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Weather in India

POST-MONSOON SEASON (October-December 1999)*

1. Introduction

During the post monsoon season of 1999, two cyclonic storms (one very severe cyclonic storm during 15-19 October and the other super cyclonic storm during 25-31 October 1999) and one depression (8-10 December 1999) formed over the Bay of Bengal. The super cyclonic storm which crossed the Orissa coast in the last week of October, was one of the most intense storms in the history of the Indian cyclone. Track of the storms and the depression are shown in Fig. 1.

Southwest monsoon withdrew from the entire country on 21 October 1999. Simultaneously, northeast monsoon rains commenced over Tamil Nadu & Pondicherry, Kerala and adjoining states of Karnataka and Andhra Pradesh on 21 October 1999. Seasonal rainfall was excess in 20, normal in 6, deficient in 6 and scanty (departure from normal rainfall is between -60% to -99%) in 3 meteorological subdivisions.

In addition to northeast monsoon rainfall activity over Peninsular India as a seasonal feature, rainfall activity over Northeast India, plains of Uttar Pradesh, Rajasthan, Madhya Pradesh, Gujarat and Maharashtra was also good during the season.

Cold wave conditions prevailed (temperature departure from normal is -3° to -4° C for the regions where normal minimum temperature is less than 10° C) on a few days over many parts of northwest India during the month of December 1999.

2. Seasonal rainfall (October-December)

Rainfall was also normal in Nagaland, Manipur, Mizoram & Tripura, plains of west Uttar Pradesh, Rajasthan, east Madhya Pradesh and Tamil Nadu; deficient in Andaman & Nicobar Islands, hills fo west Uttar Pradesh, Jammu & Kashmir and Andhra Pradesh and scanty in Haryana, Punjab and Himachal Pradesh. It was excess over the rest of the 20 meteorological sub-divisions. Seasonal rainfall departures are given in Fig. 2 and percentage departures in Table 1.

3. Monthly features

3.1. *October*

3.1.1. *Withdrawal of southwest monsoon*

Southwest monsoon withdrew from extreme west Rajasthan on 18 September, with a delay of 17 days from the normal date of withdrawal. It further withdrew from Madhya Pradesh (12 days delay), Orissa (10 days delay), Maharashtra (10 days delay) and northeast India (one week's delay) by 15 October. It withdrew from the entire country on 21 October 1999.

3.1.2. *Onset of northeast monsoon*

Northeast monsoon rains commenced on 21 October 1999 over Tamil Nadu & Pondicherry and Kerala and adjoining states of Karnataka and Andhra Pradesh.

3.1.3. *Storms/depressions*

During the month of October, one very severe cyclonic storm and one super cyclonic storm formed over the Bay of Bengal. Details are presented below:

(a) *Very severe cyclonic storm over the Bay of Bengal (15-19 October 1999)*

Under the influence of an upper air cyclonic circulation, a depression formed over north Andaman Sea and adjoining parts of east-central Bay and was centred at 0300 UTC of 15 near Lat. 13.5° N/Long. 92.5° E, about 200 kms north of Port Blair. It moved northwest and rapidly intensified into a cyclonic storm and lay centred at 0300 UTC of 16 near Lat. 16.0° N/Long. 88.5.0° E, about 530 kms southeast of Puri. It further intensified into a severe cyclonic storm at 1900 UTC of 16 and lay centered near Lat. 17.6° N/Long. 86.0° E. It further moved in a northerly direction and intensified into a very severe cyclonic storm at 0000 UTC of 17 and was centred at 0300 UTC of 17 near Lat. 18.0° N/Long. 85.0° E and at 1200 UTC of 17 near Lat. 19.0° N/Long. 85.0° E. It moved in a northwesterly direction and crossed Orissa coast between 1900 and 2000 UTC of 17, very close to Gopalpur. It weakened into a cyclonic storm at 0900 UTC of 18 and lay centred near Lat. 20.5° N/85.0° E about 50 kms

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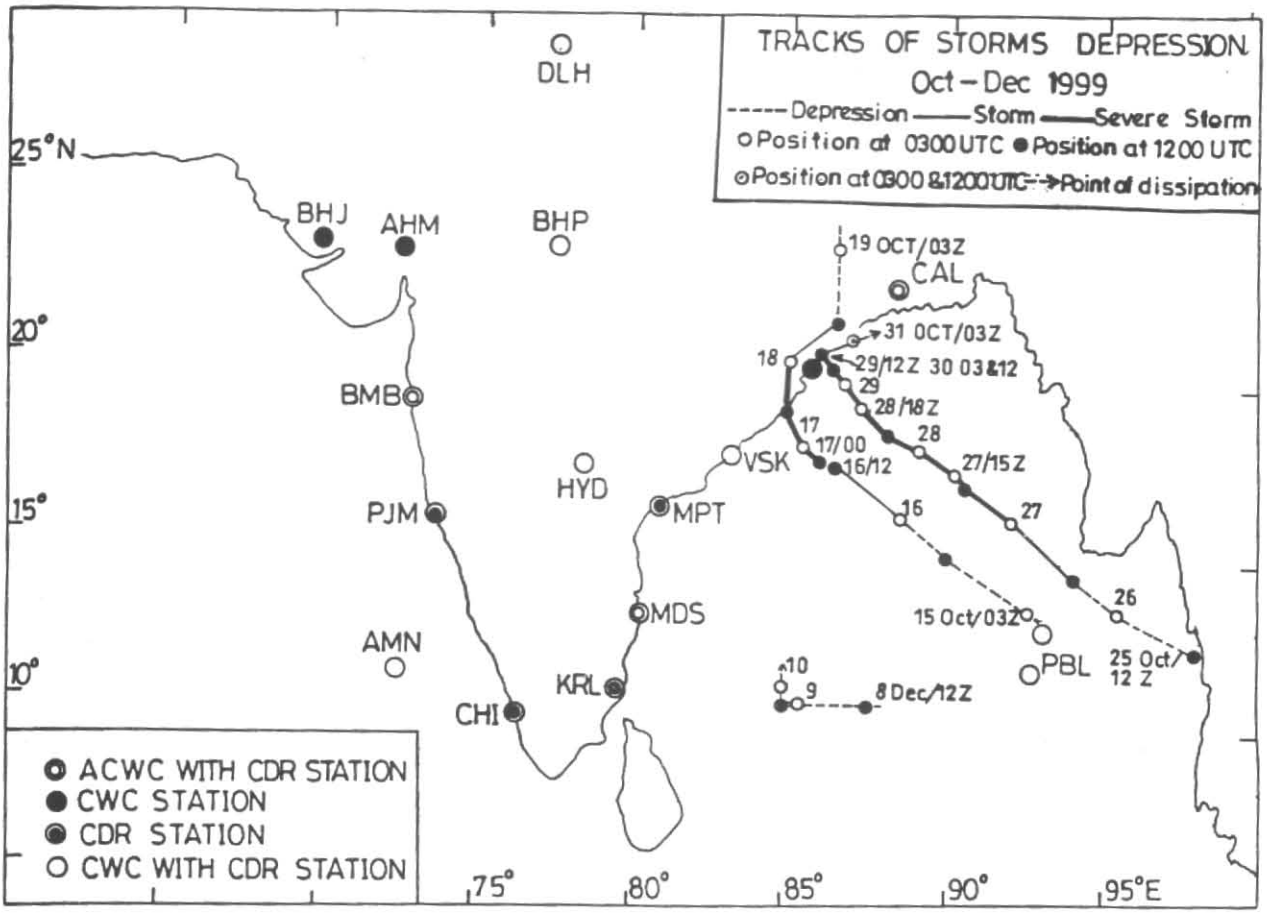

Fig.1. Tracks of the storm/depressions during October to December 1999

west of Bhubaneswar. The cyclonic storm over Orissa then moved in a northerly direction and weakened into a deep depression at 1200 UTC of 18 and lay near Lat. 21.5° N/ 86.5° E. It further weakened into a depression and lay centred near Lat. 23.5° N/86.5° E at 0300 UTC of 19, very close to Purulia. The depression then weakened into a well-marked low pressure area and lay over Bihar Plateau and adjoining Gangetic West Bengal in the evening of 19 and on 20, it became less marked. However, associated cyclonic circulation lay over Sub- Himalayan West Bengal & Sikkim and adjoining Bihar Plains and extened upto lower levels on 20 and became less marked on 21.

The maximum intensity of the system reported by ICI on Dvorak's scale was T 4.5 from 0300 of 17 to 2200 UTC of 18. ICI also showed "eye" from 2000 UTC of 16 to 0300 UTC of 17 and the "eye" was well defined at 0000 UTC and 0300 UTC of 17. In general, vortex given by ICI was consistent particularly when the system was near Orissa coast. However, available observation as given above, indicate that the maximum satellite derived intensity could be T 5.5 at the time of landfall and accordingly the estimated lowest central pressure could be less than 954.0 hPa.

Cyclone Detection Radar (CDR) Paradip reported the storm centre from 1600 UTC of 16 to 2300 UTC of 17. CDR Paradip also reported "eye" from 2200 UTC of 16 to 0000 UTC of 17. CDR Visakhapatnam reported eye from 1800 UTC of 16 to 2000 UTC of 17. Gopalpur estimated maximum wind 180/98 kts at 2000 and 2100 UTC of 17.

Widespread rainfall with heavy to very heavy falls occured over the coastal districts of Orissa on 17, 18 and 19 and over Gangetic West Bengal on 18 and 19 causing widespread waterlogging in Calcutta. Tornado was reported at Kalna (Dist. Burdwan) on 18 damaging 400 Kutcha house. Storm surge of 2 to 2.5 meters was reported at Chilka lake at the time of storm crossing the coast.

According to the reports from Relief Commissioner's Office of Govt. of West Bengal, 197 persons died, more than 8,300 cattles were lost and crops over thousand hectares of land were destroyed.

TABLE 1

Sub-divisionwise rainfall (mm) for each month and season as a whole (October-December 1999)

S. No.	Meteorological sub-divisions	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.	A & N Islands	347	320	8	110	253	-57	108	171	-37	566	744	-24
2.	Arunachal Pradesh	220	121	82	16	24	-35	2	11	-81	238	156	53
3.	Assam & Meghalaya	223	159	40	11	27	-61	2	10	-80	235	196	20
4.	Naga., Mani., Mizo. and Tri.	188	150	25	15	32	-53	16	9	81	219	191	15
5.	Sub-Himalayan West Bengal & Sikkim	226	145	56	10	17	- 43	3	6	-57	238	168	42
6.	Gangetic West Bengal	198	117	69	9	20	-53	0	3	-100	207	139	49
7.	Orissa	288	127	127	17	29	-42	0	6	-100	305	162	89
8.	Bihar Plateau	162	84	93	5	11	-57	0	5	-100	167	100	67
9.	Bihar Plains	129	64	101	4	8	-57	0	3	-100	132	75	75
10.	East Uttar Pradesh	74	48	53	0	5	-97	4	6	-34	78	59	32
11.	Plains of west Uttar Pradesh	41	35	20	0	4	-100	2	8	-79	43	47	-8
12.	Hills of west Uttar Pradesh	59	59	0	1	8	-84	12	26	-55	72	93	-23
13.	Haryana, Chandigarh & Delhi	6	19	-66	0	4	-99	0	8	-95	7	31	-78
14.	Punjab	3	22	-88	0	4	-97	0	15	-99	3	42	-93
15.	Himachal Pradesh	3	42	-92	12	14	-15	2	39	-95	17	95	-82
16.	Jammu & Kashmir	2	32	-94	56	28	97	0	55	-100	58	116	-50
17.	West Rajasthan	10	5	95	0	2	-100	0	3	-100	10	9	5
18.	East Rajasthan	23	14	67	0	4	-100	0	4	-100	23	22	5
19.	West Madhya Pradesh	88	31	178	0	14	-100	0	7	-99	88	52	68
20.	East Madhya Pradesh	72	51	42	1	12	-92	0	7	-97	74	70	5
21.	Gujarat Region	104	27	287	0	9	-100	0	2	-100	104	37	180
22.	Saurashtra & Kutch	78	16	399	0	10	-100	0	1	-100	78	26	196
23.	Konkan & Goa	175	113	55	2	25	-94	0	9	-100	177	147	20
24.	Madhya Maharashtra	172	71	140	1	29	-96	0	7	-100	173	108	60
25.	Marathwada	115	57	101	0	19	-100	0	9	-100	115	85	35
26.	Vidarbha	101	46	117	0	16	-100	0	11	-100	101	73	38
27.	Coastal Andhra Pradesh	180	191	-5	51	98	-48	1	22	-94	233	311	-25
28.	Telangana	52	76	-31	1	19	-96	0	6	-100	53	101	-47
29.	Rayalaseema	106	115	-7	46	73	-36	7	26	-73	160	214	-25
30.	Tamil Nadu	251	195	29	190	194	-2	60	88	-32	501	478	5
31.	Coastal karnataka	366	196	86	14	71	-80	2	16	-89	381	283	35
32.	North Interior Karnataka	181	97	86	0	29	-99	0	8	-100	182	135	35
33.	South interior Karnataka	301	147	104	43	52	-18	5	12	-58	349	212	64
34.	Kerala	545	297	83	71	166	-57	5	43	-88	621	506	23
35.	Lakshadweep	305	163	87	51	102	-50	49	69	-29	405	334	21

TABLE 2

Details of the weather systems during October 1999

S.No.	System	Period	Place of first location	Direction of movement	Place of dissipation	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A) *Storms*						
1	Very severe cyclonic storm	15-19	North Andaman Sea and adjoining parts of east-central Bay	Northwesterly	Sub-Himalayan West Bengal & Sikkim and adjoinng Bihar Plains	Under the influence of an upper air cyclonic circulation, a depression formed over north Andaman Sea and adjoining parts of east-central Bay and was centred at 0300 UTC of 15 near Lat. 13.5° N/Long. 92.5° E, about 200 kms north of Port Blair. It rapidly intensified into a cyclonic storm and lay centred at 0300 UTC of 16 near Lat. 16.0° N/Long. 88.5° E, about 530 kms southeast of Puri. It further intensified into a severe cyclonic storm at 1500 UTC of 16 and lay centered near Lat. 17.6° N/Long. 86.0° E. It further moved in a northerly direction and intensified into a very severe cyclonic storm and lay centered at 0000 UTC of 17 near Lat. 17.7° N/Long. 86.0° E. It moved in a north northwesterly direction and crossed Orissa coast between 1900 and 2000 UTC of 17, very close to Gopalpur. It weakened into a cyclonic storm at 0300 UTC of 18 and lay centered near Lat. 20.5° N/85.0°E about 50 kms west of Bhubaneswar. The cyclonic storm over Orissa moved in a northerly direction and weakened into a deep depression at 1200 UTC of 18 and lay near Lat. 21.5° N/86.5° E. It further weakened into a depression and lay centered near Lat. 23.5° N/86.5° E at 0300 UTC of 19, very close to Purulia. The depression weakened into a low pressure area and lay over Bihar Plateau and adjoining Gangetic West Bengal in the evening of 19 and on 20, it became less marked. However, associated cyclonic circulation lay over Sub-Himalayan West Bengal & Sikkim and adjoining Bihar Plains and extended upto lower levels on 20 and less marked on 21
2	Super cyclonic storm	25-31	Gulf of Siam and neighbour-hood	Northwesterly and then southeasterly	Northwest Bay and adjoining north Orissa-West Bengal coast	A well-marked low pressure over Gulf of Siam and neighbourhood on 24. Associated cyclonic circulation extended upto lower tropospheric levels. Moving westwards, it entered into North Andaman Sea and concentrated into a depression over North Andaman Sea and neighbourhood at 1200 UTC of 25 and lay near Lat. 12.5° N/ Long. 98.0° E. It further moved in a westnorthwesterly direction and intensified into a cyclonic storm and lay centred at 0300 UTC of 26 near Lat. 13.5° N/Long. 95.5° E, about 350 kms northeast of Port Blair. The cyclonic storm moved in a northwesterly direction and lay at 1200 UTC of 26 near Lat. 14.5° N/Long. 94.0° E, about 350 kms northnortheast of Port Blair. It further intensified into a severe cyclonic storm at 0300 UTC of 27 and lay centered near Lat. 16.0 ° N/Long 92.0° E, about 750 kms southeast of Paradip. Moving in a northwesterly directin it further intensified into a very severe cyclonic storm at 1500 UTC of 27 near Lat. 17.2° N/Long 90.3°E. It became a super cyclonic storm at 1800 UTC of 28 near Lat. 19.3° N/Long. 87.2°E. It crossed Orissa coast near Paradip on 29 between 0400 and 0530 UTC. After crossing the coast, it weakened into a very severe cyclonic storm and lay centered at 1200 UTC of 29 near Lat. 20.5° E/Long. 86.0° E, about 30 kms northeast of Bhubaneswar. It remained practically stationary and further weakened into a cyclonic storm and lay centred at 0300 UTC of 30 near Lat. 20.5° N/ Long. 86.0° E, very close to Bhubaneswar and into a depression at 0300 UTC of 31 near Lat. 21.0° N/ Long. 87.0° E, when it was very close to Chandbali. Moving in a southeasterly direction it again entered into the Sea and weakened into a well-marked low pressure area over northwest Bay and adjoining parts of north Orissa-West Bengal coast in the evening of 31. The low pressure area became less marked on 5 November near coastal Andhra Pradesh and neighbourhood.

TABLE 2 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**B**) *Cyclonic circulations*						
1	Mid tropospheric levels	1-12	Tamil Nadu and neighbourhood	Quasi-stationary	Tamil Nadu and adjoining parts of Kerala	It lay as an extended cyclonic circulation over Tamil Nadu and adjoining parts of Kerala from 6. A tough in easterlies from this system was seen upto west Madhya Pradesh in the lower tropospheric levels from 4 to 6. Another trough from this system seen to north Maharashtra coast in the lower tropospheric levels from 7 to 12 and became less marked on 13
2	Lower tropospheric levels	2-7	Pakistan & neighbourhood	Northeasterly	Haryana and neighbourhood	Moved away across Himachal Pradesh
3	Mid tropospheric levels	3-6	Karnataka coast and neighbourhood	Westerly	Tamil Nadu and adjoining parts of Kerala	It merged with the cyclonic circulation over Tamil Nadu and adjoining parts of Kerala on 6
4	Do	6-8	Northwest Madhya Pradesh and adjoining parts of east Rajasthan	Northeasterly	Plains of Uttar Pradesh and neighbourhood	The cyclonic circulation became less marked on 8. However, a trough extending upto mid tropospheric levels ran from east Uttar Pradesh to south Gujarat Region on 8 and became less marked on 9
5	Lower tropospheric levels	7-10	South Pakistan and neighbourhood	Eastnortheasterly	South Pakistan and adjoining west Rajasthan	
6	Do	9-16	Southwest Bay off Tamil Nadu coast	Northeasterly	Coastal Orissa	It merged with the cyclonic storm centered near Lat. 16.0° N/Long. 88.5° E, about 530 kms southeast of Puri. It tilted southwards with height on 11
7	Do	11-13	Northwest Rajasthan and neighbourhood	Northeasterly	Haryana and neighbourhood	Moved away northeastwards across Himachal Pradesh
8	Do	12-13	East-central and adjoining parts of northeast Arabian Sea	Stationary	*In situ*	
9	Mid tropospheric levels	13-14	Saurashtra and Kutch	Quasi-stationary		
10	Lower tropospheric levels	13 -16	West Rajasthan and adjoining Pakistan	Northeasterly	Punjab and neighbourhood	Moved away across hills of west Uttar Pradesh
11	Do	18-27	Tenasserim coast and adjoining north Andaman Sea	Westsouth-westerly	South interior Karnataka and neighbourhood	
(**B**) *Troughs*						
1	Trough in mid and upper air tropospheric westerlies	2 -3	Long. 65°E, north of Lat. 20° N	Stationary	*In situ*	
2	Lower tropospheric levels	14-25	Karnataka to Kerala coast	Stationary	*In situ*	Merged with the cyclonic circulation over north Tamil Nadu and adjoining Kerala
3	Do	27-28	Centre of the cyclone (Lat. 16.0° N/Long. 92.0° E) to south Konkan and Goa across south coastal Andhra Pradesh	Do	Do	

TABLE 3

Details of the weather systems during November 1999

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	Well-marked low pressure area	20 - 25	Southwest Bay off north Sri Lanka-Tamil Nadu coast	Westerly	East-central and adjoining southeast Arabian Sea off Karnataka coast	The well- marked low pressure area formed under the influence of the upper air cyclonic circulation which was a remnant of Super Cyclone (25-31 October) associated cyclonic circulation extended upto mid tropospheric levels
(B) *Western disturbances*						
1	As an upper air system	12 - 16	North Pakistan and neighbourhood	Northeasterly	Jammu & Kashmir and neighbourhood	Moved away northeastwards
2	Do	18 - 20	North Pakistan and adjoining parts of Jammu & Kashmir	Do	Do	Do
3	Do	22 - 26	North Pakistan	Do	Eastern parts of Jammu & Kashmir, Himachal Pradesh and neighbourhood	Do
4	Do	26 - 28	Western parts of Jammu & Kashmir and adjoining parts of Pakistan	Do	Jammu & Kashmir	Do
5	Do	28 - 30	Northern parts of Jammu & Kashmir and adjoining parts of Pakistan	Do		Do
(C) *Cyclonic circulations*						
1	Low tropospheric levels	4 - 6	North Pakistan and adjoining parts of west Rajasthan	Northeastwards	Punjab and neighbourhood	
2	Do	5 - 10	Gulf of Siam	Do	Tenasserim coast and adjoining Andaman Sea	
3	Mid tropospheric levels	6 - 8	North Pakistan and neighbourhood	Do	Punjab and neighbourhood	Moved away across Himachal Pradesh
4	Lower levels	10 - 11	Northwest Rajasthan	Stationary	*In situ*	
5	Do	16 - 17	South Andaman Sea	Quasi stationary	Southeast and adjoining southwest Bay	It merged with the cyclonic circulation which was a remnant of the super cyclonic storm over southeast Bay and adjoining southwest Bay
6	Mid tropospheric levels	22 - 23	Lakshadweep area and neighbourhood	Stationary	*In situ*	Merged with the well-marked low pressure area over Lakshadweep and neighbourhood
7	Lower tropospheric levels	26 - 27	Bihar Plains	Do	Do	
(D) *Troughs*				Do	Do	
1	Lower levels	20 - 22	Karnataka coast to Commorin area			
2	Trough of low (on sea level chart)	25 Nov-1 Dec	East-central Bay and adjoining southeast Bay	Westerly	Southwest Bay off Tamil Nadu coast	
3	Do	25 - 26	Lat. 10°N/ Long. 68°E East Arabian to north Maharashtra coast	Stationary	*In situ*	

TABLE 4

Details of the weather systems during December 1999

S.No. (1)	System (2)	Period (3)	Place of first location (4)	Direction of movement (5)	Place of dissipation (6)	Remarks (7)
(A) *Depression*						
1	Depression	8 - 10	Southern parts of Gulf of Siam with its central region near Lat.8.5° N/Long. 100.5°E	Westerly	Southwest Bay off south Tamil Nadu-Sri Lanka coast	A well-marked low pressure area formed over southeast and adjoining east-central Bay on 8. It concentrated into a depression on 8 evening and lay centred at 1200 UTC of 8 near Lat. 10.5° N/Long. 87.5°E,about 800 kms east of Nagapattinam. It moved in a westerly direction and lay centered at 0300 UTC of 9 near Lat. 10.5°N/Long. 85.5°E about 600 kms east of Nagapattinam. It remained practically stationary and then moved in a north westerly direction and lay centred at 0300 UTC of 10 near Lat. 11.0°N/ Long. 85.0°E. It weakened into a well marked low pressure area over southwest Bay and neighbourhood on 10 evening.
(B) *Low pressure/well-marked low pressure areas*						
1	Well-marked low pressure area	30 Nov-9 Dec	Lakshadweep area and neighbourhood	Northwesterly	North Somalia coast	It was first seen as a trough of low pressure area on sea level chart over Laksfhadweep area on 29. It became low pressure area over the same area on 30 and became well-marked on 1 December over southeast Arabian Sea and neighbourhood. Associated cyclonic circulation extended upto mid tropospheric level
(C) *Western disturbances*						
1	As an upper air system	30 Nov - 2 Dec	North Pakistan and adjoining Jammu & Kashmir	Northeasterly	Jammu & Kashmir and neighbourhood	Moved away northeastwards
2	Do	4 - 5	Central Pakistan and neighbourhood	Do	Jammu & Kashmir	Moved away across Jammu & Kashmir
3	Do	7 - 9	North Pakistan and neighbourhood	Do	Jammu & Kashmir and neighbourhood	Moved away across northeastwards
4	Do	16 - 20	Do	Do	Do	Do
5	Do	29 - 30	Northern parts of Jammu & Kashmir	Do	Do	Do
(D) *Induced cyclonic circulations*						
1	Lower tropospheric levels	7 - 9	East Rajasthan and neighbourhood	Easterly	Bihar Plains and neighbourhood	
(E) *Other cyclonic circulations*						
1	Lower tropospheric levels	4 - 6	Lakshadweep area and adjoining parts of southeast Arabian Sea	Quasi-Stationary	Southeast Arabian Sea and neighbourhood	
2	Do	12 - 14	Eastern parts of Gulf of Siam	Do	Southearn parts of Gulf of Siam	
(F) *Troughs in westerlies*						
1	Mid and upper troposphere	11 - 12	Bihar Plains to north coastal Andhra Pradesh	Stationary	*In situ*	
2	Do	18 - 20	Long. 68°E, north of Lat. 20°N	Quasi Stationary	Do	
(G) *Troughs in easterlies*						
1	Lower tropospheric levels	15 - 16	South Karnataka to south Kerala coast	Stationary	Do	
(H) *Other troughs*						
1	Lower levels	6 - 8	Southwest Bay off Sri-Lanka coast	Do	Do	
2	Lower tropospheric levels	18 - 24	South Karnataka to south Kerala coast	Do	Do	
3	Lower levels	21 - 27	Southwest Bay Tamil Nadu coast	Do	Do	
4	Lower tropospheric levels	26 - 29	South Karnataka coast to south Kerala coast	Do	Do	
5	Trough of low	29 Dec - 1 Jan 2000	Southwest Bay Tamil Nadu- Sri Lanka coast	Do	Do	

TABLE 5

Principal amounts of rainfall (cms) (3 cms and above)

Date (1)	October (2)	November (3)	December (4)
1	Bahraich, Sarotari & Lakhatar 10 each, Bangalore & Kalyandurg 9 each, Chitradurga 8, Karjat, T.G. Halli & Minicoy 7 each, Hindpur & Laxmeshwara 6 each, Varanasi, Kadana Dam, Rajkot, Bhira, Gaganbawda & Koppal 5 each, Port Blair, Passighat, Miao & Kakinada 4 each, Beki Road Bridge, Chottabekra, Khowang, New Kandla, Mahabaleshwar, Bhimavaram & Panchegda 3 each	Sandheads 3	Nil
2	Raebarely 13, Malegaon & Tiptur 10 each, Dalmau 9, Dhule 7, Badami 6, Calcutta, Nasik & Paltan 5 each, Gangtok & Bhimavaram 4 each, Uttarkashi, Ajmer ,Chiplun, Bhira , Mumbai, Nagpur, Kunavaram, Belgaum, Shimoga, Chickmagalur & Piravon 3 each	Kalingapatnam 5, Car Nicobar 4, Sriniketan 3	Vedaranniyam 9,
3	Bhuj 12, Regoli 11, Akola 7, Gorakhpur & Jodia 7 each, Machilipatnam & Gulbarga 6 each, Dehra Dun, Dohad & Chickmagalur 5 each, Kondul ,Purulia, Varanasi, Rajkot, Pandharpur & Kuppady 4 each, Bihubar, Pune, Mudibidere & Agumbe 3 each	Kakinada 7, Guwahati 4	Karaikal 6, Kochi & Minicoy 3 each
4	Kankavali & Guledgud 12 each, Ausa 10, Punjim 9, Nilanga & Khanapura 7 each, Jamshedpur & Hospet 6 each, Katerniaghat, Bhakhudar & Sinor 5 each, Chottabekra, Jalpaiguri, Kodaikanal & Udupi 4 each, Banbasa, Kolhapur & Konni 3 each	Aska & Karaikal 4 each	Nil
5	Eligen Bridge & Karaikal 10 each, Dharampur, Madurai, Coimbatore & Hassan 9 each, Uppinangaddy 8, Dhond & Gokak 6 each, Udgir & Tada 4 each, Nancowry, Khamba, Panjim, Katol & Satyavedu 3 each	Banihal 6, Kanakapura 4, Car Nicobar 3	Nil
6	Chennai 12, Sandheads & Alapuzha 9 each, Namsai 6, Kakinada & Satyavedu 5 each, Manas N.H.X-ing, Cooch Behar & Jaipur 4 each , Bahraich, Ratnagiri & Belgaum 3 each	Banihal 8, Pamban 7	Port Blair 3
7	Cherrapunji 15, Nagpur & Khanapura 12 each, Coimbatore 10, Joshimath & Haliyal 9 each, Karad 8, Kamareddy & Indore 4 each, Baghdogra & Kankavali 3 each	Mangalore 4, Car Nicobar & Mandya 3 each	Port Blair 3
8	Mumbai 13, Karimganj 11, Palsana 8, Wai 7, Pendra 6, Belthangady & Hidkal Dam 4 each, Kailashshahar, Paradip, Seoni, Manora, Machilipatnam, Palmner & Sringeri 3 each	Nil	Port Blair 3
9	Itanagar 12, North Lakhimpur 11, Chikhli 7, Nasik & Akola 5 each, Ongole, Tiruchirapalli & Hubli 4 each, Pendra 3	Hut Bay 3	Port Blair 8
10	Pune 11, Bardoli 9, Khokar 6, Mumbai 5, Umrala 4, Kampur & Pandharkwada 3 each	Nil	Nil
11	Nanipalsan 18, Pune 11, Sringeri 9, Kondul Karwar & Punalur 6 each, Bhachau, Gangtok, Shajapur & Minicoy 5 each, Dahanu, 3	Nil	Nil
12	Latur 11, Ahwa 9, New Kandla 7, Mount Abu 6, Gulbarga 5, Peermade 4, Kondul, Dahanu & Parola 3 each	Car Nicobar 4	Nil
13	Pathardi 11, Rampur, Ausa & Alapuzha 9 each, Bhachau 8, Bangalore 6, Gadag 3	Nil	Cuddalore 12, Pondicherry 4
14	Punalur 9, Calcutta 6, Pune & Minicoy 5 each, Buldhana & Mangalore 4 each, Coimbatore 3	Konni 7	
15	Kottayam 11, Berhampore & Gadhinglaj 6 each, Kavali & Palayamkottai 5 each, Kondul, Bhubaneswar, Jamshedpur, Belgaum & Tirupathi 3 each	Nil	Pondicherry 11
16	Kavali & Kottayam 11 each, Mangalore 8, Agartala 7, Daitari 6, Anandpur 5, Amini Divi 4, gulbarga 3	Nil	Nil
17	Kalinga 21, Puri 9, Sompeta 8, Alapuzha 7, Hut Bay 5, K.Paramathy 4, Shillong, Panjim, Tekra, Karwa & Mysore 3 each	Nil	Nil
18	Berhampore 39, Kavali 31, Purushottampur 25, Sandheads 15, Cooch Behar & Parambikulam 11 each, Ramgarh 9, Hut Bay & Guwahati 5 each, Tirupattur 4, Seppa & Proddater 3 each	Hut Bay 5, Vedaranniyam 4	Nil
19	Jhumpura 16, Darjeeling & Jamshedpur 12 each, Tikarpara 11, Bankura & Jamsolaghat 10 each, Keojhargarh & Rengali 9 each, Thodupuzha 7, Daporijo & Shillong 6 each, Port Blair & Amini Divi 5 each, Tirupathi & Tiruttani 4 each	Vedaranniyam 6	Maya Bandar 3
20	Hut Bay, Cooch Behar, Gangtok, Taliparamba & Kozha 10 each, Darjeeling, Malda, Inamachel & Thodupuzha 9 each, Seppa, Baghdogra & Jalpaiguri 8 each, Quilandy 7, North Lakhimpur, Rajghat & Adirampattinam 5 each	Vedaranniyam 9, Thiruvalla 5	Nil
21	Nagapattinam, Alapuzha & Haripad 10 each, Kondul, Imphal & Surada 6 each, Mangalore 4, Amini Divi 3	Karaikal 9, Nagapattinam 8, Thanjavur 7, Nellore & Alapuzha 5 each	Nil
22	Sandheads & Bhograi 5 each, Rajghat & Visakhapatnam 4 each, Cuddalore 3	Tiruchirapalli 31, Thanjavur 20, Adirampattinam 14, Punalur 12, Cuddalore 10, K Paramathy 9, Kodaikanal 8, Karaikal & Madurai 7 each, Tirupathi 5	Chennai 6
23	Chitradurga 8, Nagapattinam 6, Sandheads 5, Shirali 4, Gopalpur 3	Palayamkottai 12, Mandya 5, Nellore 4	Vellore 4, Cuddalore 3
24	Digha & Gannavaram 6 each, Baripada, Bellary & Punalur 4 each, Valparai & Mudibidere 3 each	Adirampattinam 3	Nil
25	Kakinada & Dharamapuri 14 each, Thodupuzha 13, Kondul, Champua & Mysore 6 each, Karkala 5	Nil	Nil
26	Palaya 10, K.R.Sagara, Srirangapattanam & Chitradurga 7 each, Munnar 6, Port Blair, Kamakhyanagar, Tiruchirapalli, Athani & Palakkad 5 each, Mangalore 4	Nil	Nil

TABLE 5 (*Contd.*)

(1)	(2)	(3)	(4)
27	Maya Bandar 7, Bagalkote 5, Somwarpet & Bijapur 4 each, Rayagada, Satara & Kodaikanal 3 each	Pamban & Kottayam 3 each	Nil
28	Mangalore 9, Gouribindanur 8, Panambur 7, Sankeshwara 6, Kondul 5, Hut Bay 4, Angaipuram 3	Nellore & Karaikal 6 each	Nil
29	Mudigere & Hosdurg 11 each, Bantwal & Udala 9 each, Port Blair, Panambur & Mangalore 7 each, Salem 5, Balasore 4, Bhubaneswar 3	Parangipettai 8, Nellore & Tirupati 4 each, Bangalore 3	Nil
30	Bhubaneswar 43, Anandpur 40, Akhuapada 36, Cuttack 25 ,Alapuzha 6, Car Nicobar & Dibrugarh 3 each	Vedaranniyam 10, Kanyakumari 7, Alapuzha 5, Kondul 4	Nil
31	Chandbali 36, Anandpur 30, Puri 11, Bhubaneswar 10, Balasore 9, Port Blair 3		Nil

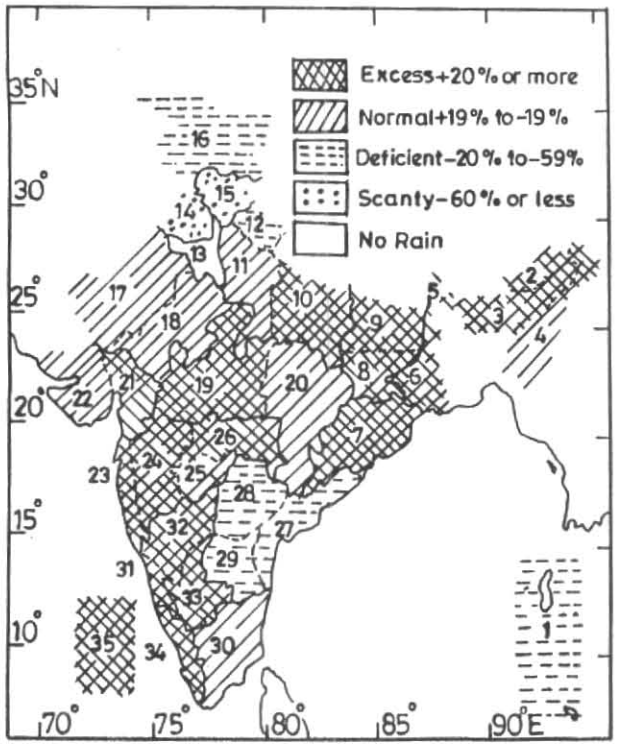

Fig.2. Sub-division wise rainfall departures from normal (percentage), for Post monsoon season (Oct-Dec) of 1999. Sub-divisions are indicated by numbers on the map.
(1) - 24, (2) + 53,(3) + 20, (4) + 51,(5) + 42, (6) + 49 (7) + 89, (8) + 67, (9) + 75, (10) + 32, (11) -8, (12) - 23,(13) - 78, (14) - 93, (15) - 82, (16) -50, (17) +5, (18) +5, (19) + 68, (20) +5 , (21) + 180, (22) + 196, (23) + 20, (24) +60, (25) + 35, (26) + 38, (27) – 25, (28) –47, (29) - 25, (30) +5, (31) + 35, (32) + 35, (33) + 64, (34) + 23, (35) + 21

Exceptionally heavy rainfall reported (cms) are given below:

18 October 1999: Coastal Andhra Pradesh : Kaviti 32, Itchhapuram 30, Kanchili 18, Sompeta 16 and Mandasa 12. West Bengal & Sikkim: Manmathnagar 20, Alipore 12 and Cooch Behar 11.

(b) *Super cyclonic storm over the Bay of Bengal (25-31 October 1999)*

A well-marked low pressure area lay over Gulf of Siam and neighbourhood on 24. Associated cyclonic circulation extended upto lower tropospheric levels. Moving westwards, it concentrated into a depression over North Andaman Sea and neighbourhood at 1200 UTC of 25 and lay near Lat. 12.5° N/Long. 98.0° E. It further moved in a westnorthwesterly direction and intensified into a cyclonic storm and lay centered at 0300 UTC of 26 near Lat. 13.5° N/Long. 95.5° E, about 350 Kms northeast northeast of Port Blair, and at 1200 UTC of 26 near Lat. 14.5° N/Long. 94.0°E. It further intensified into a severe cyclonic storm at 0300 UTC of 27 and lay centered near Lat. 16.0° N/Long. 92.0° E, about 750 kms southeast of Paradip. It further moved in a northwesterly direction and lay at 1200 UTC of 27 near Lat. 17.0° N/Long. 90.5° E. It further intensified into a very severe cyclonic storm at 1500 UTC of 27 near Lat. 17.2° N/Long 90.3° E. At 0300 UTC of 28, it was centred near Lat. 18.0° N/Long. 89.0° E and 1200 UTC of 28 near Lat. 18.5° N/Long. 88.0°E. It became a **super cyclonic storm** at 1800 UTC of 28 near lat. 19.3° N/Long. 87.2° E. AT 0300 UTC of 29 it was near Lat. 19.9° N/Long. 86.7° E. It crossed Orissa coast near Paradip on 29 between 0400 and 0530 UTC. After crossing the coast, it weakened into a very severe cyclonic storm and lay centred at 1200 UTC of 29 near Lat. 20.5° N/Long. 86.0° E, about 30 kms northeast of Bhubaneswar. It remained practically stationary and further weakened into a cyclonic storm and lay centred at 0300 UTC of 30 near Lat. 20.5° N/Long. 86.0°E, very close to Bhubaneswar. It, then, weakened into a depression at 0300 UTC of 31 near Lat. 21.0° N/Long. 87.0°E, when it was very close to Chandbali. Moving in a southeasterly direction, it again entered into the Sea and weakened into a well-marked low pressure area over northwest Bay and adjoining parts of north Orissa-West Bengal coast in the evening of 31. The low pressure area became less marked on 5 November near coastal Andhra Pradesh and neighbourhood.

The intensity of the system was reassessed to T 7.0 from 1800 UTC of 28 to 0300 UTC of 29. The lowest estimated central pressure was 912 hPa from 1800 UTC of 28 till the storm crossed the coast. It is the most intense storm of its kind with T 7.0 as assessed on D'voraks scale with INSAT Cloud Imagery. The earlier storm of T 7.0 was Andhra Cyclone 14-20 November 1977 where the intensity

was assessed on D'voraks scale with the help of NOAA satellite.

The maximum wind of northeasterly/80 kts was recorded by Paradip at 0300 UTC of 29. Later, the wind instrument went out of order. Puri reported a maximum estimated wind of southwesterly / 95 kts at 0700 UTC of 29. According to Touring Officers Report, storm surge of 9 m above astronomical tide was reported at Paradip from 0630 to 1600 hrs (IST) on 29 October 1999. Storm surge penetrated into the land and there was a tidal inundation upto 35 kms from coast.

Based on ICI, the maximum sustained wind speed was estimated to be of the order of 140 kts (252 kmph) at 281800 UTC corresponding to T 7.0. The post cyclone survey information from available sources revealed that a storm surge of 9 mtrs above astronomical tide occurred at Paradip at the time of landfall on 29. However, the sea water inundation at CDR Paradip revealed that the storm surge near Paradip could be of the order of 7 mtrs. This observation is close to the prediction made by IMD. Storm surge penetrated into the land and there was a tidal inundation upto 35 kms from coastline.

CDR Paradip reported radar centres and "eye" from 0800 UTC of 28 to 0200 UTC of 29. CDR Paradip also reported RMR (Radius of Maximum Reflectivity) as 10 km at 0100 UTC and 0200 UTC of 29. Radar centres reported by CDR Paradip and vortices reported by ICI agreed very well helping to fix the centres accurately.

As the system was of unprecedented intensly, it caused very heavy damage and devastation along the coastal districts of Orissa and adjoining districts in West Bengal.

Widespread rainfall with heavy to very heavy falls and also with exceptionally heavy falls occurred over coastal Orissa and West Bengal on 29, 30 and 31 October. Exceptionally heavy and very heavy rainfall reported (cms) are as follows.

30 October 1999: Bhubaneswar 43, Anandpur 40, Akhuapada 36, Jenapur 26, Balasore, Naraj 21 each, Balimundali & Jaypur 20 each and Puri 18.

31 October 1999: Anandpur 30, Akhuapada 17, Jenapur 13, Puri 12 and Bhubaneswar 10.

According to the information received from the State Relief commissioner, Bhubaneswar, (*i*) The total persons died were 9885, (*ii*) The number of persons injured were 2142 and (*iii*) The crops over more than 1 lakhs hectares were damaged.

According to the press reports, damage caused in the districts of Orissa are:

Area affected	*Casualties/damage*	*Source*
Jagatsinghpur	8119 people died. More than 1 lakh cattle heads perished.	
Cuttack	381 people died. 44,000 cattle heads perished.	
Puri	287 people died. 47,000 cattle heads perished.	The New India Express dated 14 November 1999
Kendrapada	242 people died. 24,000 cattle heads perished.	
Jajpur	125 people died.	
Khurda	147 people died.	
Dhenkanal	50 people died.	
Keonjhargarh	27 people died.	
Mayurbhanj	7 people died.	
Narayanganj	3 people died.	
Over 12.48 lakhs houses were damaged. Paddy crops in 13.87 lakhs hectares were affected. Property worth Rs. 1.2 crore was damaged in Balikuda-Nuagaon blocks of Jagatsinghpur dist.		

According to the press reports, damage caused in the districts of West Bengal were:

Area affected	*Casualties/damage*	*Source*
Chandipur	10,000 people affected.	Anandbazar Pratidin dt. 30 October 1999 Bartaman dt. 31 October 1999
District south 24 Paraganas	100 houses damaged, two children died.	
Tamluk & Kontai	250 fishermen missing, who later on returned.	Anandbazar Pratidin dt..31 October 1999
District Midnapore - Sunderban	Many houses damaged, 50 persons injured.	Anand Bazar Pratidin dt. 31 October 1999.

3.1.4. *Weather and associated synoptic features*

Table 2 gives details of synoptic features for the month of October 1999.

Southwest monsoon was vigorous (rainfall more than 4 times the normal with minimum 8 cm along the west coast and 5 cm elsewhere in atleast two stations in the sub-division) on 3 days in Madhya Maharashtra and on 1 to 2 days in west Madhya Pradesh, Konkan & Goa, Marathwada, coastal Andhra Pradesh, Tamil Nadu, Karnataka and Kerala. It was active (rainfall more than 1.5 to 4 times the normal with minimum 5 cm long the west coast and 3 cm elsewhere in atleast two stations in the sub-division) on 6 to 8 days in interior Karnataka and Kerala; on 3 to 4 days in Konkan & Goa and coastal Karnataka and on 1 to 2 days in Assam & Meghalaya, West Bengal & Sikkim, Bihar, hills of west

Uttar Pradesh, east Madhya Pradesh, Gujarat State, Madhya Maharashtra, coastal Andhra Pradesh and Tamil Nadu.

Northeast monsoon was vigorous on 1 day in coastal Andhra Pradesh and was active on 4 days in Kerala and on 1 day in coastal Andhra Pradesh.

Heavy (rainfall amounts more than 6.5 cms and less than 12.5 cms over one or two stations in the sub-division) to very heavy (rainfall amount more than 12.5 cms over one or two stations in the sub-division) rainfall occurred on 5 to 6 days in Orissa and Kerala and on 1 to 3 days in Gangetic West Bengal, plains of Uttar Pradesh, Gujarat Region, Konkan & Goa, coastal Andhra Pradesh, Tamil Nadu and coastal & south interior Karnataka. Heavy rainfall also occurred on 6 to 8 days in Gujarat Region, Madhya Maharashtra, Tamil Nadu and Karnataka ; on 3 to 5 days in West Bengal & Sikkim, east Uttar Pradesh, Vidarbha and Kerala and on 1 to 2 days in Assam & Meghalaya, Bihar, plains of west Uttar Pradesh, west Madhya Pradesh, Saurashtra & Kutch, Konkan & Goa, Marathwada and coastal Andhra Pradesh.

3.1.5. *Monthly rainfall*

Monthly rainfall was excess in 26, normal in 4, deficient in 1 and scanty in 4 meteorological sub-divisions. Rainfall was normal in Andaman & Nicobar Islands, hills of west Uttar Pradesh, coastal Andhra Pradesh and Rayalaseema and was excess over the rest of the meteorological sub-divisions outside Haryana, Punjab, Himachal Pradesh and Jammu & Kashmir where it was scanty. The rainfall was deficient in Telangana. The significant amounts of rainfall (cm) during the month are given in Table 5.

3.1.6. *Temperature*

Day temperatures were markedly above normal (departure from normal temperature is +5° C to +6° C) on 1 or 2 days in some parts of Himachal Pradesh, Jammu & Kashmir, west Rajasthan and Saurashtra & Kutch and were appreciably above (departure from normal is +3° C to +4° C) normal on many days in Himachal Pradesh and Jammu & Kashmir and on few days in Arunachal Pradesh, Assam & Meghalaya, Punjab, Rajasthan, Saurashtra & Kutch and Konkan & Goa. They were markedly below (departure from normal temperature –5° C to –6° C) normal on 3 to 5 days in Arunachal Pradesh, Assam & Meghalaya and Sub-Himalayan West Bengal & Sikkim and on 1 to 2 days in Orissa, Bihar, west Rajasthan, hills of west Uttar Pradesh, west Madhya Pradesh, Gujarat Region, Saurashtra, Rayalaseema, Tamil Nadu and south interior Karnataka.

The month's highest maximum temperature in the plains of the country was 41° C recorded at Barmer (Rajasthan) on 18 October 1999.

Night temperatures were appreciably below normal (departure from normal temperature is -3° C to -4° C) on 7 to 9 days in some parts of Punjab, Gujarat Region and Madhya Maharashtra. They were appreciably above normal on many days in some parts of Assam & Meghalaya, Manipur, plains of Uttar Pradesh, north Rajasthan, north Madhya Pradesh and Gujarat Region.

The month's lowest minimum temperature in the plains of the country was 11° C recorded at Karnal (Haryana) on 23, 25 to 27 and 29 October 1999.

3.1.7. *Disastrous weather events and associated damages*

Apart from the damages caused due to two cyclonic storms, 68 people (14 in Kerala, 22 in Karnataka, 6 in Bihar and 26 in Uttar Pradesh) died due to incessant heavy rain, lightning and floods etc. Properties worth crores of rupees were damaged.

3. 2. *November*

3. 2.1. *Storms/depressions*

No storm or depression formed during the month.

3.2.2. *Weather and associated synoptic features*

Details of synoptic features for the month of November 1999 are given in Table 3. Northeast monsoon was vigorous on 1 to 2 days in Rayalaseema and Tamil Nadu. It was active on 5 days in Tamil Nadu and on 1 to 3 days in Rayalaseema and Kerala. Heavy to very heavy rainfall occurred on 2 days in Tamil Nadu. Heavy rainfall also occured on 6 days in Tamil Nadu and on 1 to 2 days in Gangetic West Bengal, Orissa, Jammu & Kashmir, coastal Andhra Pradesh and Kerala.

3.2.3. *Monthly rainfall*

Monthly rainfall was excess in 1, normal in 3, deficient in 12 and scantly in 11 meteorological sub-divisions. There was no rain in the remaining 8 meteorological sub-divisions. It was excess in Jammu & Kashmir, normal in Himachal Pradesh, Tamil Nadu and south interior Karnataka and deficient in Andaman & Nicobar Islands, Arunachal Pradesh, Nagaland, Manipur, Mizoram & Tripura, West Bengal & Sikkim, Orissa, Bihar, coastal Andhra Pradesh, Rayalaseema, Kerala and Lakshadweep. It was scanty over the rest of the country outside plains of west Uttar Pradesh, Rajasthan, west Madhya Pradesh, Gujarat State, Marathwada and Vidarbha where there was no rain. The significant amounts of rainfall (cm) during the month are given in Table 5.

3.2.4. *Temperature*

Night temperatures were appreciably below normal on a few days in Orissa, Punjab, Rajasthan and east Madhya Pradesh and were below normal on many days in Orissa, Punjab, Rajasthan, Madhya Pradesh, Gujarat State, Madhya Maharashtra and Andhra Pradesh. They were appreciably above normal on few days in Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, West Bengal & Sikkim, Uttar Pradesh, Himachal Pradesh, Jammu & Kashmir, Rajasthan, west Madhya Pradesh and interior Karnataka.

Month's lowest minimum temperature in the plains of the country was 5.1° C recorded at Amritsar (Punjab) on 27 November 1999.

3.2.5. *Disastrous weather events and associated damages*

According to press reports, heavy rains took a toll of 37 human lives (24 in Kerala and 13 in Tamil Nadu) due to heavy rains and floods. 45,000 people rendered homeless due to heavy rains and floods in Tamil Nadu. Properties worth crores of rupees were damaged.

3.3. *December*

3.3.1. *Storms/depressions*

Only one depression formed during the month.

(a) *Depression over the Bay of Bengal (8-10 December 1999)*

A well-marked low pressure area formed over southeast and adjoining east-central Bay on 8. It concentrated into a depression on 8 evening and lay centred at 1200 UTC of 8 near Lat. 10.5° N/Long. 87.5° E, about 800 kms east of Nagapattinam. It moved in a westerly direction and lay centred at 0300 UTC of 9 near Lat. 10.5° N/Long. 85.5° E, about 600 kms east of Nagapattinam. It remained practically stationary and then moved in a northwesterly direction and lay centred at 0300 UTC of 10 near Lat. 11.0° N/Long. 85.0° E. It weakened into a well marked low pressure area over southwest Bay and neighbourhood on 10 evening.

Maximum intensity of T 1.5 was reported by INSAT Cloud Imageries from 1200 UTC of 8 to 0300 UTC of 10.

As it did not cross the coast, no damages and adverse weather were reported.

3.3.2. *Weather and associated synoptic features*

Table 4 gives the details of synoptic features for the month of December 1999.

Northeast monsoon was vigorous on 1 day in Tamil Nadu. Heavy rain occured on 4 days in Tamil Nadu and on 1 day in Rayalaseema.

3.3.3. *Monthly rainfall*

Monthly rainfall was excess in 1, deficient in 7 and scanty in 12 meteorological sub-divisions. There was no rain in the remaining 15 meteorological sub-divisions.

Rainfall was excess in Nagaland, Manipur, Mizoram & Tripura; deficient in Andaman & Nicobar Islands, Sub-Himalayan West Bengal & Sikkim, east Uttar Pradesh, hills of west Uttar Pradesh, Tamil Nadu, south interior Karnataka and Lakshadweep and was scanty in Arunachal Pradesh, Assam & Meghalaya, plains of west Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, Madhya Pradesh, coastal Andhra Pradesh, Rayalaseema, coastal Karnataka and Kerala. There was no rain over the rest of the 15 sub-divisions. The significant amounts of rainfall (cm) during the month are given in Table 5.

3.3.4. *Temperature*

Cold wave conditions (temperature departure from normal minimum temperature is – 5° C to – 6° C over the regions where mean normal temperature is more than or equal to 10° C and – 3° C to – 4° C where mean normal minimum temperature is less than 10° C) prevailed on few days in some parts of Haryana, Punjab, Himachal Pradesh, Jammu & Kashmir, Rajasthan, Gujarat Region and of Madhya Maharashtra. Night temperatures were below normal on many days in some parts of Orissa, Punjab, west Madhya Pradesh, Gujarat Region, Madhya Maharashtra, Marathwada, Vidarbha, Andhra Pradesh and north interior Karnataka and were above normal on a few days in some parts of Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, West Bengal & Sikkim, Orissa, south Gujarat Region, Marathwada and interior Karnataka.

Month's lowest minimum temperatures over plains of the country was -0.8° C recorded at Churu (Rajasthan) on 25 December 1999.

3.3.5. *Disastrous weather events*

According to press reports, 5 people died in Bihar due to cold wave.