MAUSAM, 50, 4 (October 1999), 409-426

Weather in India

POST-MONSOON SEASON (October to December 1998)*

1. Introduction

During the post-monsoon season 1998, four cyclonic storms (two very severe cyclonic storms over the Bay of Bengal during 13-16 November and 19-22 November, one severe cyclonic storm over the Arabian Sea during 13-17 December and one cyclonic storm over the Arabian Sea during 11-17 October) and three deep depressions (two over the Bay of Bengal during 13-15 October and 26-30 October and one over the Arabian Sea during 6-9 October) formed. The tracks of these systems are shown in Fig.1.

The southwest monsoon withdrew from the entire country on 20 October 1998. The northeast monsoon set in over Tamil Nadu & Pondicherry, Kerala and adjoining parts of Andhra Pradesh and Karnataka States on 28 October 1998. There was good rainfall (more than 80% sub-divisions received normal or excess rainfall) over peninsular India during the season. Rainfall over all the sub-divisions of peninsular India was excess (departure from normal rainfall was + 20% or more) except in south interior Karnataka where it was normal (departure from normal was between + 19% to -19%).

In addition to the seasonal northeast monsoon rainfall activity, most parts of India, particularly northeast India, Madhya Pradesh, Maharashtra and Gujarat State received good rainfall during October.

Cold wave conditions (temperature departure from normal being - 3°C to - 4°C for the regions where the normal minimum temperature is less than 10°C), sometimes severe (departure from normal being - 5°C or less for the regions where the normal minimum temperature is less than 10°C and departure from normal being -7°C or less where the normal minimum temperature is 10°C or more), prevailed on most of the days in Kashmir during the month of December. Cold wave conditions also prevailed on few days in the last week of December in Bihar Plains, Uttar Pradesh, Punjab and Jammu.

2. Chief features

(*i*) Two cyclonic storms (one severe) and a deep depression formed over the Arabian Sea during the season.

(*ii*) Two very severe cyclonic storms and two deep depressions formed over the Bay of Bengal during the season.

(*iii*) Northeast monsoon rains commenced on 28 October over Tamil Nadu, Kerala and adjoining parts of Karnataka and Andhra Pradesh.

(*iv*) Northeast monsoon withdrew from Tamil Nadu, Kerala and adjoining parts of Andhra Pradesh and Karnataka on 22 December 1998.

(*v*) The seasonal rainfall during northeast monsoon was excess over the peninsular India except south interior Karnataka where it was normal. The rainfall was excess or normal in 33 Met. Sub- divisions during the season.

(*vi*) Cold wave conditions prevailed over Kashmir in the month of December on most of the days. Cold wave conditions also prevailed on few days in the last week of December in Bihar Plains, Uttar Pradesh, Punjab and Jammu.

3. Seasonal rainfall (October-December)

Seasonal rainfall was excess in 27, normal in 6, deficient (departure from normal rainfall being between - 20 % to - 59%) in 1 and scanty (departure from normal rainfall being between - 60% to - 99%) in 1 meteorological sub-divisions.

Rainfall was normal in Andaman & Nicobar Islands, Assam & Meghalaya, Sub-Himalayan West Bengal & Sikkim, east Uttar Pradesh, west Madhya Pradesh, south interior Karnataka; deficient in Nagaland, Manipur, Mizoram & Tripura and scanty in Jammu & Kashmir. It was excess over the rest of the 27 meteorological sub-divisions. Seasonal rainfall departures are given Fig.2 and percentage departures in Table 1.

4. Monthly features

4.1. *October*

4.1.1. *Withdrawal of southwest monsoon*

Southwest monsoon withdrew from western parts of west Rajasthan on 7 September, 6 days after the normal date

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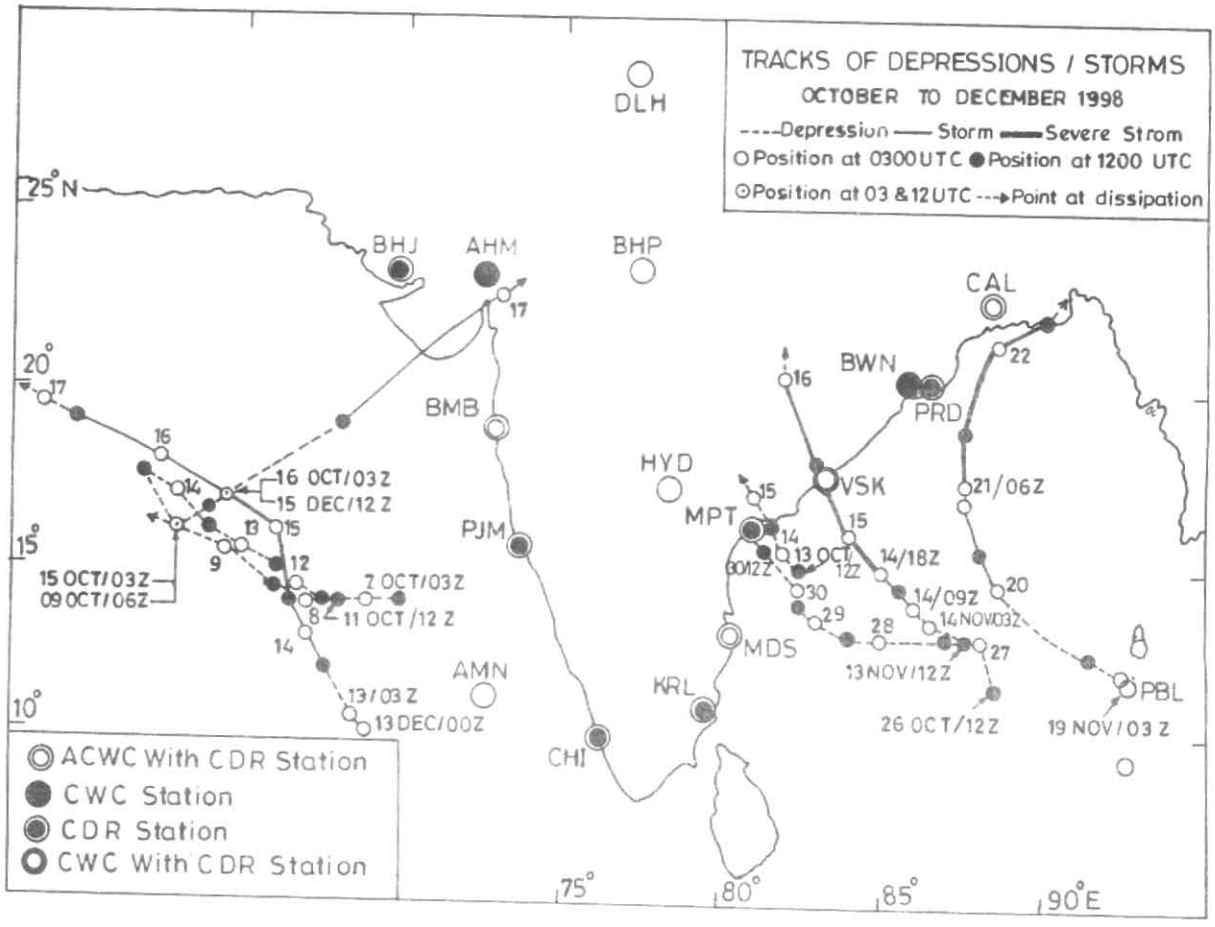

Fig. 1. Tracks of the storms/depressions during October to December 1998

of withdrawal. It further withdrew from Madhya Pradesh, Orissa, Maharashtra and northeast India by 9 October. It withdrew from the entire country by 20 October.

4.1.2. *Onset of northeast monsoon*

Northeast monsoon rains commenced over Tamil Nadu & Pondicherry, Kerala and adjoining parts of Andhra Pradesh and Karnataka on 28 October.

4.1.3. *Storms/depressions*

During the month of October one cyclonic storm and one deep depression formed over the Arabian Sea. Two deep depressions formed over the Bay of Bengal during this month.

(a) *Deep depression over Arabian Sea (6 - 9 October 1998)*

A well-marked low pressure area formed over southeast Arabian Sea and neighbourhood. It concentrated into a depression and centred at 1200 UTC of 6 near Lat. 14.0° N/Long. 70.0°E. It moved in a westerly direction and further intensified into a deep depression and lay centred at 0300 UTC of 8 near Lat. 14.0° N/Long. 67.0°E. Then, it moved in a westnorthwesterly direction and lay centred at 1200 UTC of 8 as a depression near Lat. 14.5° N/Long. 66.0°E. Then, it moved in a northwesterly direction and lay centred at 0300 UTC of 9 near Lat. 15.5° N/Long. 64.5° E. Continuing its northwesterly movement, it weakened into a depression and lay centred at 0600 UTC of 9 near Lat. 16.0°N/63.0°E. It, then moved in a northwesterly direction and weakened into a low pressure area over the sea area. INSAT reported peak intensity of T 2.0 from 1000 UTC of 8 to 0000 UTC of 9 on D'vorak's scale.

(b) *Cyclonic storm over Arabian Sea (11 - 17 October 1998)*

A well-marked low pressure area formed on 10 evening over east- central and adjoining Southeast Arabian Sea off Karnataka-north Kerala coast. It concentrated into a depression on 10 evening and was centred at 1200 UTC of 11 near

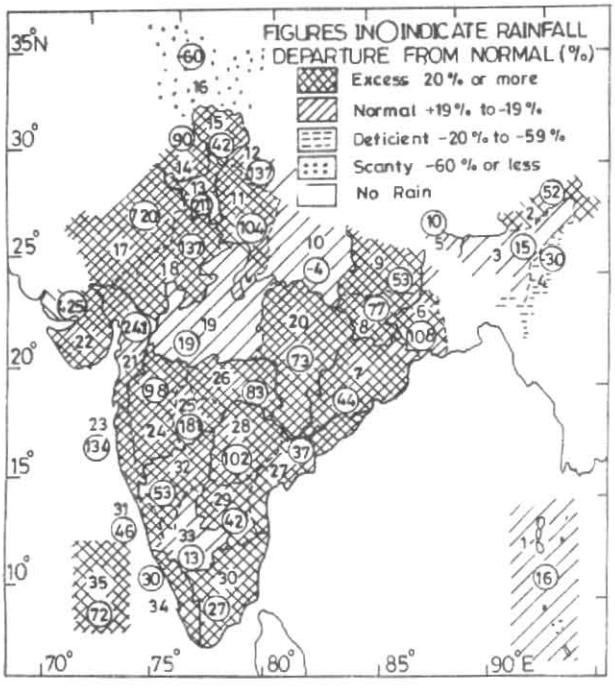

Fig. 2. Sub-divisionwise percentage departures from normal of rainfall of the post-monsoon season 1998

Lat. 14.0° N/Long. 67.5°E and at 0300 UTC of 12 near Lat. 14.5° N/Long. 66.5°E. It intensified into a deep depression at 0900 UTC of 12 and lay as deep depression till 0300 UTC of 13 near Lat. 15.5° N/Long. 65.0° E. The system then weakened into a depression and was centred near Lat. 16.0°N/Long. 64.0° E at 1200 UTC of 13. It moved in a northwesterly direction and made an anti-clockwise loop and again intensified into deep depression at 1200 UTC of 15 and lay centred near Lat. 17.0° N/Long. 64.5° E at 0300 UTC of 16. It intensified into a cyclonic storm in the evening of 16 near Lat. 19.0° N/Long. 68.0° E. Moving in a northeasterly direction, it crossed south Gujarat coast near Veraval in the morning of 17. Continuing its northeasterly movement after crossing the coast, it weakened into a deep depression over south Gujarat Region when it was about 50 kms northwest of Bhavnagar. Then it moved in a northeasterly direction and weakened into a well-marked low pressure area on 17 evening over south Rajasthan and adjoining north Gujarat and adjoining northwest Madhya Pradesh. The system was mainly tracked with the help of satellite observations and there were no supporting ship's observations till it came close to the coast.

Positions and intensities given by INSAT Cloud Imagery (ICI) were not consistent. This caused difficulty in assessing the intensity of the system and fixing the centre of the system. Sat. Met. relocated the position of the system on 0300 UTC and 0600 UTC of 12, 0300 UTC of 13 and 0300 UTC of 15, probably based on visible imageries. As a result, it was difficult to keep continuity of the system on real time basis. When the system was close to the coast, coastal observations, ONGC rigs off Mumbai were helpful. Cyclone Detection Radar (CDR) Bhuj at 2100 UTC of 16 reported broken cloud configuration in the range of about 100-200 kms. There were no significant signals reported from CDR Mumbai and Bhuj. Maximum intensity reported by satellite (ICI) was T 2.5 from 1700 UTC to 2200 UTC of 16. The lowest estimated central pressure was 996 hPa when the system intensified into a CS near Lat. 18.5° N/Long. 68.0°E at 1200 UTC of 16. After 1200 UTC of 15, the system came under the influence of a strong westerly trough aloft. As a result, the system recurved to the northeast and moved very fast. It moved with the speed of 15 kmph from 1200 UTC of 15 to 0300 UTC of 16,38 kmph from 0300 UTC to 1200 UTC of 16 and 26 kmph from 1200 UTC of 16 to 0100 UTC of 17. Associated cloud structure and the convection got sheared off northeastwards into the Gujarat region at the time of crossing the coast.

A well-marked trough of low extending upto lower tropospheric levels lay over northern parts of east-central Arabian Sea off coastal area of Saurashtra. ICI also showed well-organized clouds indicating intense convection. The cyclonic storm moving northeastwards merged with the above trough of low on 16 evening.

In addition, there was a deep depression between 13 evening and 14 evening over west-central Bay of Bengal. Thus, there was a simultaneous presence of deep depression over the west-central Bay of Bengal and deep depression over central parts of Arabian Sea which are separated by about 16° longitude. The interaction between these two deep depressions cannot be ruled out.

The system caused widespread heavy rainfall over Gujarat, south Rajasthan and adjoining parts of west Madhya Pradesh. There was no report of loss of life or damage to property in Gujarat and Maharashtra. However, in Maharashtra due to gale force winds, 300 fishermen were reported missing, but subsequently all returned except 9.

(c) *Deep depression over Bay of Bengal (13-15 October 1998)*

A well-marked low pressure area formed over west-central Bay off Andhra coast on the morning of 13. It concentrated into a depression and lay centred at 1200 UTC of 13 near Lat. 15.0° N/82.5°E. It moved in a northwesterly direction and further intensified into a deep depression and was centred near Lat. 15.5° N/Long. 82.0°E. It continued its northwesterly movement retaining its intensity as deep depression and was centred at 1200 UTC of 14 near Lat. 16.2°N/Long. 81.5°E. The system then crossed Andhra coast between Machilipatnam and Kakinada, very close to

TABLE 1

Sub-divisionwise rainfall (mm) for each month and season as a whole (October-December 1998)

S. No.	Sub-division	October			November			December			Season		
		Actual (mm)	Normal (mm)	Dep (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep (%)	Actual (mm)	Normal (mm)	Dep. (%)
1.	Andaman & Nicobar Island	484	320	51	301	253	19	78	171	-54	863	744	16
2.	Arunachal Pradesh	218	127	73	21	21	1	3	12	-74	243	160	52
3.	Assam & Meghalaya	172	164	5	59	30	97	1	9	-89	232	202	15
4.	Naga., Mani.,Mizo & Trip.	70	150	-53	64	31	106	0	10	-98	134	191	-30
5.	SHWB & Sikkim	173	145	20	12	17	-33	0	6	-100	185	168	10
6.	Gangetic West Bengal	204	117	74	87	20	343	0	3	-100	291	140	108
7.	Orissa	156	120	30	67	29	129	0	6	-100	223	155	44
8.	Bihar Plateau	141	83	70	35	12	197	0	5	-100	176	100	77
9.	Bihar Plains	93	64	44	23	8	187	0	3	-100	116	76	53
10.	East Uttar Pradesh	34	48	-30	23	5	364	0	6	-100	57	59	-4
11.	Plains of west U.P.	86	34	151	9	4	134	0	8	-100	95	47	104
12.	Hills of west U.P.	216	59	265	4	8	-50	0	26	-100	220	93	137
13.	Haryana, Chandigarh & Delhi	85	18	361	9	4	166	0	8	-100	94	30	211
14.	Punjab	76	21	256	0	4	-92	0	15	-100	77	40	90
15.	Himachal Pradesh	130	43	205	5	13	-62	0	39	-100	135	95	42
16.	Jammu & Kashmir	46	31	45	1	29	-96	0	58	-100	47	118	-60
17.	West Rajasthan	74	5	1399	0	2	-94	0	3	-100	74	9	720
18.	East Rajasthan	49	14	255	3	4	-32	0	4	-100	51	22	137
19.	West Madhya Pradesh	50	31	59	12	14	-13	0	7	-99	62	52	19
20.	East Madhya Pradesh	77	51	50	45	12	283	0	7	-100	121	70	73
21.	Gujarat Region	119	27	344	8	9	-12	0	2	-100	127	37	241
22.	Saurashtra & Kutch	135	16	762	4	10	-64	0	1	-100	139	26	425
23.	Konkan & Goa	292	113	158	53	25	107	0	9	-98	344	147	134
24.	Madhya Maharashtra	179	71	151	35	29	19	0	7	-100	214	108	98
25.	Marathwada	197	57	245	43	19	120	0	9	-100	239	85	181
26.	Vidarbha	64	46	38	69	16	336	0	11	-100	133	73	83
27.	Coastal A.P.	287	191	50	137	98	39	4	22	-80	429	312	37
28.	Telangana	179	76	137	24	18	30	0	6	-100	202	100	102
29.	Rayalaseema	180	116	56	92	71	30	26	25	7	299	211	42
30.	Tamil Nadu & Pondicherry	124	195	-36	255	194	31	228	88	158	607	478	27
31.	Coastal Karnataka	315	196	61	83	70	19	15	16	-5	414	283	46
32.	N.I. Karnataka	188	97	93	18	29	-39	1	8	-93	206	134	53
33.	S.I. Karnataka	160	147	8	64	52	22	16	12	27	239	212	13
34.	Kerala	442	297	49	129	166	-22	88	43	104	658	506	30
35.	Lakshadweep	178	163	9	144	102	41	254	69	267	576	334	72

TABLE 2

Details of the weather systems during October 1998

S. No.	System	Duration	Place of first location	Direction of movement	Place of dissipation	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A) *Storms and depressions*						
(1)	Deep depression	6-9	East-central Arabian Sea	Initially westerly, then west north-westerly, westerly and again westnorthwesterly	East-central and adjoining west-central Arabian Sea	A low pressure area formed over the east-central Arabian Sea off south Madhya Maharashtra coast. It concentrated into a depression and centred at 061200 UTC near Lat. 14.0° N/Long. 70.0°E. It moved in a westerly direction and further intensified into a deep depression and lay centred at 080300 UTC near Lat. 14.0° N/Long.67.0°E. Then, it moved in a westnorthwesterly direction and lay centred at 081200 UTC as a depression near Lat. 14.5° N/Long. 66.0°E. Then, it moved in a northwesterly direction and lay centred at 090300 UTC near Lat. 15.5°N/Long. 64.5°E. Continuing its northwesterly movement, it weakened into a depression and lay centred at 090600 UTC near Lat. 16.0°N/63.0° E. It, then moved in a northwesterly direction and weakened into a low pressure area over the sea area
(2)	Cyclonic storm	11-17	East-central and adjoining southeast Arabian Sea off Karnataka-North Kerala coast	Initially westerly, then westnorth-westerly and finally north easterly	South Rajasthan, north Gujarat Region and adjoining northwest Madhya Pradesh	A well-marked low pressure area formed on 10 evening over east-central and adjoining Southeast Arabian Sea off Karnataka-north Kerala coast. It concentrated into a depression on 10 evening and was centred at 1200 UTC of 11 near Lat. 14.0°N/Long. 67.5°E and at 0300 UTC of 12 near Lat. 14.5° N/Long. 66.5°E. It intensified into a deep depression at 0900 UTC of 12 and lay as deep depression till 0300 UTC of 13 near Lat. 15.5° N/Long. 65.0°E. The system then weakened into a depression and was centred near Lat. 16.0° N/Long. 64.0°E at 1200 UTC of 13. It moved in a northwesterly direction and made an anti-clockwise loop and again intensified into deep depression at 1200 UTC of 15 and lay centred near Lat. 17.0° N/Long. 64.5°E at 0300 UTC of 16. It intensified into a cyclonic storm in the evening of 16 near Lat. 19.0° N/Long. 68.0°E. Moving in a northeasterly direction, it crossed south Gujarat coast near Veraval in the morning of 17. Continuing its northeasterly movement after crossing the coast, it weakened into a deep depression over south Gujarat Region when it was about 50 kms northwest of Bhavnagar. Then it moved in a northeasterly direction and weakened into a well-marked low pressure area on 17 evening over south Rajasthan and adjoining north Gujarat and adjoining north-west Madhya Pradesh

TABLE 2 *(Contd.)*

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(3)	Deep depression	13 - 15	West-central Bay off Andhra coast	Westnorth-westerly	Southeast Madhya Pradesh	A well-marked low pressure area formed over west-central Bay off Andhra coast on the morning of 13. It concentrated into a depression and lay centred at 131200 UTC near Lat. 15.0° N/82.5°E. The system was then tracked by Machilipatnam radar from 1800 UTC of 13 to 1500 UTC of 14. It moved in a northwesterly direction and further intensified into a deep depression and was centred near Lat. 15.5° N/Long. 82.0°E. Radar, at this time reported the centre near Lat. 15.5° N/Long. 81.9°E. It continued its northwesterly movement retaining its intensity as deep depression and was centred at 141200 UTC near Lat. 16.2° N/Long. 81.5°E. At this time, Machilipatnam radar reported centre near Lat. 16.2° N/Long. 81.7°E. The system then crossed Andhra coast between Machilipatnam and Kakinada, very close to Narasapur at 1600 UTC of 14 as seen by Machilipatnam radar. Then, it weakened into a depression and lay centred at 150300 UTC near Lat. 17.0° N/Long. 81.0° E. CDR Machilipatnam reported last radar observation at 141500 UTC near Lat. 16.4° N/Long. 81.8° E. The system then moved in a northwesterly direction and weakened into a low pressure area over Telangana
(4)	Deep depression	26 - 30	Southeast Bay and adjoining south Andhra coast	Initially westnorthwesterly, then westerly and finally westnorth-westerly	Southern parts of Telangana, adjoining Rayalaseema and coastal Andhra Pradesh	A well-marked low pressure area moved into southeast Bay and neighbourhood on the morning of 26. It concentrated into a depression and was centred at 261200 UTC near Lat. 11.5° N/Long. 88.5°E. It moved in a northwesterly direction and further intensified into a deep depression and lay centred at 271200 UTC near Lat. 13.0° N/Long. 87.0°E. It then moved in a westerly direction and lay centred at 281200 UTC as a deep depression near Lat. 13.0° N/Long. 84.0°E. It, then changed the course and moved in a northwesterly direction and weakened into a depression at 290900 UTC and was centred near Lat. 16.0° N/Long. 82.5°. Countinuing its northwesterly movement, it lay as a depression at 301200 UTC near Lat. 15.5° N/Long. 81.5° E. Then, it weakened into a low pressure area off Andhra coast
(B) *Well-marked low/low pressure area*						
(1)	Well-marked low pressure area	17-24	Northwest Bay off Orissa coast	Northeasterly	East Madhya Pradesh Vidarbha and neighbourhood	Associated cyclonic circulation extended upto 3.1 kms. a.s.l. It lay as a low pressure area from 17 to 19. On 20, it became well-marked low pressure area over North Bay and adjoining West Bengal and coastal

TABLE 2 *(Contd.)*

(1)	(2)	(3)	(4)	(5)	(6)	(7)
						Orissa. It moved inland and lay as a low pressure area on 21 over Gangetic West Bengal, Bihar Plateau and adjoining east Madhya Pradesh and Orissa. It lay as a trough of low on 23 over east Madhya Pradesh and neighbourhood and became less marked on 24 over east Madhya Pradesh, Vidarbha and neighbourhood
(C) *Induced cyclonic circulations*						
(1)	Lower levels	9 - 10	South Rajasthan and neighbourhood	Stationary	*In situ*	
(2)	Lower tropospheric levels	17 - 20	Punjab, Haryana and neighbourhood	Eastnortheasterly	East Uttar Pradesh and neighbourhood	
(D) *Other cyclonic circulation*						
(1)	Mid tropospheric level	30 Sept - 8 Oct	North Karnataka coast and neighbourhood			Persisted throughout the week
(2)	Mid tropospheric levels	2-6	East Uttar Pradesh and adjoining parts of Bihar Plains	Easterly	Bihar Plains and neighbourhood	A trough from this system to south Assam was observed on 3 and 4
(3)	Lower levels	3-6	Northwest Rajasthan and neighbourhood	Northeasterly	Punjab and neighbourhood	
(4)	Do	5-7	West Rajasthan and neighbourhood	Stationary	*In situ*	
(5)	Mid tropospheric levels	8-10	North Rajasthan and neighbourhood	Northeasterly	Northeast Rajasthan and adjoining Haryana and neighbourhood	
(6)	Lower tropospheric levels	24-25	Gangetic West Bengal and neighbourhood	Stationary	*In situ*	
(7)	Mid tropospheric levels	25-26	South Andaman Sea	Quasi- stationary	South Andaman Sea and adjoining southeast Bay	
(8)	Lower levels	27-28	Northwest Rajasthan	Stationary	*In situ*	
(9)	Lower tropospheric levels	28-29	Karnataka and North Kerala coast	Do	Do	
(10)	Mid tropospheric levels	30 Oct - 1 Nov	South Andaman Sea and neighbourhood	Do	Do	

TABLE 2 *(Contd.)*

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(E) *Western disturbances*						
(1)	As an upper air system	10-11	North Pakistan and neighbourhood	Northeasterly	Jammu & Kashmir and neighbourhood	Moved away
(2)	Do	15-19	Jammu & Kashmir and neighbourhood	Do	Do	Do
(3)	Do	23-25	Do	Do	Do	Do
(4)	Do	24-27	North Pakistan and adjoining Jammu & Kashmir	Do	Do	Do
(F) *Troughs in westerlies*						
(1)	Mid and upper troposphere	19-20	Central Uttar Pradesh to south Madhya Maharashtra	Stationary	*In situ*	
(2)	Do	13-18	63°E, north of 25°N	Easterly	66°E, north of 20° N	It deepened further on 15
(G) *East-west troughs*						
(1)	Mid troposphere	24-26	Coastal Andhra Pradesh to north Konkan-south Gujarat coast	Stationary	*In situ*	
(H) *Other troughs*						
(1)	Sea level Chart	3-7	Maharashtra coast to Kerala coast	Stationary	*In situ*	
(2)	Well-marked trough of low pressure area	16-17	Saurashtra & Kutch and adjoining Arabian Sea	Do	Do	Associated cyclonic circulation extended upto lower tropospheric levels
(3)	Lower tropospheric levels	22-24	Sub-Himalayan West Bengal & Sikkim to south Tamil Nadu through east Madhya Pradesh	Northeasterly	Arunachal Pradesh to south Konkan & Goa	

Narasapur at 1600 UTC of 14. Then, it weakened into a depression and lay centred at 0300 UTC of 15 near Lat. 17.0° N/Long. 81.0°E. The system then moved in a northwesterly direction and weakened into a low pressure area over Telangana. INSAT reported peak intensity of T 2.0 from 1200 UTC of 13 to 0200 UTC of 14 on D'vorak's scale.

The system took a toll of 101 human lives, 50 villages got submerged and crops in thousands of acres of agricultural land got damaged. Total loss of about Rs. 600 crores was reported by Andhra Pradesh Government. Widespread heavy rainfall was also experienced in north coastal Andhra Pradesh.

(d) *Deep depression over Bay of Bengal (26 - 30 October 1998)*

A well-marked low pressure area moved into southeast Bay and neighbourhood on the morning of 26. It concentrated into a depression and was centred at 1200 UTC of 26 near Lat. 11.5° N/Long. 88.5°E. It moved in a northwesterly direction and further intensified into a deep depression and lay centred at 1200 UTC of 27 near Lat. 13.0° N/Long. 87.0°E. Subsequently it moved in a westerly direction and lay centred at 1200 UTC of 28 as a deep depression near Lat. 13.0° N/Long. 84.0° E. It, then changed the course and moved in a northwesterly direction and weakened into a depression at 0900 UTC of 29 and was centred near Lat. 14.0° N/Long. 82.5° E. Continuing its northwesterly movement, it lay as a depression at 1200 UTC of 30 near Lat. 15.5° N/Long 81.5°E. Then, it weakened into a low pressure area off Andhra coast. INSAT reported peak intensity of T 2.0 from 1200 UTC of 27 to 0800 UTC of 29 on D'vorak's scale.

Most of the crops like paddy sugar, cotton etc. submerged in water in all the coastal districts of Andhra Pradesh. Very heavy rainfall (rainfall amount exceeding 12.5 cms) was experienced in the coastal area on 31 October.

4.1.4. *Weather and associated synoptic features*

Table 2 gives details of the synoptic features for the month October 1998.

Southwest monsoon was vigorous (rainfall more than 4 times the normal with minimum 8 cms along the west coast and 5 cms elsewhere in atleast two stations in the sub-division) on 3 to 4 days in coastal and north interior Karnataka and on 1 to 2 days in Konkan & Goa, Madhya Maharashtra, Marathwada, coastal Andhra Pradesh, Telangana and Kerala. It was active (rainfall more than 1.5 to 4 times the normal with minimum 5 cms along the west coast and 3 cms elsewhere in atleast two stations in the sub- division) on 7 days each in coastal Andhra Pradesh, coastal and south interior Karnataka and Kerala; on 3 to 4 days in Rayalaseema and north interior Karnataka and on 1 to 2 days in Konkan & Goa, Madhya Maharashtra, Marathwada and Telangana.

Heavy (rainfall amount more than 6.5 cms and less than 12.5 cms over one or two stations in the sub-division) to very heavy rainfall occurred on 5 to 7 days in Orissa, Konkan & Goa, coastal Andhra Pradesh, Tamil Nadu, interior Karnataka and Kerala on 3 to 4 days in Andaman & Nicobar Islands, Sub-Himalayan West Bengal & Sikkim, plains of west Uttar Pradesh, Himachal Pradesh, Madhya Maharashtra and coastal Karnataka and on 1 to 2 days in Gangetic West Bengal, Bihar Plateau, east Uttar Pradesh, Hills of west Uttar Pradesh, Haryana, Rajasthan, Madhya Pradesh, Gujarat State, Marathwada and Vidarbha.

4.1.5. *Monthly rainfall*

Monthly rainfall was excess in 29, normal in 3 and deficient in 3 meteorological sub-divisions. Rainfall was normal in Assam & Meghalaya, south interior Karnataka and Lakshadweep; deficient in Nagaland, Manipur, Mizoram & Tripura, east Uttar Pradesh and Tamil Nadu. It was excess over the rest of the 29 meteorological sub-divisions. The significant amounts of rainfall (cm) during the month are given in Table 5.

4.1.6. *Temperature*

Day temperatures were appreciably (departure from normal temperature + 3°C to + 4°C) to markedly above normal (departure from normal temperature + 5° C to + 6°C) on many days in northeast India, Hills of west Uttar Pradesh, Himachal Pradesh, Kashmir, west Rajasthan, Madhya Pradesh and Saurashtra & Kutch in the second week of the month. They were appreciably (departure from normal temperature - 3°C to -4°C) to markedly below normal (departure from normal temperature - 5° C to - 6° C on most days in Arunachal Pradesh, Hills of west Uttar Pradesh, Haryana, Punjab, Rajasthan, Gujarat State, Madhya Maharashtra and Marathwada in the third week of the month.

Cold wave conditions, sometimes severe, prevailed on 3 days in Hills of west Uttar Pradesh and on 1 day in Jammu. Night temperatures were generally appreciably to markedly above normal on most of the days in north and central India and in Maharashtra and Gujarat States.

The month's lowest minimum temperature in the plains of the country was 10.4°C recorded at Sawai Madhopur in Rajasthan on 29 October 1998.

4.1.7. *Disastrous weather events and associated damages*

During this month 374 people (162 in Karnataka, 101 in Andhra Pradesh, 44 in Kerala, 39 in Tamil Nadu, 14 in Maharashtra and 14 in other states) died due to incessant

TABLE 3

Details of the weather systems during November 1998

S. No.	System	Duration	Place of first location	Direction of movement	Place of dissipation	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A) *Storms and depressions*						
(1)	Very severe cyclonic storm	13 - 16	Southern and adjoining west-central Bay	Initially Northwesterly and finally northnorthwesterly	East Madhya Pradesh	A low pressure area formed over southeast Bay on 13 with central region near Lat. 11.5° N/Long. 88.0°E. It became well marked over southeast and adjoining west-central Bay. It rapidly concentrated into a deep depression over central and adjoining south Bay at 140300 UTC near Lat. 13.5° N/Long. 86.5° E, about 600 kms southeast of Visakhapatnam. Moving in a northwesterly direction it intensified into a cyclonic storm in the afternoon of 14 and was centred at 1200 UTC of 14 near Lat. 14.5° N/Long. 85.5° E. It further intensified into a severe cyclonic storm in the early morning of 15. It moved in a northwesterly direction and furhter intensified into a very severe cyclonic storm and was centred at 150300 UTC within half a degree of Lat. 16.0° N/Long. 84.0° E, about 220 kms southsoutheast of Visakhapatnam. It moved in a northwesterly direction and crossed north Andhra Pradesh coast close to but south of Visakhapatnam in the evening of 15. It weakened into a severe cyclonic storm with its centre at 151200 UTC near Lat. 18.0° N/Long. 83.0°E, about 50 kms west of Visakhapatnam. It further moved in a northnorth westerly direction and weakened into a deep depression with centre at 160300 UTC near Lat. 20.5° N/Long. 82.0° E, about 100 kms southeast of Raipur. It weakened into a well-marked low pressure area over central parts of east Madhya Pradesh in the afternoon of 16 and further weakened into a low pressure area in the same evening
(2)	Very severe cyclonic storm	19 - 22	Andaman Sea	Initially northwesterly and then northerly	Bangladesh and adjoining Assam & Meghalaya	A well-marked low pressure area formed over Andaman Sea on 18. It concentrated into a depression with centre at 190300 UTC near Lat. 12.0° N/Long. 92.5°E. It moved in a northwesterly direction and intensified into a Deep Depression with centre at 191200 UTC near Lat. 12.5° N/Long. 91.5°E, about 130 kms northwest of Port Blair. It further moved in a northwesterly direction and intensified into a cyclonic storm and was centred at 200300 UTC near Lat. 14.5° N/Long. 88.5°E, about 650 kms

TABLE 3 *(Contd.)*

(1)	(2)	(3)	(4)	(5)	(6)	(7)
						southeast of Visakhapatnam. It moved in a westerly direction with centre at 201200 UTC near Lat. 15.5° N/Long 88.0° E. It further moved in a northwesterly direction and intensified into a severe cyclonic storm with centre at 210600 UTC near Lat. 17.5° N/Long. 87.5°E, about 520 kms south of Balasore. It further moved in a northerly direction and intensified into a very severe cyclonic storm at 1200 UTC of 21 near Lat. 19.0° N/Long. 87.5° E and weakened into a severe cyclonic storm at 0300 UTC of 22, it lay near Lat. 21.5° N/Long. 88.5° E, about 120 kms south of Calcutta. It crossed West Bengal coast near east of Sagar Island at noon of 22. It rapidly weakened into a deep depression with centre at 221200 UTC near Lat. 22.0° N/Long. 90.0°E. It further weakened into a depression and into a low pressure area over Bangladesh and neighbourhood
(B) *Well-marked low/low pressure area*						
(1)	Low pressure area	2-7	Southwest Bay off Srilanka-north Tamil Nadu coast	Quasi Stationary	South Tamil Nadu and adjoining Srilanka	Associated cyclonic circulation extended upto mid tropospheric levels from 2 to 6. It moved westwards on 7 and lay over south Tamil Nadu and neighbourhood
(2)	Well-marked low pressure area	5-16	Coastal Kerala and neighbourhood	Westerly	Southwest Arabian Sea	It was first located as a cyclonic circulation in the lower levels on 3. It became well-marked on 11 over southeast Arabian Sea. Associated cyclonic circulation extended upto lower tropospheric levels
(C) *Western disturbance*						
(1)	Upper air system	5-10	Punjab and neighbourhood	Eastnortheastwards	Himachal Pradesh and neighbourhood	Moved away across Himachal Pradesh
(2)	Do	23-24	North Rajasthan and neighbourhood	Do	Do	Do
(3)	Do	29 Nov - 1 Dec	Punjab and adjoining parts of Pakistan	Northeasterly	Jammu & Kashmir and neighbourhood	Moved away across Jammu & Kashmir
(D) *Induced cyclonic circulation*						
(1)	Mid tropospheric levels	8 - 10	North Madhya Pradesh and adjoining parts of east Rajasthan	Northeasterly	Southern parts of west Uttar Pradesh and neighbourhood	
(E) *Other cyclonic circulation*						
(1)	Lower tropospheric levels	3 - 4	South Andaman Sea and adjoining parts of southeast Bay	Stationary	*In situ*	

TABLE 3 *(Contd.)*

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(2)	Lower tropospheric levels	4 - 5	Northwest Rajasthan	Stationary	*In situ*	
(3)	Mid tropospheric levels	9 - 13	Southwest Bay off south Tamil Nadu-north Srilanka coast	Northwesterly	South Tamil Nadu and neighbourhood	Merged with the low pressure area
(4)	Do	15 - 17	South Maharashtra-Goa coast	Stationary	*In situ*	
(5)	Do	17 - 20	South Maharashtra and adjoining Goa coast	Do	Do	
(6)	Do	18 - 20	Off south Orissa-north Andhra coast	Do	Do	
(7)	Mid tropospheric levels	29 Nov - 1 Dec	Karnataka-Goa coast	Do	*In situ*	
(F) *Troughs in westerlies*						
(1)	Mid and upper troposphere	16 - 21	66°E, north of 16°N	Northeasterly	Along 80°E over the country	
(2)	Do	23 - 25	67°E, north of 20°N	Do	69°E, north of 20°N	
(3)	Do	29 Nov - 1 Dec	68°E, north of 15°N	Stationary	*In situ*	
(G) *Other troughs*						
(1)	Mid tropospheric levels	10 - 11	South Karnataka coast to Kerala coast	Stationary	*In situ*	
(2)	Sea level	17 - 29	North Maharashtra coast to Kerala coast	Do	Do	
(3)	Trough of low	26 Nov - 3 Dec	Andaman Sea and neighbourhood	Westerly	Southeast Bay	

heavy rain and floods. Properties worth crores of rupees was damaged.

4.2. *November*

4.2.1. *Storms/depressions*

Two very severe cyclonic storms formed over the Bay of Bengal during this month.

(a) *Very severe cyclonic storms over the Bay of Bengal (13-16 November 1998)*

A low pressure area formed over southeast Bay on 13 with central region near Lat. 11.5° N/Long. 88.0°E. It became well-marked over southeast and adjoining west-central Bay. It rapidly concentrated into a deep depression over central and adjoining south Bay and was centred at 0300 UTC of 14 near Lat. 13.5° N/Long. 86.5°E, about 600 kms southeast of Visakhapatnam. Moving in a northwesterly direction, it intensified into a cyclonic storm in the afternoon of 14 and was centred at 1200 UTC of 14 near Lat. 14.5° N/Long. 85.5° E. It further intensified into a severe cyclonic storm in the early morning of 15. It further intensified into a very severe cyclonic storm and was centred at 0300 UTC of 15 near Lat. 16.0° N/Long. 84.0° E, about 220 kms southsoutheast of Visakhapatnam. Moving in northwesterly direction, it crossed north Andhra Pradesh coast close to, but south of Visakhapatnam in the evening of 15. It weakened into a severe cyclonic storm and was centred at 1200 UTC of 15 near Lat. 18.0° N/Long. 83.0° E, about 50 kms west of Visakhapatnam. Moving in northnorthwesterly direction, it weakened into a deep depression and was centred at 0300

TABLE 4

Details of the weather systems during December 1998

S. No.	System	Duration	Place of first location	Direction of movement	Place of dissipation	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A) *Storms and depressions*						
(1)	Severe cyclonic storm	13 - 17	Northern parts of southeast Arabian Sea and neighbourhood	Initially northwesterly, then northnorthwesterly and finally northerly	Saudi Arabia coast	A low pressure area formed on 9 off Kerala coast and adjoining Commorin-Maldives area. It became well-marked over northern parts of south-east Arabian Sea and neighbourhood on 12 evening. It concentrated into a depression and was centred at 130300 UTC near Lat.10.5°N/Long. 68.5°E about 750 kms southwest of Goa. It moved in a northwesterly direction and intensified into a cyclonic storm with centre at 131200 UTC near Lat. 12.0°N/Long. 67.5°E, about 780 kms southwest of Goa. It then moved in a northwesterly direction and further intensified into a severe cyclonic storm and was centred at 141200 UTC near Lat. 14.0° N/66.5° E and at 150300 UTC near 16.0° N/66.0° E. It moved in a northerly direction and then a northnorthwesterly direction and weakened into a cyclonic storm and lay at 1200 UTC of 15 near Lat. 17.0° N/Long. 64.5°E and was centred at 0300 UTC of 16 near Lat. 18.0° N/Long. 62.5°E, about 620 kms westsouthwest of Veraval. It further weakened into a deep depression in the afternoon of 16 and further rapidly weakened into a well-marked low pressure area over west-central Arabian Sea and neighbourhood in the evening of 17
(B) *Western disturbance*						
(1)	Upper air system	2 - 3	Punjab and adjoining parts of Pakistan	Northeasterly	Jammu & Kashmir and neighbourhood	Moved away
(2)	Do	5 - 7	North Pakistan and neighbourhood	Do	North Pakistan and adjoining parts of Jammu & Kashmir	Do
(3)	Do	26 - 27	North Pakistan and adjoining parts of Jammu & Kashmir	Do	Jammu & Kashmir and neighbourhood	Do
(4)	Do	29 - 31	North Pakistan and neighbourhood	Do	Do	Do
(C) *Cyclonic circulation*						
(1)	Lower levels	1 - 3	North Srilanka and neighbourhood	Stationary	*In situ*	
(2)	Lower tropospheric levels	11 - 16	Southwest Bay off north Srilanka coast	Do	Do	

TABLE 4 *(Contd.)*

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(3)	Lower levels	16 - 23	Andaman Sea and neighbourhood	Quasi- stationary	South Andaman Sea and neighbourhood	
(4)	Do	17 - 18	Off Goa-Karnataka coast	Stationary	*In situ*	
(5)	Do	19 - 21	Lakshadweep and neighbourhood	Do	Do	
(6)	Do	20 - 23	North Rajasthan and neighbourhood	Eastnortheasterly	Punjab and adjoining parts of Himachal Pradesh	Moved away
(E) *Troughs*						
(1)	Lower levels	4 - 11	Southwest Bay off south Tamil Nadu coast	Stationary	*In situ*	
(2)	Sea level chart	23 Dec - 6 Jan	North Kerala coast to Comorin area	Stationary	*In situ*	It extended upto lower levels on 26 and upto lower tropospheric level from 30 December to 5 January

UTC of 16 near Lat. 20.5° N/Long.82.0°E, about 100 kms southeast of Raipur. It weakened into a well-marked low pressure area over central parts of east Madhya Pradesh in the afternoon of 16 and further weakened into a low pressure area in the same evening. Position given by ICI were consistent and correct and helped to track the system accurately. CDR Machilipatnam and Visakhapatnam reported radar fixes from 0100 UTC to 1500 UTC of 15 and from 1500 UTC of 14 to 1500 UTC of 15 respectively. The position given by CDR Machilipatnam, CDR Visakhapatnam and ICI agreed very well and there was no difficulty to track the system accurately. All these observations also agreed very well with hourly coastal observations. This helped to forecast the landfall point and time without any difficulty. X-band radar at Visakhapatnam only reported at 1000 UTC of 15, "EYE" of diameter 20 kms and eye wall width of 20 kms.

Maximum intensity reported by ICI on D'vorak's scale was T 4.5 at 0600 UTC and 0700 UTC of 15. The system had lowest estimated central pressure of 988 hPa while on sea at 0300 UTC of 15.

The system caused 16 human deaths. About 28,000 families affected, thousands of houses got damaged in Visakhapatnam district. Very heavy rain reported on 16 in north coastal Andhra Pradesh. Gale force wind exceeding 75 kts were recorded at Visakhapatnam and Waltair observatories. Strong winds and heavy rainfall caused damage to the property to the extent of rupees 306 crores as per the report given by the State Government officials.

(b) *Very severe cyclonic storm over the Bay of Bengal (19 - 22 November 1998)*

A well-marked low pressure area formed over Andaman Sea on 18. It concentrated into a depression and was centred at 0300 UTC of 19 near Lat. 12.0° N/Long. 92.5°E. It moved in a northwesterly direction and intensified into a deep depression with centre at 1200 UTC of 19 near Lat. 12.5° N/Long. 91.5°E, about 130 kms northwest of Port Blair. It further moved in a northwesterly direction and intensified into a cyclonic storm and was centred at 0300 UTC of 20 near Lat. 14.5° N/Long. 88.5° E, about 650 kms southeast of Visakhapatnam. It moved in a northwesterly direction with centre at 1200 UTC of 20 near Lat. 15.5° N/Long 88.0°E. It further moved in a northwesterly direction and intensified into a severe cyclonic storm with centre at 0600 UTC of 21 near Lat. 17.5° N/Long. 87.5°E, about 520 kms south of Balasore. It then moved in a northerly direction and intensified into a very severe cyclonic storm at 1200 UTC of 21 near Lat. 19.0° N/Long. 87.5°E and weakened into a severe cyclonic storm at 0300 UTC of 22, it lay near Lat. 21.5° N/Long 88.5°E, about 120 kms south of Calcutta. it crossed West Bengal coast between Sagar Island and Sundarban area of West Bengal at noon of 22. It rapidly weakened into a deep depression with centre at 1200 UTC of 22 near Lat. 22.0° N/Long. 90.0°E. It further weakened into a depression and into a low pressure area over Bangladesh and neighbourhood. The system was tracked mainly with the help of INSAT Cloud Imageries. The maximum intensity reported by ICI was T 4.0 from 1000 UTC of 21 to 0000 UTC of 22. The position given by ICI were consistent and accurate for fixing the centre. CDR Paradip

TABLE 5
Principal amounts of rainfall (cm)

Date	October	November	December
(1)	(2)	(3)	(4)
1	Dharampur 15, Sawai Madhopur & Pendra 8 each, Cuddalore 7, Port Blair, Calcutta (ALP) & Gaya 6 each, Birdghat, Kangra, Goa (Panjim) & Arogyavaram 5 each, Kalamb 4, Naraingarh 3	Hut Bay & Kodaikanal 6 each, Kakinada 4, Imphal & Pendra 3 each, Shajapur & Talegaon DD 2 each, Berhampore, Paradip, Ranchi, Parbhani & Punalur 1 each	Nellore 3, Long Island 2, Chennai 1
2	Bareilly 9, Midnapore & Sinner 7 each, Ambad 6, Raipur, Rajpipla, Goa (Panjim) & Pondicherry 5 each, Long Island, Bhubaneswhar, Akola & Karwar 4 each, Khanitar, Ranchi, Gaya, Tohana & Kottayam 3 each	Tirupathi 9, Jamshedpur, Bapatla, Chennai & Mandya 4 each, Hut Bay & Chhindwara 3 each, Pendra, Sujrat & Peint 2 each, Gopalpur 1	Nedumanagad 5, Thiruvananthapuram (AP) 3, Punalur 2, Mysore 1
3	Mohol 24, Long Island 19, Mumbai (CLB) 14, Bhira & Manjlegaon 11 each, Surat 9, Agumbe 8, Jagdalpur 7, Saralpara, Chandrapur & Kottayam 5 each, Thanesar & Ramagundam 4 each, Ranchi, Chennai & Karwar 3 each	Nellore & Coimbatore 7 each, Nancowry & Tirupathi 5 each, Navapur 4, Cuttack, Nagpur & Bangalore 3 each, Lanja, Kundapura & Nilambur 2 each, Betul 1	Palayamkottai 1
4	Churu & Mumbai (CLB) 11 each, Hut Bay & Parner 9 each, Mohanpur 8, Keonjargarh & Patna 7 each, Gannavaram 6, Annapurnaghat, Nelanga & Hyderabad 5 each, Chennai 4, Ranchi 3	Karaikal 19, Vedaranniyam 17, Amini Divi 4, Nasik 3, Car Nicobar & Thiruvananthapuram 2 each, Bhatsa, Kavali, Arogyavanam & Mangalore 1 each	Nagapattinam 4, Car Nicobar & Karaikal 3 each
5	Kankavali 9, Mangalore 8, Gaganbavda 6, Bhimadole & Hosdurg 5 each, Kondul & Purulia 4 each Jammu & Hyderabad 3 each	Thiruvananthapuram (AP)19, Kanyakumari 17, Malvan 5, Mayabandar 3, Vaijapur, Visakhapatnam & Minicoy 2 each, Rajkot & Peint 1 each	Karaikal 4, Nagapattinam 2, Port Blair 1
6	Kondul & Perinthalmanna 9 each, Bareilly & Gubbi 5 each, Bhopal, Kankavali, Radhanagri, Bapatla & Bantwal 4 each, Pondicherry 3	Chennai (AP) 11, Nellore 7, Ambala 6, Alapuzha 5, Gopalur & Amini Divi 4 each, Port Blair & Tirupathi 3 each, Peint 1	Vedaranniyam 9, Karaikal 5, Kozhikode 3, Car Nicobar 2
7	Harnai & Mahabaleshwar 4 each, Haripad 3	Kavali 14, Nellore 10, Tirupath & Chennai City 7 each, Kolar Gold field & Alapuzha 5 each, Gopalpur 4, Sudhagad 3, Nilokheri & Panambur 1 each	Kondul 5, Vedaranniyam 2, Hut Bay 1
8	Ongole 11, Mahabaleshwar 10, Pali, Karaikal & Thiruvananthapuram 7 each, Bangalore 6, Dharwad 5, Car Nicobar, Theog & Aurangabad 3 each	Kodaikanal 12, Nellore 5, Chikmaglur 4, Alibag, Satara, Tirupathi & Belgaum 3 each, Nelanga & Palakkad 2 each, New Delhi (PLM), Rajgarh, Jaipur, Nizamabad & Mangalore 1 each	Vedaranniyam 7, Nancowry 5, Thiruvananthapuram 3, Minicoy 2
9	Cherthala 9, Kankavali, Shirola & Gannavaram 5 each, Vapi & Bangalore 3 each, Patoda, Uthagamandalam & Minicoy 2 each	Mana 7, Car Nicobar 6, Harnar & Ambad 5 each, Nagpur & Chennai(AP) 4 each, Pune, Nellore, Tumkur & Thiruvananthapuram 3 each, Allahabad, Sarkaghat, Tirupathi & Karwar 2 each, Bareilly & Sagar 1 each	Nagapattinam & Karaikal 15 each, Adirampattinam & Minocy 7 each Punalur 1
10	Visakhapatnam 13, Dharavi, Chamrajnagar & Cherthala 9 each, Gaganbavda & Khanapur 5 each, Hut Bay, Chottabekra, Uthagamandalam, Kollur & Amini Divi 4 each, Gangtok, Vaijapur & Kurnool 2 each	Jalna 8, Hut Bay 6, Jagdalpur & Thanjavur 5 each, Kagal & Yeotmal 4 each, Uran, Chikmaglur, Palakkad & Amini Divi 3 each, Baghdogra, Karwar & Belgaum 2 each, Varanasi & Machilipatnam 1 each	Pondicherry 17, Thanjavur 15, Thirupathi 6, Neyyantinkara 3, Kolar Gold Fields & Minicoy 2 each
11	Punalur 17, Gangtok 10, Long Island, Vihar, Bellary & Minicoy 5 each, Gaganbavda, Ongole & Kurnool 4 each, Annapurnaghat & Purna 3 each, Paradip 2	Calcutta (AP) 5, Maya Bandar & Cochi 4 each, Malda, Patna, Rajnandgaon, Aurangabad, Narsapur & Coimbatore 2 each, Bhira & Akola 1 each	Kodaikanal 17, Coimbatore 10, Karipur 4, Tirupathi 3, Kolar Gold Field & Amini Divi 2 each, North Lakhimpur 1
12	Chiplun 18, Tamini & Punalur 11 each, Almatti & Kozhikode 10 each, Tiruthani & Bangalore 7 each, Kalingapatnam & Siddapur 6 each, Kondul 4, Jagdalpur, Vapi & Minicoy 2 each	Sudhagad 5, Car Nicobar & Dawdi 3 each, Kondul 2	Amini Divi 16, Tirupathi 10, Chennai (AP) 6, Cochi 2

TABLE 5 *(Contd.)*

(1)	(2)	(3)	(4)
13	Tirupathi 8, Porbandar & Vellore 6 each, Kondul & Ausa 5 each, Madhuban 4, Sudhagad, Hyderabad, Mangalore & Thiruvananthapuram 3 each, Shillong, Jalpaiguri & Thakurwadi 2 each	Hut Bay 8, Long Island 6, Kakinada & Nilambur 3 each, Chikmaglur 1	Pondicherry 9, Amini Divi 6, Kodungallur 4, Tuticorin 3, Tirupathi 2
14	Ahwa 14, Berhampore 13, Kalingapatnam 12, Tirupattur & Raichur 10 each, Nancowry 9, Mulky 8, Kozhikode 7, Siliguri, Kurnool & Mysore 5 each, Tansa 4, Khavda, Sholapur, Aurangabad & Minicoy 3 each, Matizuri 2	Maya Bandar & Thiruvananthapuram 5 each, Addanki & Minicoy 2 each, Coimbatore 1	Cuddalore 9, Karaikal & Panambur 5 each, Kannur 3, Amini Divi 2
15	Puri & Tilakwada 13 each, Ratnagiri & Agumbe 11 each, Pathri 10, Paradip 9, Niphad 8, Shirali & Piravom 6 each, Beki road bridge, Naliya & Kalingapatnam 5 each, Motala, Kurnool & Gadag 4 each, Calcutta (ALP) 3, Kanyakumari & Amini Divi 2 each	Nimapada & Punalur 5 each, Puri & Kakinada 4 each, Maya Bandar 3, Minicoy 1	Nagapattinam 6, Kondul 5, Kunnamkulam 3
16	Bhuj 20, Yellapura 16, Naliya 15, Danta & Malkapur 11 each, Medak 10, Port Blair 9, Sankluj & Hunchadakatle 8 each, Digha, Agra & Bikaner 6 each, Balasore, Manjlegaon & Gulbarga 5 each, Jammu, Udaipur, Jagdalpur & Dahanu 3 each, Agartala, Jamshedpur, Ajnala, Bhopal & Nandyal 2 each	Elamanchili 15, Chodavaram 12, Nimapada 11, Paradip 8, Jagdalpur 5, Amini Divi 2, Maya Bandar, Chandrapur & Ramagundam 1 each	Kondul 2, Shimoga & Amini Divi 1 each
17	Manali 23, Mount Abu 17, Deesa 16, Bhakudar & Savarkundla 15 each, Fatehgarh 14, Hissar 13, Anandpur Sahib 10, Dehra Dun & Jalore 9 each, Batote 8, Raigarh 5, Mahabaleshwar 4, Port Blair, Alibag & Kozhikode 3 each, Chhindwara & Agumbe 2 each	Kondul 6, Jharsuguda & Pendra 4 each, Contai & Agumbe 3 each, Minicoy 2, Varanasi & Aluva 1 each	Punalur 4, Kondul 3, Thiruvananthapuram & Minicoy 1 each
18	Rajgarh & Gwalior 11 each, Maya Bandar 10, Sawai Madhopur & Cochi 7 each, Cuttack 6, Narwana 5, Bareilly & Shegaon 3 each, Patiala, Batote & Harnaweir 2 each	Car Nicobar 5, Varanasi 3, Mumbai (SCZ) 2, Patna, Pune, Karwar & Kudulu 1 each	Vedaranniyam & Minicoy 1 each
19	Siliguri 12, Ranchi 8, Gorakhpur 5, Dibrugarh & Bhagalpur 3 each, Paradip, Danta & Cherthala 2 each	Port Blair 9, Long Island & Honavar 6 each, Tiruthani 5, Sagar 3, Vaijapur 1	Nancowry 4, Thiruvananthapuram 3
20	Cooch Behar, Sankalan & Suri 16 each, Moharo 9, Maya Bandar & Bhagalpur 4 each, Guwahati 2	Ramanugunj & Arogyavaram 3 each, Hut Bay 2, Vellore 1	Punalur 6, Alapuzha 5, Thiruvananthapuram 4
21	Tezpur 13, Kondul & Bhubaneshwar 5 each, Baghdogra, Calcutta (ALP) & Jamshedpur 3 each	Kolar Gold Fields 4, Paradip 2, Pamban 1	Thiruvananthapuram 5
22	Purulia 7, Long Island & Cooch Behar 5 each, Jharsuguda 4, Guwahati & Raipur 3 each, Jamshedpur & Kankavali 2 each, Imphal 1	Contai 9, Medikeri & Tondi 3 each, Long Island 2, Paradip 1	Kollam 2
23	Bankura, Cuttack & Jamshedpur 5 each, Tumsar 4, Malda & Chennai 2 each, Port Blair 1	Agartala & Krishnanagar 10 each, Shillong & Hosdurg 3 each	Thiruvananthapuram 3
24	Mumbai (SCZ) 5, Chhindwara 4, Hut Bay 3, Silvassa 2, Gangtok & Arogyavaram 1 each	Shillong 5, Kochi 2	
25	Mayabandar & Jalpaiguri 2 each, Contai & Bangalore 1 each	Ongole 2, Long Island & Karipur 1 each	Port Blair 2, Hut Bay & Car Nicobar 1 each
26	Nancowry 4, Mysore 2, Akola & Kozhikode 1 each	Car Nicobar, Narsapur, Tiruthani & Vaikom 3 each, Hut Bay 2	
27	North Lakhimpur, Gannavaram, Nagapattinam & Aryankavu 2 each, Kondul, Malvan & Gargoti 1 each	Kondul 3, Neyyantinkara 2	Car Nicobar 3, Kondul 2, Vedaranniyam 1

TABLE 5 *(Contd.)*

(1)	(2)	(3)	(4)
28	Alapuzha 4, Madurai 3, Port Blair, Honavar & Shimoga 2 each	Palayamkottai 3, Kanyakumari 2	Kundul & Karaial 3 each, Pamban 2, Tondi 1
29	Lanja 4, Cuddalore 3, Mayabandar 1	Nancowry 3, Kondul & Alapuzha 1 each	
30	Paradip 12, Punalur 10, Machilipatnam 4, Gadhinglaj & Nippani 2 each, Madurai, Ankola & Kollegal 1 each	Kondul & Cuddalore 1 each	Minicoy 2, Kondul 1
31	Calcutta (ALP) 15, Balasore & Machilipatnam 4 each, Agartala 3, Port Blair & Kunnamkulam 2 each, Malda & Nalgonda 1 each		Pamban 1

reported Radar observations from 0600 UTC of 20 to 0900 UTC of 22. It reported "EYE" at 0900 UTC, 1000 UTC and 1100 UTC of 21. On the basis of spiral bands, CDR Paradip reported Centre of the system at 1200 UTC, 1800 UTC and 1900 UTC of 21. CDR Calcutta reported Radar observations from 0600 UTC of 20 to 0900 UTC of 22. On the basis of spiral bands, it reported the centre of the system at 2300 UTC of 21, 0000 UTC of 22 and 0100 UTC of 22. The centres given by CDR Calcutta, CDR Paradip and ICI agreed very well and helped not only to fix the centre of the system, but to predict landfall time and place accurately. The lowest estimated central pressure was 984 hPa at 0300 UTC of 22. The system recurved to the northeast under the influence of strong westerly trough aloft.

It is reported that strong winds, speed reaching 80-100 kmph accompanied by heavy rain caused damage to crops, unrooted trees and electric poles in north Balasore district. Parts of Sagar Island submerged and affected 25,000 people in eight villages and 3,000 mud houses collapsed. Lakhs of people were affected in 24-Paraganas and Midnapore districts.

4.2.2. *Weather and associated synoptic features*

Details of synoptic features for the month of November 1998 are given in Table 3. Northeast monsoon was vigorous on 1 to 3 days in Rayalaseema and Tamil Nadu. It was active on 8 days in Tamil Nadu, 4 days in Kerala and on 1 day in Rayalaseema. Heavy to very heavy rainfall occurred on 3 to 4 days in Orissa and Tamil Nadu and on 1 to 2 days in Andaman & Nicobar Islands, Gangetic West Bengal, east Uttar Pradesh, Vidarbha, coastal Andhra Pradesh and Kerala.

4.2.3. *Monthly rainfall*

Monthly rainfall was excess in 19, normal in 6, deficient in 5 and scanty in 5 meteorological sub-divisions. Rainfall was normal in Andaman & Nicobar Islands, Arunachal Pradesh, west Madhya Pradesh, Gujarat Region, Madhya Maharashtra and coastal Karnataka; deficient in Sub-Himalayan West Bengal & Sikkim, Hills of west Uttar Pradesh, east Rajasthan, north interior Karnataka and Kerala and was scanty in Punjab, Himachal Pradesh, Jammu & Kashmir, west Rajasthan and Saurashtra & Kutch. It was excees over the rest of the 19 meteorological sub-division.

4.2.4. *Temperature*

Severe cold wave conditions prevailed on 1 to 2 days in Arunachal Pradesh and Hills of West Uttar Pradesh during the month. Cold wave conditions also prevailed on 1 day each in Arunachal Pradesh and Kashmir. Night temperatures were appreciably to markedly above normal on many days in northeast India, plains of Uttar Pradesh, Haryana, Rajasthan, Madhya Pradesh, Madhya Maharashtra, Marathwada, Vidarbha, coastal Andhra Pradesh and Telangana and on few days in Gujarat and Rayalaseema.

The month's lowest minimum temperature in the plains of the country was 3.6°C recorded at Amritsar in Punjab on 30 November 1998.

4.2.5. *Disastrous weather events and associated damages*

Apart from heavy damage caused due to very severe cyclonic storms, 82 people died in Tamil Nadu due to heavy rain and 1 person died in Maharashtra due to lightning There was widespread loss of agriculture in Kerala due to incessant rain.

4.3. *December*

4.3.1. *Storms/depressions*

(a) *Severe cyclonic storms over the Arabian Sea (13 - 17 December 1998)*

A low pressure area formed on 9 off Kerala coast and adjoining Commorin-Maldives area. It became well-marked over northern parts of southeast Arabian Sea and neighbourhood on 12 evening. It concentrated into a depression and was centred at 0300 UTC of 13 near Lat. 10.5° N/Long. 68.5°E, about 750 kms southwest of Goa. It moved in a northwesterly direction and intensified into a cyclonic storm with centre at 1200 UTC of 13 near Lat. 12.0° N/Long. 67.5°E, about 780 kms southwest of Goa. Moving in a northwesterly direction, it further intensified into a severe

cyclonic storm and was centred at 1200 UTC of 14 near Lat. 14.0° N/Long.66.5°E and at 0300 UTC of 15 near Lat. 16.0°N/Long.66.0°E. It moved in a northerly direction and then in a northnorthwesterly direction and weakened into a cyclonic storm and lay at 1200 UTC of 15 near Lat. 17.0° N/Long. 64.5°E. It was centred at 0300 UTC of 16 near Lat. 18.0°E N/Long. 62.5°E, about 620 kms westsouthwest of Veraval. It further weakened into a deep depression in the afternoon of 16 and further rapidly weakened into a well-marked low pressure area over west-central Arabian Sea and neighbourhood in the evening of 17. It further moved westwards. The positions given by ICI were inconsistent, did not help to track the system on real time basis. Many times the positions were relocated adding further difficulties in maintaining the continuity of the system. Number of ships, some of them were crucial, helped to track the system to some extent. As the system was far away out in the Sea, no radar observations were reported. The lowest estimated central pressure was 996 hPa from 1200 UTC of 14 to 0000 UTC of 15 and again from 0900 UTC of 15 to 0000 UTC of 16. INSAT reported peak intensity of T 3.5 from 0700 UTC of 14 to 2100 UTC of 14 on D'vorak's scale. Formation of severe cyclonic storm over the Arabian Sea in the month of December is rare. The earlier cyclonic storm which formed over the Arabian Sea were 14 - 21 December 1971, 6 - 12 December 1965, 1 - 7 December 1963, 17 - 23 December 1923, 17 - 18 December 1912, 29 November-2 December 1920, 30 November - 2 December 1909, and 7 - 12 December 1902.

The system did not cause any weather or damage over India.

4.3.2. *Weather and associated synoptic features*

Table 4 gives the details of the synoptic features for the month of December 1998.

Northeast monsoon was vigorous on 2 days in Kerala. Heavy to very heavy rain occurred on 12 days in Tamil Nadu and on one day each in Rayalaseema, south interior Karnataka, Kerala and Lakshadweep.

4.3.3. *Monthly rainfall*

Monthly rainfall was excess in 4, normal in 2, deficient in 1 and scanty in 7 meteorological sub-divisions. There was no rain over 21 other meteorological sub-divisions.

The rainfall was excess in Tamil Nadu, south interior Karnataka, Kerala and Lakshadweep; normal in Rayalaseema and coastal Karnataka; deficient in Andaman & Nicobar Islands and scanty in Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, west Madhya Pradesh, Konkan & Goa, coastal Andhra Pradesh and north interior Karnataka.

4.3.4. *Temperature*

Cold wave conditions, sometimes severe, prevailed on most days during the month in Kashmir and on 6 days in Jammu. Cold wave conditions also prevailed on 1 to 3 days in Bihar Plains, Uttar Pradesh, Punjab and Marathwada during the month. Temperatures were appreciably to markedly below normal on 8 to 10 days in Madhya Maharashtra, Marathwada, north interior Karnataka; on 6 days in Telangana and on 1 to 3 days in Bihar Plateau, west Madhya Pradesh, Konkan & Goa, Vidarbha, coastal Andhra Pradesh, Rayalaseema, Tamil Nadu and coastal Karnataka.

The month's lowest minimum temperature in the plains of the country was 0.5°C recorded at Amritsar in Punjab on 30 December 1998 and over hills -7° C on 17, 18, 27 and 28 December over Srinagar.

4.3.5. *Disastrous weather events and associated damages*

In Bihar, 77 people died due to severe cold wave in the last week of the month. According to press reports, 28 people lost their lives in Andhra Pradesh because of heavy rain. Thousands of huts were damaged and several thousand acres of standing crops were damaged due to flood in Andhra Pradesh.