west Uttar Pradesh	
9.	Do	13-17	West Rajasthan and adjoining parts of Pakistan			A trough from this system to Madhya Maharashtra on 14 to south interior Karnataka on 15 to southwest Madhya Pradesh on 16
10.	Do	19-23	South parts of west Rajasthan	Northnortheasterly	West Rajasthan and neighbourhood	A trough from this system to west Madhya Pradesh on 19, 20
11.	Do	24-27	Bihar plains and adjoining east Uttar Pradesh	Quasi-stationary	Bihar Plateau and neighbourhood on 26	Merged with the cyclonic circulation. A trough from this system to south Tamil Nadu on 24 to Manipur on 25, 26
12.	Lower tropospheric levels Mid tropospheric levels	26-31	West Punjab and adjoining Pakistan	Northeasterly	Hills of west Uttar Pradesh	Moved away northeastwards. A trough from this system to north Bay across Bihar Plateau was seen on 27 to east Uttar Pradesh on 28. On 29
13.	Do	26-31	South Tamil Nadu coast and adjoining parts of Cormorin area	Westerly	Maldives and Comorin areas and adjoining south Kerala coast	
(F) *Troughs in the westerlies*						
1.	Mid and upper troposphere	7-8	66° E, north of 25° N	Stationary	*In situ*	
(G) *East-West troughs*						
1.	Lower tropospheric levels	13-18	Bihar Plains to west Assam	Quasi-stationary	Bihar Plateau to Mizoram	
2.	Do	21-22	Bihar Plateau to Assam	Stationary	*In situ*	
(H) *Troughs in easterlies*						
1.	Lower tropospheric levels	14-15	Marathwada to south Kerala coast	Stationary	Do	
(I) *Troughs of low pressure area*						
1.	Sea level chart	14-18	Lakshadweep and neighbourhood	Quasi- stationary	East-central Arabian Sea and adjoining Lakshadweep area	
2.	Do	15	Southwest Bay off Srilanka coast	Stationary	*In situ*	
3.	Do	16-17	South Tamil Nadu and adjoining parts of Comorin area	Do	*In situ*	
4.	Do	20-23	South Andaman Sea and adjoining parts of southeast Bay	Do	*In situ*	
(J) *Other troughs*						
1.	Lower tropospheric levels	22-27	East Madhya Pradesh to south Tamil Nadu	Easterly	South coastal Andhra Pradesh	

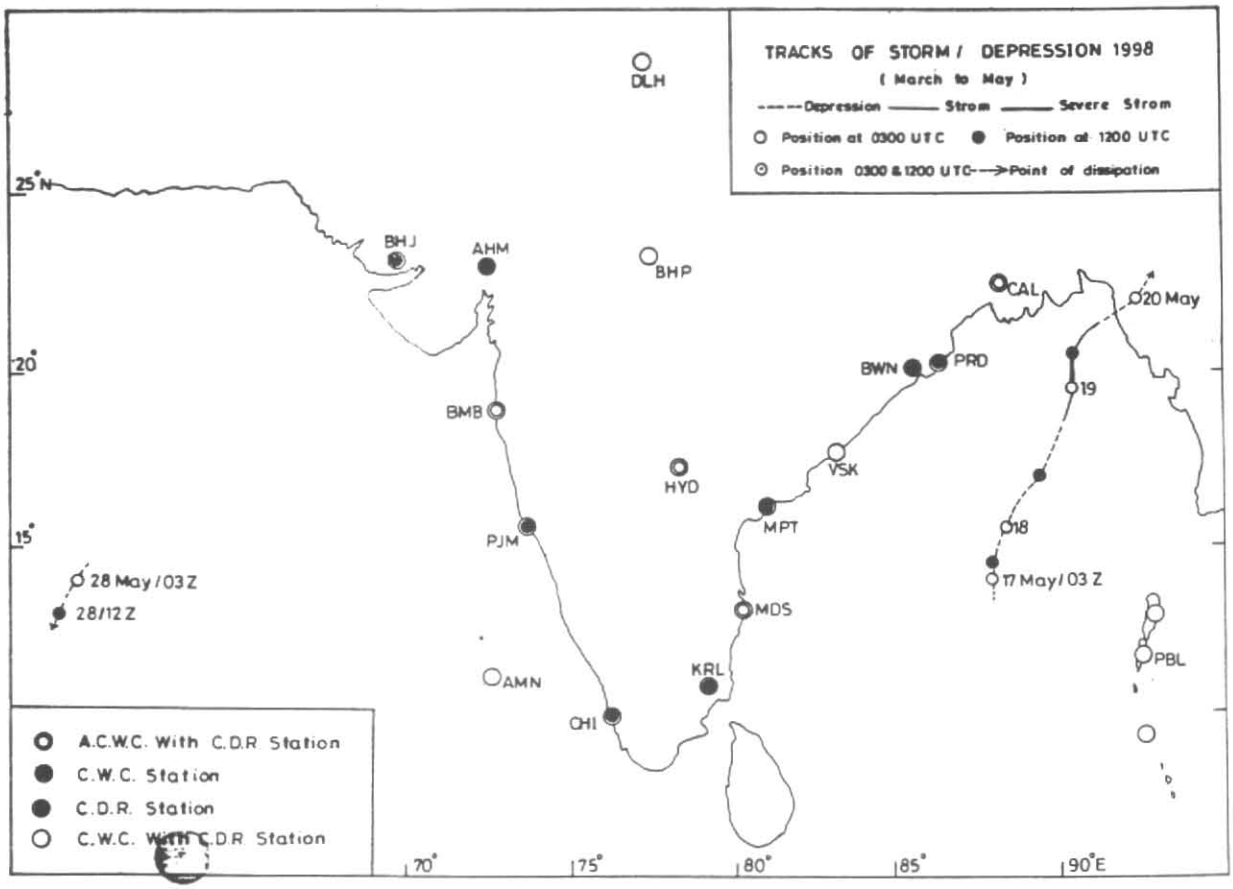

Fig. 2. Track of the cyclonic storm (Mar - May 1998)

3.2. *April*

3.2.1. *Weather and associated synoptic features*

During this month 6 western disturbances, 6 induced cyclonic circulations and 11 other cyclonic circulations in the lower levels affected the weather over north and northwest India. Besides these there were troughts in the westerlies that affected the weather over India. Details of these systems are given in Table 3.

Rain or thundershowers occurred at most places or at many places on 4 to 6 days in Assam and Meghalaya, Sub-Himalayan West Bengal and Sikkim, Himachal Pradesh and Jammu & Kashmir and on 1 to 3 days in Negaland, Manipur, Mizoram and Tripura, Gangetic West Bengal, Orissa, Bihar Plains, Punjab, coastal Andhra Pradesh and Kerala. Rainfall occurred at isolated places over peninsular India during the month.

3.2.2. *Month's Rainfall*

During the month of April, rainfall was excess in 18, normal in 5, deficient in 4 and scanty in 5 Meteorological sub-divisions. There was no rain in 3 Meteorological subdivisions.

Rainfall was excess in West Bengal, Orissa, Bihar, Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, Jammu and Kashmir, Rajasthan, East Madhya Pradesh, coastal Andhra Pradesh, Rayalaseema and south interior Karnataka, normal in Assam and Meghalaya, Negaland, Manipur, Mizoram and Tripura, west Madhya Pradesh, Vidarbha and Lakshadweep, deficient in Arunachal Pradesh, Telangana, north interior Karnataka and Kerala and scanty in Andaman and Nicobar Islands, Madhya Maharashtra, Marathwada, Tamil Nadu and coastal Karnataka. There was no rain over Gujarat State and Konkan & Goa. The Principal amounts of rainfall (cm) are given in Table 5.

3.2.3. *Month's Temperature*

During the month of April, heat wave conditions prevailed on 2 to 6 days in northwest India, west Uttar Pradesh, Haryana and Jammu & Kashmir and on 1 day in Himachal Pradesh during the month. Day temperatures were below normal or appreciably below normal in the east and northeastern parts of the country on many days during the month. They were generally above normal or appreciably above normal on most of the days in the remaining parts of the country. The highest maximum temperature in the plains

TABLE 5

Principal amounts of rainfall (cm) for the months of March, April and May 1998

Date	March	April	May
(1)	(2)	(3)	(4)
1	Nil	Ghumarwin 3, Tonk 2, Amritsar, Batote, Jaisalmer, Belgaum & Kolar Gold Field 1 each	Gannavaram 6, Shimla & Punalur 4 each, Ganganagar, Ajmer & Ahmednagar 2 each, Car Nicobar 1
2	Tuticorin 2, Srinagar 1	Rohtak 6, Perinthalmanna 5, Madikeri 3, Agartala, Batote & Tondi 2 each, Car Nicobar, Silchar, Gangtok, Ganganagar, Sikar & Jagdalpur 1 each	Mathabhanga 5, Durgapur 4, Shillong, Bellary & Kottyam 3 each, Dehra Dun, Sundernagar & Ahmednagar 2 each, Nancowry, Chapra, Amritsar & Madurai 1 each
3	Bhuntar 1	Chepan 9, Ellenabad 5, Durgachak, Amb & Pendra 4 each, Ludhiana & Ramagundam 3 each, Guwahati, Balasore, Dehra Dun, Kota, Baroda & Tiruchirapalli 2 each, Agartala, Srinagar & Nandurbar 1 each	Jalakuda 9, Canning Town 5, Erinpura Road, Nandyal & Adoor 4 each, Dehra Dun 3, Nangal, Shimla, Udaipur, Mehbubnagar & Mangalore 2 each
4	Kollam 4, Punalur 1	Bapatla 9, Kangra 6, Jammu & Kanyakumari 5 each, Bhubaneswar & Khammam 4 each, Gorakhpur, Ballabhgarh & Gurudaspur 3 each, Ghumarwin, Ganganagar, Khajuraho, Rajnandgaon, Tirupathi & Bangalore 2 each, Gangtok, Bellary & Wardha 1 each	Tadons 5, North Lakhimpur 4, Ellenabad 3, Port Blair, Almoh, Una & Batote 2 each, Ajmer 1
5	North Lakhimpur 1	Jagdalpur & Mavelikara 4 each, Anandpur Sahib & Palayamkottai 3 each, Gohana 2, Shillong, Ghamroor, Gannavaram, Nalgonda & Bidar 1 each	Gangtok 5, Samrala, Sikar & Alathur 4 each, Kangra, Deesa, Ramgundam, Tondi & Bangalore 3 each, Hut Bay, Rania & Churu 2 each, Tezpur, Kailashahar & Jagdalpur 1 each
6	Gangtok 1	Arogyavaram 5, Ongole & Karaikal 4 each, Bangalore, Thiruvananthapuram & Minicoy 3 each, North Lakhimpur, Gangtok & Ghumarwin 1 each	Car Nicobar, Rewari, Kavali & Madurai 6 each, Raya & Cuddapah 4 each, North Lakhimpur & Barobisha 3 each, Bhopal 2, Varanasi, Kangra, Udaipur, Jagdalpur, Parbhani, Gondia, Nizamabad, Bellary & Minicoy 1 each
7	Nil	Car Nicobar 6, Contai, Bangalore & Minicoy 3 each, North Lakhimpur 2, Hosdurg 1	Sevoke 10, Bharari 5, Dibrugarh 4, Thiruvananthapuram 3, Tuni 2, Car Nicobar, Pendra, Salem & Chitradurga 1 each
8	Nil	Car Nicobar 4, Agartala 3, Guwahati, Kakinada & Mathabhanga 1 each	Kottyam 9, Sundernagar 7, Malda 6, Nangal, Batote & Palayamkottai 4 each, Shillong 3, Karnal 2, Hut Bay 1
9	Nil	Baijnath 5, Talwadi Sahib 3, Gangtok 2, Nancowry, Rattia, Ganganagar & Kochi 1 each	Piravom 11, Dehra Dun 6, Purulia 5, North Lakhimpur 4, Banihal 2, Bhuntar & Belgaum 1 each
10	Gangtok 1	Gangtok & Uluberia 5 each, Kathua 4, Nangal & Bharari 3 each, Nancowry 2, Shillong, Bareilly, Dehra Dun, Chandigarh & Kalingapatnam 1 each	Guwahati & Palayamkottai 2 each, Chickmagalur & Kayamkulam 1 each
11	Nil	Calcutta 5, Gopalpur, Purnea & Palayamkottai 3 each, Nancowry, Shillong, Baghdogra & Chittorgarh 2 each, Imphal 1	Mysore & Punalur 1 each
12	Nil	Kalingapatnam & Chennai 3 each, Silchar, Katra & Calcutta 1 each	Shimoga 2, Anantnag & Parumbavoor 1 each
13	Nil	Gangtok 5, Dehra Dun 2, North Lakhimpur & Karaikal 1 each	Gangtok 5, Guwahati 4, Punalur 3, Nancowry & Manali 1 each
14	Guwahati 1	Calcutta 3, Baghdogra 1	Imphal, Palayamkottai, Chitradurga & Kasargod 2 each, Kondul, Siliguri, Kalpa & Srinagar 1 each
15	Midnapore, Silchar & Manali 1 each	Srinagar 6	Minicoy & Kunnamkulam 4, Kondul & Mathabhanga 3 each, Berhampore 2, Tezpur & Srinagar 1 each
16	Jammu 3, North Lakhimpur, Gangtok & Deragopipur 2 each, Dehra Dun, Hissar, Kurnool & Kasargode 1 each	Bharari 9, Contai 5, Nangal 3, Jagadhari & Srinagar 2 each, Gangtok & Dehra Dun 1 each	Tiruvadanai 8, Port Blair 5, Kohza 4, Cooch Behar 3, North Lakhimpur & Gulbarga 1 each

TABLE 5 (*Contd.*)

(1)	(2)	(3)	(4)
17	North Lakhimpur & Bhuntar 3 each, Dehra Dun 2, Imphal 1	Gopalpur 5, Gangtok 3, Shillong, Shantiniketan & Bhuntar 2 each, Udhampur, Jagdalpur, Khammam & Bangalore 1 each	Port Blair 9, Sankalan 7, Mananthavady 5, Durgachak 3, Tezpur 2, Mysore 1
18	North Lakhimpur & Bharari 3 each, Imphal & Gangtok 1 each	Kodaikanal 7, Nellore & Mancompur 5 each, Dibrugarh & Mahabubnagar 4 each, Gangtok & Purulia, Mysore 1 each	Maya Bandar & Hut Bay 8 each Kalingapatnam & Dharamapuri 3 each, Jalpaiguri 2
19	Sarkaghat 4, Fatehabad, Gurdaspur & Jammu 2 each	Ramgundam 4, Tadong & Cuddapah 3 each, Patoda & Tumkur 1 each	Maya Bandar 5, Thodupuzha 2, Champasarai & Forbesganj 1 each
20	Rattia 5, Dibrugarh & Konni 2 each, Imphal & Amb 1 each	Mandya 3, Shimla & Pendra 1 each	Aizwal 8, Port Blair 6, Passighat & Silchar 3 each
21	Chengannur 6, Jogindernagar 2, Bangalore 1	Gargoti 9, Kottyam 4, Cooch Behar 2, Guwahati 1	Silchar 8, Cooch Behar 5, Passighat & Agartala 3 each, Hut Bay & Berhampore 1 each
22	Palakkad 3	Kolhapur 4, Hassan 1	Gangtok 10, Saralpara 7, Seppa 4, Chottabekra 2, Hut Bay, Jawai Dam & Bangalore 1 each
23	Agartala 3, Calcutta 1	Shillong 5, Kailashahar & Calcutta 3 each, Balasore, Ahmednagar & Palayamkottai 2 each, Mangalore 1	Tezpur 5, Kalimpong 3, Imphal & Krishnangar 1 each
24	Dibrugarh 3, Nidadavole, Anantpur & Kochi 2 each, Coimbatore 1	Shillong & Jharsuguda 1 each	Calcutta 6, Gangtok 4, Beki Mathanguri, Agartala & Palakkad 2 each, Namsai, Jaipur & Uthagamandalam 1 each
25	Digha 10, Balasore 8, Machilipatnam 1	Balurghat 2	Dibrugarh 5, Khajuraho 4, Calcutta, Chandbali & Shimla 3 each, Gorakhpur & Kottayam 2 each, Jamshedpur & Bikaner 1 each
26	Jagdalpur 7, North Lakhimpur 3	Tezpur 4, Calcutta 2, Jalpaiguri 1	Krishnanagar 7, Matizuri & Jalpaiguri 3, Tezu & Salem 2 each, Agartala & Kalingapatnam 1 each
27	Kochi 2	Guwahati 9, Bhagalpur 3, Tadong & Guler 2 each, Belgaum 1	Dhubri & Kunnamkulam 5 each, Imphal, Bhagalpur & Dharmapuri 2 each, Passighat 1
28	Sholapur 2, Srinagar 1	Kasauli 9, Tezpur 4, Bhubaneswar 3, Car Nicobar, Agartala, Berhampore, Kolhapur, Hyderabad, Pamban, Honavar & Thiruvananthapuram 2 each, Zira & Kalingapatnam 1 each	Chauldhowaghat 8, Agartala & Baghdogra 4 each, Gurgaon & Minicoy 3 each, Kodaikanal1
29	Banihal 9, Bhuntar & Punalur 3 each, Bikaner 2, Gangtok, New Delhi, Amritsar, Jaipur & Tuticorin 1 each	Shimoga 7, Balasore & Bikaner 4 each, Balurghat & Kochi 3 each, Satara 2, Purulia, Dehra Dun, Ambala & Gurdaspur 1 each	Darjeeling 6, Shillong 4, Krishnanagar & Balasore 3 each, Bhagalpur, Muzzaffarnagar, Gurgaon & Dharamsala 1 each

was 45°C recorded at Barmer on 3, Chandrapur on 21 and Cudappah on 22 and 23.

3.2.4. *Disastrous weather events and damages*

During April, about 3 persons in Gangetic West Bengal, 5 persons in Assam, 10 persons in Andhra Pradesh and 4 persons in Karnataka lost their lives due to heavy rain and hail storm during the month.

3.3. *May*

3.3.1. *Severe cyclonic storm over the Bay of Bengal (17-20 May)*

In this month the well marked low pressure area over southern parts of central Bay and adjoining southwest Bay concentrated into a depression on 17 evening and was centred at 1200 UTC of 17 near Lat. 14.5° N/ long. 88.0° E. Moving in a northnortheasterly direction, it intensified into a deep depression in the afternoon of 18 and into a cyclonic storm in the same evening and was centred at 1200 UTC of 18 near Lat. 17.0 ° N / Long. 89.5 ° E. On 19 at 0300 UTC it was near Lat. 19.5 ° N/ Long. 90.5° E. Continuing its northnortheasterly movement, it intensified into a severe cyclonic storm at 1200 UTC of 19 near Lat. 20.5°N / Long. 90.5°E. It crossed Bangladesh coast in the morning of 20 and weakened into a deep depressions 0300 UTC of 20 near Lat. 22.0° N/ Long. 92.5° E, about 50 kms northeast of Cox's Bazar. The deep depression moved in a northnortheasterly direction, weakened into a depression and further weakened

into a low pressure area over Assam and Meghalaya on 21. The track of the severe cyclonic storm is given in Fig. 2.

The system did not cause any damage over India.

3.3.2. *Deep depression over the Arabian sea (28 -29 May)*

A deep depression formed over southern parts of west-central Arabian Sea and was centred at 0300 UTC of 28 May near Lat. 14.0° N/ Long 60.0° E. It weakened into a low pressure area and lay over western part of west Arabian sea on 29. Further it moved away westwards.

3.3.3. *Weather and associated synoptic features*

During the month 2 western disturbances, one induced cyclonic circulation and 13 other cyclonic circulations affected the weather over the country. Besides these, there were troughs in the easterlies and westerlies. Details of these systems are given in Table 4.

Rain or thundershowers occurred almost places or at many places on 8 to 10 days over Andaman and Nicobar Islands. Assam & Meghalaya & Nagaland, Manipur and Mizoram & Tripura, on 6 to 7 days over Arunachal Pradesh and Sub-Himalayan West Bengal and Sikkim and on 1 to 4 days over Gangetic West Bengal, Orissa, Bihar, Hills of west Uttar Pradesh, Punjab, Himachal Pradesh, Jammu & Kashmir, east Madhya Pradesh, Madhya Maharashtra, Marathwada, Rayalaseema, Tamil Nadu, costal and south interior Karnataka, Kerala and Lakshadweep. Rainfall occurred at a few places or at isolated places on most of the days over Peninsular India and on many days over north and northeast India outside plains of Uttar Pradesh, Haryana, Punjab, Rajasthan, west Madhya Pradesh and Konkan & Goa where it was on 2 to 10 days. There was no rain over Gujarat state throughout the month.

3.3.4. *Month's rainfall*

Rainfall during May was excess in 5, normal in 13, deficient in 10 and scanty in 6 meteorological sub-divisions. There was no rain in the 1 meteorological sub-divisions.

Rainfall was excess in Bihar, plains of Uttar Pradesh, Madhya Maharashtra, normal in Arunachal Pradesh, Nagaland, Manipur, Mizoram & Tripura, Orissa, Hills of west Uttar Pradesh, Haryana, Himachal Pradesh, Jammu & Kashmir, east Madhya Pradesh, Marathwada, Vidarbha, Telengana, Tamil Nadu and north interior Karnataka, deficient in Andaman & Nicobar Islands, Assam & Meghalaya, West Bengal, Konkan & Goa, Rayalaseema, coastal and south interior Karnataka, Kerala and Lakshadweep and scanty in Punjab, west Madhya Pradesh, Rajasthan Saurashtra & Kutch and coastal Andhra Pradesh. There was no rain in Gujarat Region. The principal amounts of rainfall are given in Table 5.

3.3.5. *Advance of southwest monsoon*

The southwest monsoon advanced over south Andaman sea on 15th May. It further advanced into parts of south Bay and north Andaman sea on 18. By the end of May, it further advanced over parts of south Andaman sea and of Maldives Comorin area and over the entire Bay of Bengal outside northwest Bay and into Assam and adjacent states.

3.3.6. *Month's temperature*

Severe heat wave conditions prevailed in northwest and north India during second fortnight of the May.

Day temperatures were appreciably above normal on 21 days in Saurashtra and Kutch, on 12 days in coastal Karnataka, on 6 to 10 days in Assam and Meghalaya, Sub-Himalayan West Bengal and Sikkim, Bihar Plains, Hills of west Uttar Pradesh, Himachal Pradesh, Jammu & Kashmir, Gujarat Region, Konkan & Goa, Madhya Maharashtra, Marathwada, coastal Andhra Pradesh, Telangana, Tamil Nadu and interior Karnataka and on 1 to 5 days in Nagaland, Manipur, Mizoram, & Tripura, Gangetic West Bengal, Bihar Plateau, east Uttar Pradesh, east Rajasthan, Madhya Pradesh, Vidarbha, Rayalaseema and Kerala. They were generally above normal on many days over most parts of the country. Day temperature were appreciably to markedly below normal over north and eastern parts of India during 7 to 12 of the month. The season's highest temperature of 50°C was recorded at Dholpur on 28.

3.3.7. *Disastrous weather events and damages*

During the month May, about 1579 people lost their lives in many parts of the country due to heat wave. Two major avalanches in Ladakh on 7th May killed 13 persons.