MAUSAM, 52, 3 (July 2001), 609-644

Weather in India

MONSOON SEASON (June to September 2000)*

1. Introduction

Rainfall during the monsoon 2000 was excess (percentage departure from normal rainfall is 20% or more) in 5 and normal (percentage departure from normal rainfall is between 19% to –19%) in 23 met-sub-divisions. No meteorological sub-division received scanty (percentage departure from normal rainfall is between –60% to –99%) rainfall during the season. During the season, no cyclonic storm formed. However, two depressions formed, one over the ocean (August) and another over the land (September) in the season. June and July were devoid of depressions. Similarly, there were only two depressions in 1992 (one each in June and July) and in 1995 (two in September). Off-shore trough along different parts of west coast (surface and lower levels) persisted on most of the days (from 16 May to 4 September 2000), except for the periods 8-10 June, 16-25 June, 16 July – 7 August, 23-30 August. The seasonal rainfall departures, stationwise and sub-divisionwise are given in Fig. 1 on the basis of real time data and Fig. 2 on updated data.

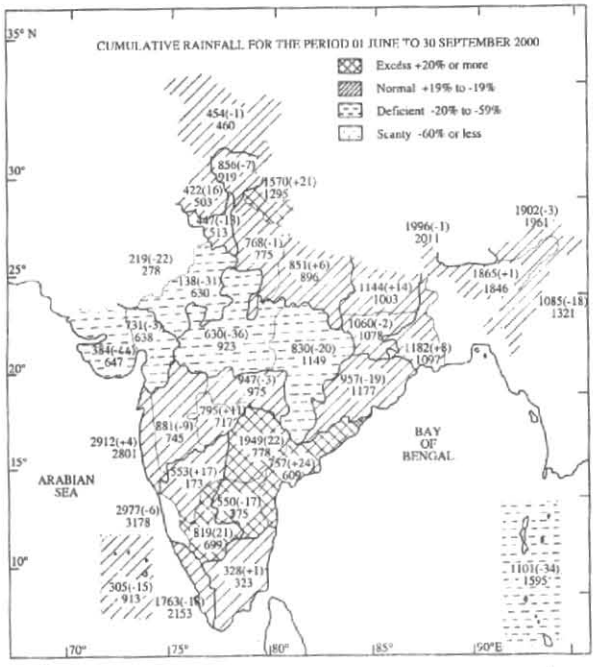

Fig. 1. Sub-division seasonal rainfall departure (%) for the period of June-September 2000 (operational data)

2. Characteristic features of southwest monsoon 2000

2.1. Total seasonal monsoon rainfall over the country as a whole was 92% of its long period average. Thus making 2000 as the 12 successive normal (±10%) monsoon year as predicted by IMD's long range forecast.

2.2. The southwest monsoon set in over Kerala on 1 June; on its normal date. Thus, the monsoon advanced over northeast India (29 May) before it arrived over Kerala. Similar situation was noticed in the years 1998, 1996, 1995 and 1972 when monsoon set in over northeast India before it arrived over Kerala.

2.3. The southwest monsoon covered the entire country by 2 July, (13 days earlier than the normal date of 15 July), even though there was hiatus in the northern limit of monsoon from 10 to 22 June and from 24 to 29 June. In the years 1967, 1971 & 1989 monsoon also covered the entire country by 2 July.

2.4. Southwest monsoon withdrew from west Rajasthan and some parts of Kutch on 13 September as against the normal date of 15 September. It further withdrew by 4 October from Madhya Pradesh (a delay of only 1 day from normal date), by 13 October from northeastern states (delay of 5 days) and Orissa (delay of 3 days) and by 23 October from Maharashtra (a delay of 20 days). It withdrew from the entire country by 25 October with a delay of 10 days.

2.5. Only two depressions formed (one in August, and one land depression in September) in this season. June and July were devoid of depressions. Similarly, there were only two depressions in 1992 (one each in June and July) and in 1995 (two in September). No cyclonic storms formed during this season as was noted in the years 1999, 1995, 1993, 1991, 1990 and 1988.

2.6. Rainfall during the monsoon 2000 was excess in 5, normal in 23 and deficient in 7 met-sub-divisions. In recent years similar spatial distribution was found in 1999 when 28 meteorological sub-divisions received excess (3) or normal (25) rainfall and in 1991 when 27 meteorological sub-divisions received excess (1) or normal (26) rainfall.

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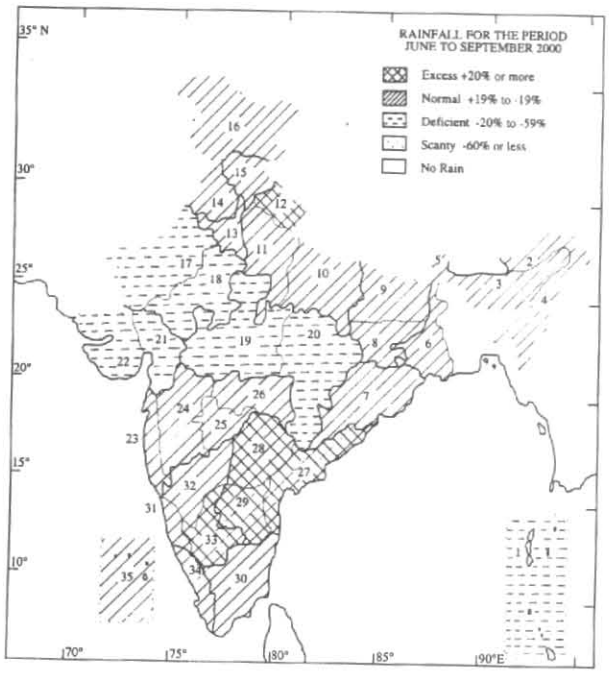


Fig. 2. Sub-divisionwise seasonal rainfall departure from normal (%) for monsoon season June-September 2000. Sub-division are indicated by number on the map.
(1)-31, (2)–3, (3) +1, (4) –16, (5) –1, (6)+8, (7) –19, (8)+8, (9)+14, (10)+6, (11) –2, (12)+23, (13) –15, (14) –16, (15) –14, (16) –2, (17) –21, (18) –31, (19) –37, (20) –29, (21) –30, (22) –45, (23) +4, (24) –9, (25)+11, (26) –4, (27) +24, (28)+22, (29)+46, (30)+2, (31) –6, (32)+17, (33)+22, (34) –18, (35) –15

Rainfall activity was good in June (Excess – 17, Normal –9) and in July (Excess – 3, Normal – 21). It was subdued in August (Excess – 9, Normal – 10) and also in September (Excess–7, Normal–7). Seasonal rainfall was excess in Hills of west Uttar Pradesh, coastal Andhra Pradesh, Telangana, Rayalaseema and in south interior Karnataka. Rainfall was excess / normal throughout the season in Sub-Himalayan West Bengal & Sikkim, Hills of west Uttar Pradesh and north interior Karnataka. In Saurashtra & Kutch rainfall was deficient (percentage departure from normal rainfall is between –20% to –59%)/ scanty, throughout the season & normal in one week. This sub-division was a deficient sub-division in the last year also. During the season, 70% of the area of the country and 65% of districts received excess/ normal rainfall.

2.7. Monsoon trough got established on 2 July and Tibetan anticyclone on 5 June. The Off-shore trough persisted on most of the days from 16 May to 4 September along different parts of west coast. Cross equatorial flow in general was very weak than normal over the Arabian Sea and the Bay of Bengal.

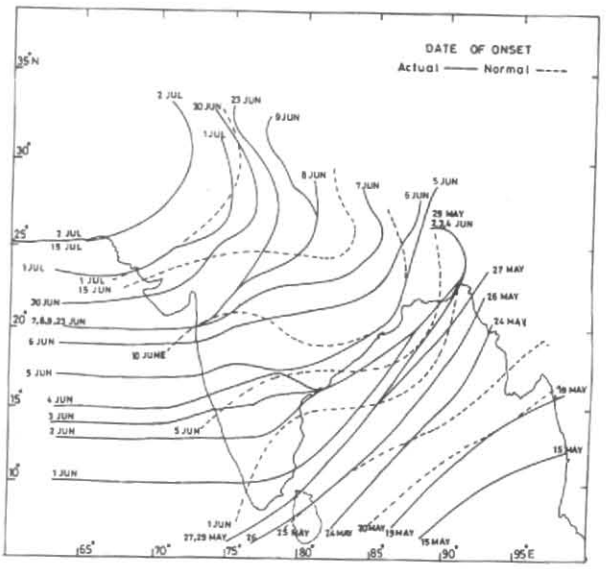


Fig. 3. Advance of southwest monsoon 2000

2.8. Northeast monsoon rains commenced over Tamil Nadu & Pondicherry, Kerala and adjoining states of Karnataka and Andhra Pradesh on 2 November. Northeast monsoon rains ceased in Tamil Nadu & Pondicherry, Kerala, southern states of Andhra Pradesh and Karnataka on 6 January 2001.

3. Features of monsoon

3.1. *Advance of southwest monsoon*

The southwest monsoon set in over Kerala on 1 June; on its normal date like in 1980. Even before the onset over Kerala, the monsoon advanced over to northeast India on 29 May. In the years 1998, 1996, 1995 and 1972 also, monsoon advanced over northeast India before the onset over Kerala.

The southwest monsoon covered the entire country on 2 July, 13 days earlier than the normal date of 15 July, even though there was hiatus in the northern limit of monsoon from 10 to 22 June and from 24 to 29 June. In the years 1967, 1971 & 1989 also monsoon covered the entire country on 2 July.

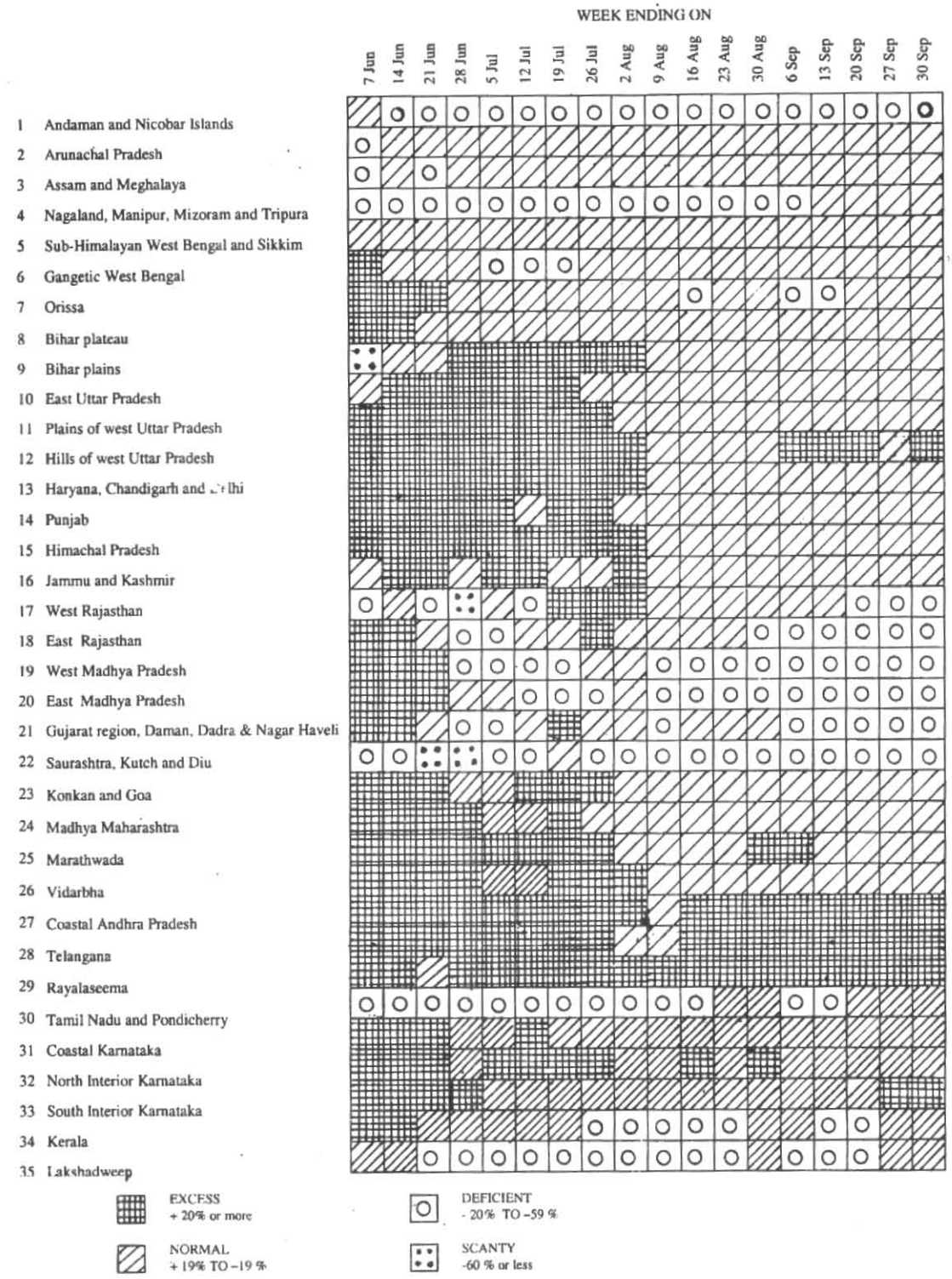
Isochrones of advance of southwest monsoon 2000 are shown in Fig. 3.

3.2. *Week by week cumulative rainfall distribution (1 June 2000 to 30 September 2000)*

Meteorological sub-divisionwise cumulative rainfall departures (percentage departure from normal) during the southwest monsoon season from 1 June 2000 to

TABLE 1

Progress of the monsoon week by week (cummulative) 1 June – 30 September 2000



30 September 2000 comprising of 18 weeks are given in Table 1. It is seen from the table that the rainfall was well distributed week by week throughout the period from 1 June 2000 to 30 September 2000.

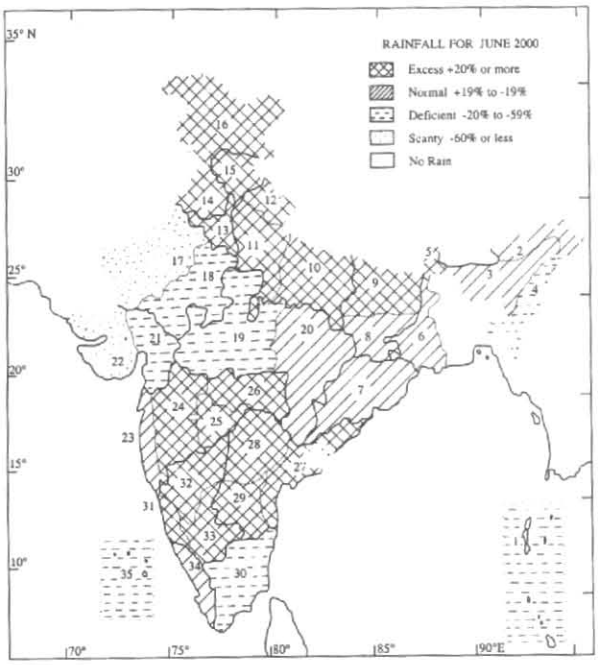


Fig. 4. Sub-divisionwise seasonal rainfall departure from normal (%) for June 2000. Sub-divisions are indicated by number on the map.
(1) −43, (2)+4, (3) +7, (4) −34, (5) +14, (6) −16, (7) +6, (8)+18, (9)+91, (10)+111, (11) +93, (12)+134, (13) +74, (14) +66, (15) +115, (16) +57, (17) −73, (18) −54, (19) −27, (20) −7, (21) −47, (22) −83, (23)+4, (24) +26, (25)+38, (26) +41, (27)+66, (28)+79, (29)+63, (30) −22, (31) +21, (32)+30, (33)+24, (34) −7, (35) −27

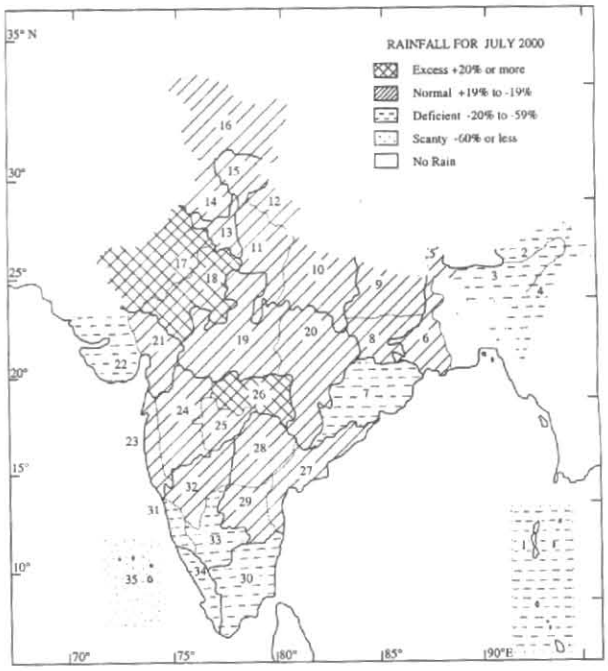


Fig. 5. Sub-divisionwise seasonal rainfall departure from normal (%) for July 2000. Sub-divisions are indicated by number on the map.
(1) −46, (2) −29, (3) −35 , (4) −29, (5) −12, (6) +12, (7) −22, (8) −1, (9) −15, (10) −17, (11) 0, (12)+1, (13) +19, (14) +3, (15) −5, (16) +10, (17) +73, (18) +25, (19) −5, (20) −11, (21) +4, (22) −21, (23)+16, (24) −19, (25) −14, (26) +30, (27) −4, (28) −12, (29)+19, (30) −50, (31) −27, (32) −7, (33) −28, (34) −56, (35) −66

Cumulative rainfall was excess or normal throughout the monsoon season in Sub-Himalayan West Bengal & Sikkim, Bihar plateau, Uttar Pradesh and Haryana, Punjab, Himachal Pradesh, Jammu & Kashmir, Maharashtra, Andhra Pradesh and Karnataka. Rainfall was also excess or normal in most parts of the monsoon season in Gangetic West Bengal (except for the week ending on 5, 12 and 19 July) and Orissa (except for the week ending on 16 August, 6 and 13 September). Rainfall was excess or normal from the week ending on 14 June in Arunachal Pradesh, Assam and Meghalaya (except for the week ending on 21 & 7 June) Bihar plains (except for the week ending on 7 June) and west Rajasthan (except for the week ending on 21 and 28 June, 12 July and 20 & 27 September)

Rainfall was excess or normal during 11 weeks in Kerala, 10 weeks in east Rajasthan and Gujarat region and 6 weeks in east Madhya Pradesh and 5 weeks in west Madhya Pradesh. Rainfall was deficient throughout the season in Andaman and Nicobar Islands (except for the week ending on 7 June), Nagaland, Manipur, Mizoram and Tripura (except for the week ending on 13, 20 and 27 September), Tamil Nadu (except for the week ending on 23 & 30 August and 20 & 27 September), Lakshadweep (except for the weeks ending on 7 & 14 June, 30 August and 27 September). Rainfall was deficient and scanty throughout the period in Saurashtra and Kutch (except week ending on 19 July).

3.3. *Month by month performance of monsoon rainfall*

Figs. 5-8 show monthwise distribution of monsoon rainfall.

Rainfall figures and departures for each month and season as a whole sub-divisionwise are given in Table 2 (a) and principal amounts of daily rainfall are given in Table 11.

3.4. *Seasonal performance of monsoon rainfall*

Meteorological sub-divisionwise seasonal rainfall distribution in terms of percentage departures from normal

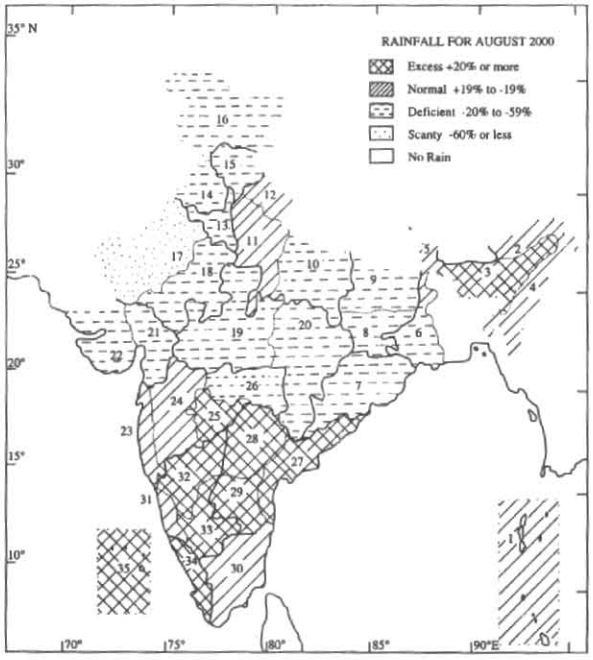


Fig. 6. Sub-divisionwise seasonal rainfall departure from normal (%) for August 2000. Sub-divisions are indicated by number on the map.
(1)+14, (2) −3, (3) +31, (4) +8, (5) −10, (6) −36, (7) −26, (8) −47, (9) −26, (10) −20, (11) −6, (12)+15, (13) −41, (14) −42, (15) −41, (16) −30, (17) −74, (18) −58, (19) −52, (20) −48, (21) −38, (22) −35, (23) +15, (24) +5, (25)+92, (26) −22, (27)+98, (28)+101, (29)+153, (30)+7, (31)+6, (32)+57, (33)+73, (34)+32, (35)+67

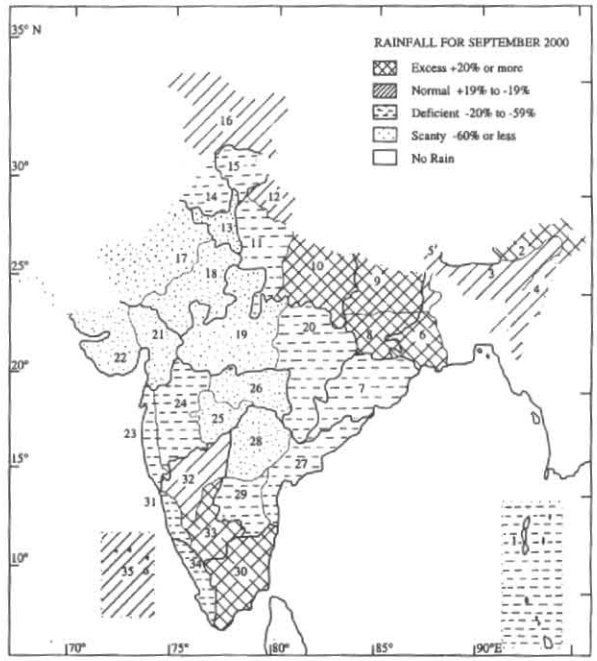


Fig. 7. Sub-divisionwise seasonal rainfall departure from normal (%) for September 2000. Sub-divisions are indicated by number on the map.
(1) −44, (2)+42, (3) +12, (4) −3, (5)+8, (6)+89, (7) −26, (8) +90, (9)+51, (10)+24, (11) −45, (12) 0, (13) −68, (14) −42, (15) −54, (16) −13, (17) −79, (18) −71, (19) −74, (20) −47, (21) −86, (22) −87, (23) −57, (24) −36, (25) −67, (26) −77, (27) −46, (28) −64, (29) −22, (30)+46, (31) −32, (32) −1, (33)+52, (34) −21, (35)+2

is given in Table 2 (a) and in Fig.2. The seasonal rainfall was excess in 5, normal in 23 and deficient in the remaining 7 meteorological sub-divisions. Seasonal total rainfall for the country as a whole was normal and country received 92% of its long period average value.

3.5. *Districtswise distribution of monsoon rainfall*

Districtwise distribution of rainfall, for each state given as number of districts with excess, normal, deficient and scanty rainfall for the period 1 June to 30 September 2000 is shown in Table 2(b). Data from 413 districts were received of which 268 (65%) districts received excess/normal rainfall and 145 districts received either deficient or scanty rainfall.

3.6. *Withdrawal of southwest monsoon*

Southwest monsoon withdrew from west Rajasthan and some parts of Kutch on 13 September as against the normal date of 15 September. It further withdrew from Madhya Pradesh by 4 October (with a delay of only 1 day), from northeastern states (5 days delay) and Orissa (3 days delay) by 13 October and from Maharashtra by 23 October (with a delay of 20 days). It withdrew from the entire country by 25 October with a delay of 10 days. Withdrawal dates of southwest monsoon are given in Fig. 8.

3.7. *El-Nino phenomenon*

Anomalous rise in sea surface temperatures over the east Pacific is generally referred as El-Nino while a see-saw relationship between sea level pressure over the southeastern Pacific Ocean and the Indian Ocean is known as Southern Oscillation (SO). SO is the atmospheric response to the El-Nino, which is an oceanographic phenomenon. Both of these phenomena, together are referred to "El-Nino Southern Oscillation" or ENSO. The phase and magnitude of the ENSO can be indicated either by the sea surface temperature (SST) anomalies over the Pacific or by Southern Oscillation Index (SOI) expressed as the difference in atmospheric surface pressure between Tahiti, and Darwin (Australia). In some years an inverse relationship between ENSO and Indian summer monsoon rainfall has been noted.

TABLE 2 (a)

Rainfall figures (mm) for each month and season as a whole (June – September 2000)

S. No.	Meteorological sub – divisions	June			July			August			September			Season		
		Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)
1.	A. & N. Islands	269	470	- 43	192	357	- 46	413	360	14	228	407	- 44	1101	1595	- 31
2.	Arunachal Pradesh	561	539	4	463	651	- 29	454	469	- 3	427	301	42	1906	1961	- 3
3.	Assam & Meghalaya	591	552	7	349	540	- 35	555	425	31	371	229	12	1866	1846	1
4.	Naga., Mani., Mizo. and Tri.	263	397	- 34	250	351	- 29	350	323	8	243	250	- 3	1106	1321	- 16
5.	Sub-Himalayan West Bengal & Sikkim	589	519	14	537	609	- 12	445	496	- 10	428	396	8	1998	2020	- 1
6.	Gangetic West Bengal	207	247	- 16	350	312	12	196	308	- 36	435	230	89	1189	1097	8
7.	Orissa	234	221	6	279	356	- 22	262	355	- 26	182	244	- 26	956	1177	- 19
8.	Bihar plateau	229	195	18	332	334	- 1	173	324	- 47	429	226	90	1163	1078	8
9.	Bihar plains	322	168	91	264	312	- 15	225	303	- 26	331	219	51	1142	1003	14
10.	East Uttar Pradesh	222	105	111	252	302	- 17	239	297	-20	236	191	24	949	897	6
11.	Plains of west Uttar Pradesh	155	80	93	263	262	0	253	269	- 6	89	162	- 45	759	774	- 2
12.	Hills of west Uttar Pradesh	396	169	134	455	449	1	514	448	15	229	229	0	1594	1295	23
13.	Haryana, Chandigarh & Delhi	89	51	74	208	175	19	106	179	- 41	34	108	- 68	437	513	- 15
14.	Punjab	69	42	66	196	190	3	98	169	- 42	58	101	- 42	421	502	- 16
15.	Himachal Pradesh	208	96	115	328	346	- 5	180	320	- 44	73	157	- 54	789	919	- 14
16.	Jammu & Kashmir	89	57	57	182	166	10	111	158	- 30	69	79	- 13	451	460	- 2
17.	West Rajasthan	7	27	- 73	175	101	73	27	104	- 74	10	46	- 79	219	279	- 21
18.	East Rajasthan	26	56	- 54	279	224	25	98	233	- 58	34	117	- 71	437	631	- 31
19.	West Madhya Pradesh	83	115	- 27	303	319	- 5	151	313	- 52	45	174	- 74	582	921	- 37
20.	East Madhya Pradesh	160	172	- 7	343	385	- 11	201	386	- 48	113	213	- 47	816	1156	- 29
21.	Gujarat region	77	145	- 47	450	433	4	188	301	- 38	26	181	- 86	741	1060	- 30
22.	Saurashtra & Kutch	15	90	- 83	194	244	- 21	84	129	- 35	11	85	- 87	304	548	- 45
23.	Konkan & Goa	713	685	4	1281	1106	16	759	663	15	149	348	- 57	2902	2801	4
24.	Madhya Maharashtra	176	140	26	218	271	- 19	189	179	5	99	155	- 36	681	745	- 9
25.	Marathwada	201	146	38	177	206	- 14	359	187	92	60	179	- 67	796	717	11
26.	Vidarbha	241	171	41	440	338	30	211	272	- 22	46	197	- 77	939	979	- 4
27.	Coastal Andhra Pradesh	185	111	66	162	168	- 4	317	160	98	93	170	- 46	756	609	24
28.	Telangana	241	135	79	213	243	- 12	427	212	101	69	188	- 64	949	778	22
29.	Rayalaseema	98	60	63	101	85	19	247	98	153	103	132	- 22	548	375	46
30.	Tamil Nadu	41	52	- 22	36	72	- 50	104	97	7	149	102	46	329	323	2
31.	Coastal Karnataka	1113	923	21	885	1214	- 27	760	715	6	221	326	- 32	2980	3178	- 6
32.	North interior Karnataka	117	90	30	123	132	- 7	171	109	57	140	142	- 1	551	473	17
33.	South interior Karnataka	172	139	24	185	256	- 28	297	172	73	201	132	52	856	699	22
34.	Kerala	649	697	- 7	336	765	- 56	580	439	32	199	252	- 21	1764	2153	- 18
35.	Lakshadweep	225	307	- 27	95	283	- 66	320	192	67	165	161	2	805	944	- 15

TABLE 2 (b)

State-wise distribution of no. of districts with excess, normal, deficient and scanty rainfall for the period from 1 June 2000 to 30 September 2000 (updated)

S. No.	State/UT	Excess	Normal	Deficient	Scanty	NR	**	Total
1.	A. & N. Islands (UT)	0	0	1	0	0	0	1
2.	Arunachal Pradesh	1	3	1	0	0	0	5
3.	Assam	2	13	1	0	0	0	16
4.	Meghalaya	0	1	1	0	0	0	2
5.	Nagaland	0	0	1	0	0	0	1
6.	Manipur	0	1	0	0	0	0	1
7.	Mizoram	0	1	0	0	0	0	1
8.	Tripura	0	1	0	0	0	0	1
9.	Sikkim	0	0	1	0	0	0	1
10.	West Bengal	5	11	0	0	0	0	16
11.	Orissa	0	8	5	0	0	0	13
12.	Jharkhand	1	8	1	0	0	2	12
13.	Bihar	11	10	2	0	0	4	27
14.	Uttar Pradesh	12	26	10	0	0	0	48
15.	Uttaranchal	4	3	1	0	0	0	8
16.	Haryana	1	6	8	1	0	0	16
17.	Chandigarh (UT)	0	1	0	0	0	0	1
18.	Delhi (UT)	0	0	1	0	0	0	1
19.	Punjab	2	3	5	1	0	1	12
20.	Himachal Pradesh	0	7	4	1	0	0	12
21.	Jammu & Kashmir	1	3	5	1	0	2	12
22.	Rajasthan	1	6	24	0	0	1	32
23.	Madhya Pradesh	1	4	30	2	0	1	38
24.	Chhattisgarh	0	2	5	0	0	0	7
25.	Gujarat	0	3	14	2	0	0	19
26.	Dadra, Daman and N. Haveli (UTs)	0	1	0	0	0	0	1
27.	Diu (UT)	0	0	1	0	0	0	1
28.	Goa	0	1	0	0	0	0	1
29.	Maharashtra	4	23	3	0	0	0	30
30.	Andhra Pradesh	15	8	0	0	0	0	23
31.	Tamil Nadu	7	10	5	0	0	0	22
32.	Pondicherry (UT)	0	1	0	0	0	0	1
33.	Karnataka	16	11	0	0	0	0	27
34.	Kerala	0	7	7	0	0	0	14
35.	Lakshadweep (UT)	0	1	0	0	0	0	1
	Total	84	184	137	8	0	11	424
	Percentage of Districts	20	45	33	2	0		

NR = No Rain ** = Data Inadequate

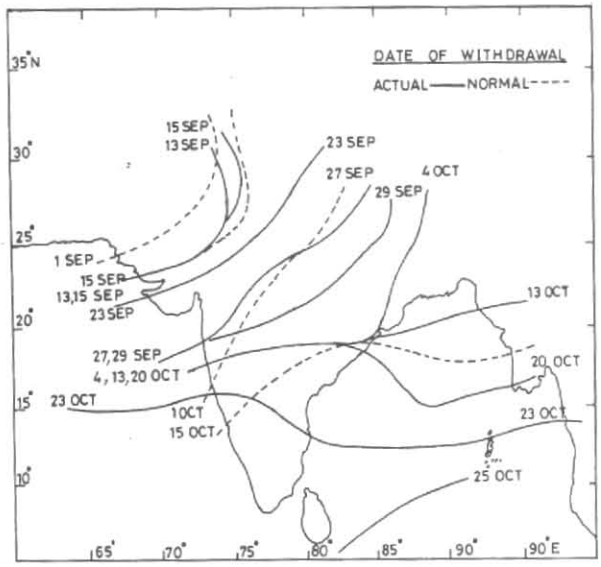


Fig. 8. Withdrawal of southwest monsoon 2000

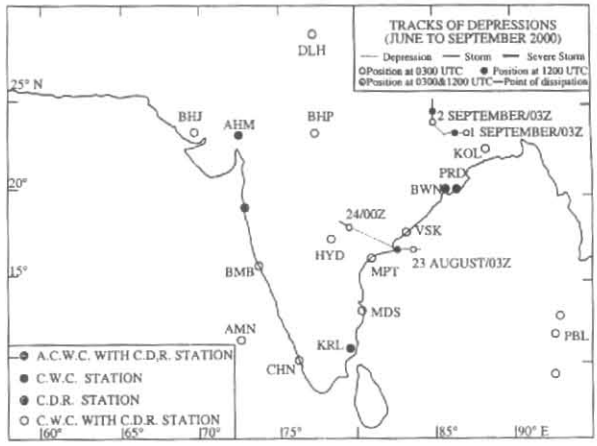


Fig. 9. Tracks of depression (June-September 2000)

It is interesting to note that the cold episode, which was started during the middle of 1998, matured towards the end of 1999 or in the beginning of 2000. Slight warming (0.6° C in N 1+2) was observed in April 2000 which subsequently weakened and weak cold episode conditions persisted during the monsoon of year 2000 (reference, Climate Diagnostic Bulletin, NWS, NCEP, NOAA, USA). The NINO 1+2 index showed significant variability in its monthly values, its lowest (−1.0) in November 1999 and the highest (0.6) in April 2000 and again turned to negative from June 2000 onwards. Similarly, the NINO 3 index, after reaching its lowest value −1.6 in January 2000, increased rapidly to 0.2 in April 2000 and again turned to negative from June 2000. The NINO 4 index after reaching its lowest negative value of −1.4 during February and March 2000 increased gradually to zero in September 2000.

4. Chief synoptic features of southwest monsoon

The synoptic disturbances which affected the Indian monsoon region in June, July, August and September are given in Table 3,4,5 and 6 respectively.

4.1. *Cyclonic storms/depressions*

No cyclonic storm formed during the season. The tracks of the two depressions are shown in Fig. 9.

4.1.1. *Depression over Bay of Bengal (23-24 August)*

A low pressure area formed over north Bay and neighbourhood on 17. It became well marked on 18 and persisted on 19 and 20. It was seen over west central Bay off Orissa–north Andhra coast on 21 and 22. It then concentrated into a depression and lay centred at 0300 UTC of 23 near Lat.16.5° N/Long.83.5° E about 150 km south of Visakhapatnam. It crossed north Andhra coast near Kakinada by the midnight of 23 & lay near Lat.18.0° N/ Long.79.5° E as depression at 0000 UTC of 24. It further weakened into a well marked low over Telangana and neighbourhood on 24. It moved in a west northwesterly direction across south Vidarbha and dissipated over south Gujarat coast and neighbourhood on 28 August.

In association with the depression, heavy rains were reported from some districts in the central parts of Andhra Pradesh. Hyderabad city received exceptionally heavy rain of 24 cm. In the above districts 131 deaths have been reported due to wall collapse, drowning *etc*. As per the preliminary estimation about 8651 houses were fully damaged, 27,026 houses partly damaged in 2886 villages/towns. 98,079 people were evacuated and kept in 189 relief camps. About 5368 cattle were reported as lost and 2389 roads of Panchayati Raj, R & B and National High Ways were damaged over a distance of 7435 km disrupting traffic. 1578 minor irrigation and Panchayati Raj tanks were breached. An estimated 1,77,987 hectors paddy and other crops were damaged in the affected districts. Due to heavy rains 902 power transformers were damaged. 28 sub-stations, 787 distribution transformers were damaged 33KV lines numbering 225 and 11 KV lines numbering 6000 were damaged. Preliminary estimate of a loss of Rs. 776.75 crores was reported by the Government of Andhra Pradesh.

TABLE 3

Details of the weather systems during June 2000

S. No. (1)	System (2)	Period (3)	Place of first location (4)	Direction of movement (5)	Place of dissipation (6)	Remarks (7)
(A)	*Low pressure areas*					
1.	Well-marked low pressure area	4 – 9	West-central Bay and neighbourhood	Northwesterly	Haryana & adjoining parts of plains of west Uttar Pradesh	It was first observed as a cyclonic circulation over west-central Bay off south Andhra coast on 1 June. It crossed coast and lay over central parts of Orissa on 6. Associated cyclonic circulation extended upto mid tropospheric levels. It became less marked over Haryana and adjoining parts of west Uttar Pradesh on 10
2.	Low pressure area	18-20 eve.	Northwest Bay off West Bengal coast	Westnorthwesterly	North Madhya Pradesh and neighbourhood	It was first observed as a cyclonic circulation over northwest Bay and adjoining coastal Orissa on 16. Associated extended upto mid tropospheric levels. It became less on 23 over southeast Uttar Pradesh and neighbourhood. A trough from this cyclonic circulation ran to Konkan between 3.1 and 5.8 km a.s.l. on 21
3.	Low pressure area	28 Jun-1 Jul	Northwest-west central Bay off Orissa – north Andhra coast	Northwesterly	East Vidarbha and adjoining parts of southeast Madhya Pradesh and of Telangana	It was first observed as a cyclonic circulation over central Bay and neighbourhood on 27.. Associated cyclonic circulation extended upto mid tropospheric levels tilting southwestwards with height from 28 to 30. It merged with the monsoon trough on 2 July over south Vidarbha and adjoining Telangana
4.	Low pressure area	30 Jun eve.-1 Jul	East Rajasthan and neighbourhood	Stationary	*In situ*	Associated cyclonic circulation extended upto lower tropospheric levels over east Rajasthan and neighbourhood. It merged with the monsoon trough on 2
(B)	*Embedded cyclonic circulation*					
1.	Lower tropospheric levels	3 – 5	North Madhya Pradesh and neighbourhood	Southerly	Southern parts of Madhya Pradesh	Merged with the monsoon trough
2.	Do	17- 19 eve.	Southwest Uttar Pradesh and neighbourhood	Westerly	Northwest Madhya Pradesh and neighbourhood	Do
(C)	*Other cyclonic circulation*					
1.	Mid tropospheric levels	1 – 6	South Madhya Maharashtra and neighbourhood	Quasi-stationary	Konkan & Goa and adjoining parts of Maharashtra	Merged with the east-west trough from Konkan & Goa to the centre of the well-marked low pressure area over Orissa

TABLE 3 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.	Mid tropospheric levels	8 – 10	North Pakistan and neighbourhood	Northeasterly	North Pakistan and adjoining parts of Jammu & Kashmir	Moved away northeastwards
3.	Do	8 – 11	South Konkan & Goa and neighbourhood	Northerly	North Konkan and neighbourhood	
4.	Lower levels	11 –14	North Bangladesh and neighbourhood	Stationary	*In situ*	
5.	Lower tropospheric levels	14 – 15	North Rajasthan and neighbourhood	Do	Do	
6.	Mid tropospheric levels	15 – 16	North Madhya Maharashtra and neighbourhood	Do	Do	
7.	Do	15 – 17 eve.	North Pakistan and adjoining Jammu & Kashmir	Eastnortheasterly	Jammu & Kashmir and neighbourhood	
8.	Do	23 – 26	North Gujarat region and neighbourhood	Stationary	*In situ*	
9.	Lower tropospheric levels	26 – 30	North Pakistan and neighbourhood	Northeasterly	Jammu & Kashmir and adjoining Himachal Pradesh	Moved away northeastwards
10.	Mid tropospheric levels	27 Jun – 15 Jul	Gujarat region and neighbourhood	Quasi-stationary	Gujarat region and neighbourhood	An east-west trough from this system to the lower pressure area over northwest-west-central Bay was seen from 28 to 30 June
(D)	*East-West trough*					
1.	Mid tropospheric levels	6 –8	Konkan & Goa to the centre of well-marked low pressure area over Orissa	Stationary	*In situ*	
2.	Do	12- 13	North Konkan to north Bay across Vidarbha	Do	Do	
3.	Do	18 –21	Maharashtra coast to centre of the low pressure area over northwest Bay off West Bengal coast	Northeasterly	Centre of the low pressure area near Satna to coastal Karnataka	
(E)	*Western Disturbance*					
1.	As an upper air system	24 – 25 eve.	Jammu & Kashmir and neighbourhood	Northeastwards		Moved away northeastwards
(F)	*Trough*					
1.	Lower tropospheric levels	1 – 3	North Pakistan to northeast Uttar Pradesh	Stationary	*In situ*	Merged with the seasonal trough

TABLE 4

Details of the weather systems during July 2000

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 area*					
1.	Low pressure area	3–8	West-central Bay off Andhra coast	Northeasterly	West-central off north Andhra – south Orissa coast	It was first observed as a cyclonic circulation over the same area. Associated cyclonic circulation extended upto mid tropospheric levels. It became less marked over east Vidarbha and neighbourhood on 10. It tilted southwestwards with height from 3 to 7
2.	Well-marked low pressure area	10 eve. – 16	Northwest Bay and neighbourhood	Northwesterly	Western parts of west Rajasthan	It was first seen as cyclonic circulation extending upto mid tropospheric levels over the same area on 10 Associated cyclonic circulation extended upto mid tropospheric levels. It also merged with the monsoon trough on 17
3.	Well-marked low pressure area	16–24	Northwest Bay off West Bengal coast	Northwesterly	Northwest Rajasthan and neighbourhood	Merged with the monsoon trough. Associated cyclonic circulation extended upto mid tropospheric levels upto 20
(B)	*Embedded cyclonic circulation*					
1.	Lower levels	9–10 eve.	Central parts of Uttar Pradesh	Westerly	Plains of west Uttar Pradesh and neighbourhood	Merged with the monsoon trough
2.	Mid tropospheric levels	19–20	Haryana and neighbourhood	Stationary	*In situ*	Merged with the monsoon
(C)	*Other cyclonic circulations*					
1.	Mid tropospheric levels	22–30	Gangetic West Bengal and neighbourhood	Westnorthwesterly	Northern parts of Uttar Pradesh	It tilted southwards with height on 22. It lay as a trough over north parts of Uttar Pradesh 31 July and became unimportant on 1 August
2.	Lower tropospheric levels	25–30	South Pakistan and neighbourhood	Northeasterly	Jammu & Kashmir and neighbourhood	Moved away northeastwards
3.	Lower tropospheric levels	28 Jul-1 Aug	North Gujarat Region and neighbourhood	Southerly	South Gujarat coast and neighbourhood	
4.	Do	29 Jul-1 Aug	North Pakistan and adjoining areas of Punjab and Jammu & Kashmir	Northeasterly	Punjab and adjoining areas	

TABLE 5

Details of the weather systems during August 2000

S. No.	System	Period	Place of first location	Direction of movement	Place of dissipation	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A)	*Depressions*					
1.	Depression	23–24	West-central Bay off north Andhra coast	Quasi-stationary	North Andhra coast near Kakinada	A low pressure area formed over north Bay and neighbourhood on 17. It became well marked on 18 and persisted on 19 and 20. It was seen over west central Bay off Orissa-north Andhra coast on 21 and 22. Subsequently, it concentrated into a depression in the morning of 23 August and lay centred at 0300 UTC of 23 near Lat.16.5° N/Long.83.5° E about 150 km south of Visakhapatnam. By the midnight of 23, it crossed north Andhra coast near Kakinada and lay near Lat.18.0° N/Long.79.5° E as depression at 0000 UTC of 24. It further weakened into a well marked low pressure area over Telangana and neighbourhood on 24. It moved in a westnorthwesterly direction across south Vidarbha and dissipated over south Gujarat coast and neighbourhood on 28 August. Associated cyclonic circulation extended upto mid tropospheric levels. It tilted southwestwards with height from 19 to 21. A trough from this system ran to Karnataka coast on 26 in the lower levels and became less marked on 29
(B)	*Low pressure area*					
1.	Well-marked low pressure area	8 – 12	Northwest Bay	Westnorthwesterly	Vidarbha and adjoining areas of Madhya Pradesh	Under the influence of a cyclonic circulation in mid tropospheric levels over northwest Bay, a low pressure area formed over the same area on 8. It was well-marked on 9 and lay over northwest Bay and adjoining areas of west-central Bay. It lay over west-central Bay off south Orissa-north Andhra coast on 10. It was seen as a cyclonic circulation over Vidarbha and adjoining areas of Madhya Pradesh on 12. The cyclonic circulation became less marked on 15 over east Uttar Pradesh. Associated cyclonic circulation extended upto mid tropospheric levels and tilted southwestwards with height on 9 and 10
(C)	*Cyclonic circulations*					
1.	Lower tropospheric levels	2 – 3	North Pakistan and adjoining Punjab and Jammu & Kashmir	Stationary	*In situ*	

TABLE 5 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.	Mid tropospheric levels	4 – 8	South Tamil Nadu and adjoining areas	Northwesterly	Northern parts of Kerala and adjoining parts of south Karnataka and Lakshadweep	
3.	Lower tropospheric levels	5 – 14	South Pakistan and adjoining areas	Southerly	Saurashtra & Kutch and adjoining areas of Gujarat region, north Maharashtra coast and northeast Arabian Sea	
4.	Do	6 – 10	North Pakistan and adjoining areas of Punjab	Northeastwards	Jammu & Kashmir and neighbourhood	
5.	Do	12 – 20	Northwest Rajasthan and adjoining areas of Pakistan	Do	Punjab and neighbourhood	It merged with the monsoon trough
6.	Lower levels	15 – 16	Tamil Nadu and adjoining areas of Kerala	Stationary	*In situ*	
7.	Mid tropospheric levels	18 – 24 eve.	South Rajasthan and adjoining Gujarat region	Quasi-stationary	South Gujarat region and neighbourhood	It tilted southwards with height on 23 and merged with the monsoon trough
8.	Mid tropospheric levels	19 – 20	East Uttar Pradesh and neighbourhood	Stationary	*In situ*	Merged with the monsoon trough
9.	Mid tropospheric levels	29 – 30	Gujarat region and neighbourhood	Do	Do	
(D)	*East-west trough*					
1.	Mid tropospheric levels	25 Aug– 1 Sep	Peninsular India along Lat. 17° N	Northerly	Gujarat region to West Bengal coast	It tilted southwards with height on 25 and 28
(E)	*Trough in easterlies*					
1.	Mid tropospheric levels	2 – 4	South of Lat. 15° N with its axis roughly along 86° E	Stationary	Long. 85° E, south Lat. 15° N	It was seen in lower and mid tropospheric levels on 3
2.	Do	14 – 15	South Bay and axis along 87° E	Do	*In situ*	
(F)	*Trough in westerlies*					
1.	Lower levels	3 – 6	89° E, north of 20° N	Stationary	Long. 88° E, north Lat. 20° N	

TABLE 6

Details of the weather systems during September 2000

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	1 – 2	Bihar plateau and adjoining parts of West Bengal	Northwesterly	Central Bihar	A low pressure area formed over west-central Bay off north Andhra south Orissa coast on 26 August and persisted on 27, it lay over northwest Bay off Orissa coast on 28 and off Orissa – West Bengal coast on 29. It became a well-marked low pressure area over northwest Bay off West Bengal coast on 30 and persisted on 31 August. It moved inland and concentrated into a depression centred at 0300 UTC of 1 September near Lat. 23.0° N/Long. 87.0° E close to Bankura. Moving in a northwesterly direction it lay centred at 0300 UTC of 2 near Lat. 24.0°N/ Long. 85.0° E about 70 km south of Gaya. It weakened into a well marked low over central Bihar near Gaya on 3 morning. It lay as a low pressure area over east Uttar Pradesh on 4 and persisted on 5 and 6 and became less marked on 8
(B)	*Low pressure area*					
1.	Low pressure area	5 – 6	Northwest Bay and neighbourhood	Stationary	*In situ*	Merged with the monsoon trough
2.	Well marked low pressure area	11 – 17	North Thailand and neighbourhood	Northwesterly	Northeast Madhya Pradesh and adjoining parts of Bihar plateau and east Uttar Pradesh	A low pressure area lay over north Thailand and neighbourhood on 11. It was well marked on 13 and lay over northeast Bay and neighbourhood. It weakened into low pressure area over Bihar plateau and neighbourhood on 15. It moved northwestwards and lay over northeast Madhya Pradesh and adjoining parts of Bihar plateau on 16, where it merged with monsoon trough on 17. Associated cyclonic circulation extended upto mid tropospheric levels till 17 and merged with the low pressure area over Gangetic West Bengal and neighbourhood on 19
3.	Well-marked low pressure area	19 – 22	Gangetic West Bengal and neighbourhood	Quasi-stationary	Bihar plateau and adjoining parts of Gangetic West Bengal	A low pressure area formed over Gangetic West Bengal and neighbourhood on 19. It was well marked on 20 and lay over Bihar plateau and adjoining parts of Gangetic West Bengal. It weakened into low pressure area over the same region on 21 and became less marked on 22

TABLE 6 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
						Associated cyclonic circulation extended upto mid tropospheric levels and became less marked on 25 over east Uttar Pradesh. A trough was seen from this system to south Tamil Nadu across coastal Andhra Pradesh till 20 and was seen from this system to Marathwada and neighbourhood on 22
4.	Low pressure area	27 – 29	Northern parts of Lakshadweep area and neighbourhood	Northeast	East-central Arabian Sea off Goa-Karnataka coast	Associated cyclonic circulation extended upto mid tropospheric levels. It became less marked over south Maharashtra and Goa coast on 3 October. A trough from this system to south Kerala coast was seen on 28 to 30
5.	Well-marked low pressure area	29 Sep - 3 Oct	East-central Bay of Bengal and neighbourhood	Northeast	Bangladesh & adjoining parts of Tripura	A low pressure area formed over east-central Bay and neighbourhood on 29 and became well-marked on 1 October over northeast Bay and neighbourhood. It moved over to Bangladesh and adjoining parts of Tripura on 2, as a low pressure area and became less marked on 3 October
(C)	*Cyclonic circulations*					
1.	Lower tropospheric levels	1 – 4	Punjab and adjoining parts of Pakistan	Northeast	Punjab and adjoining parts of Haryana	Merged with the monsoon trough
2.	Mid tropospheric levels	6 – 8	West-central Bay off Orissa coast	Quasi-stationary	Northwest Bay off Orissa coast	It tilted southwestwards with height on 6
3.	Do	7 – 8	Gujarat region and neighbourhood	Stationary	*In situ*	It tilted southwards with height on 7
4.	Lower tropospheric levels	8 – 11	Gangetic West Bengal and adjoining Bangladesh	Do	Do	A trough from this system was seen from Sub-Himalayan West Bengal & Sikkim to northeast Bay on 11 and became less marked on 12
5.	Mid tropospheric levels	14 – 16	Kerala and neighbourhood	Westwards	Lakshadweep	Moved away westwards
6.	Lower tropospheric levels	17 – 18	Tamil Nadu and neighbourhood	Stationary	*In situ*	
7.	Mid tropospheric levels	18 eve – 21	South Rajasthan and adjoining Gujarat region	Do	Do	
8.	Lower tropospheric levels	26 –29	Punjab and adjoining parts of Haryana	Northeastwards	Himachal Pradesh	Moved away northeastwards across Himachal Pradesh

TABLE 6 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(D)	*Western disturbances*					
1.	Upper air system	9 – 14	North Pakistan and neighbourhood	Northeast	Jammu & Kashmir	Moved away northeastwards
2.	Do	20 – 23	Do	Do	Punjab and neighbourhood	Do
3.	Do	22 – 23	Do	Do	Do	Do
4.	Do	24 – 27	Do	Do	Jammu & Kashmir and neighbourhood	Moved away northeastwards.
(E)	*East – west troughs*					
1.	Mid tropospheric levels	5 – 10	Along Lat. 20° N (over central India)	Stationary	North Maharashtra coast to Orissa coast	It tilted southwestwards with height on 6
2.	Do	13 – 17	South Gujarat coast to northeast Bay across Vidarbha	Quasi-Stationary	North Gujarat cost to Bihar Plateau	
3.	Lower tropospheric levels	28 mor. – 28 eve.	Andaman Sea	Stationary	*In situ*	

4.1.2. *Land depression over Gangetic West Bengal (1-2 September)*

A low pressure area formed over west central Bay off north Andhra south Orissa coast on 26 August and persisted on 27. It lay over northwest Bay off Orissa coast on 28 and off Orissa – West Bengal coast on 29. It became a well marked low pressure area over northwest Bay off West Bengal coast on 30 and persisted on 31 August. It moved inland and concentrated into a depression, centred at 0300 UTC of 1 September near Lat.23.0° N/Long.87.0° E close to Bankura. Moving in a northwesterly direction it lay centred at 0300 UTC of 2 near Lat.24.0° N/Long. 85.0° E about 70 km south of Gaya. It weakened into a well marked low over central Bihar near Gaya on 3 morning. It lay as a low pressure area over east Uttar Pradesh on 4 and persisted on 5, 6 and 7 and merged with the monsoon trough on 8.

System caused heavy rain in Bihar plains and east Uttar Pradesh on 30 August and 1 September. No significant damage to life or property was reported.

4.2. *Low pressure areas/well-marked low pressure areas (LPA/MLPA)*

During the season, 13 low pressure areas/well-marked low pressure areas formed. All these systems initially formed as upper air cyclonic circulations. Monthwise break-up of the systems are 4 in June, 3 in July, 1 in August and 5 in September. Details are given in Tables 3-6.

4.3. *Cyclonic circulations (CYCIR)*

In all 35 cyclonic circulations (in lower and upper levels) including 4 embedded cyclonic circulations formed in this season. The monthwise break-up of cyclonic circulations is –12 in June, 6 in July, 9 in August and 8 in September. Details are given in Tables 3 to 6.

4.4. *Off-shore trough*

Off-shore trough along different parts of west coast of India (surface and lower levels) persisted on most of the days (from 16 May to 4 September 2000), except for the periods 8 – 10 June, 16 – 25 June, 16 July – 7 August and 23 – 30 August. Details of the positions of off-shore trough are given in Table 7 (a). Details of off-shore trough from 1995 to 2000 are given in Table 7 (b).

4.5. *Low level troughs*

During the season, 3 troughs on sea level chart formed in June, August and September each. Details are given in Tables 3 to 6.

TABLE 7

Tropical storms / depressions in the northwest Pacific in 2000

Month	TD	TS	Typhoons	Total
June	1*	0	0	1
July	3	3	2	8
August	2	2	2	6
September	0	0	3	3
Total	6	5	7	18

* Period 21 May to 1 June.

TABLE 7 (a)

Positions of off-shore troughs during the monsoon period 2000 (on Sea level chart)

Date	Positions
1 June to 5 June	South Gujarat coast to Maharashtra coast
6 June	South Gujarat coast to Kerala coast
7 June to 8 June	South Gujarat coast to Lakshadweep area
11 June	Maharashtra coast to Kerala coast
12 June to 16 June	Maharashtra coast to Kerala coast appreciably persists
26 June	South Maharashtra coast to Karnataka coast
27 June to 9 July	Maharashtra coast to Kerala coast
10 July to 16 July	South Gujarat coast to Kerala coast
8 August	North Karnataka coast to Kerala coast
9 August to 13 August	South Gujarat coast to Kerala coast
14 August to 15 August	South Gujarat coast to north Maharashtra coast
16 August to 23 August	South Gujarat coast to south Karnataka coast
31 August to 4 September	Karnataka to Kerala coast

TABLE 7(b)

Details of off-shore trough from 1995 – 2000

Year	Details of off – shore trough
2000	Off-shore trough along different parts of west coast (surface and lower levels) persisted on most of the days (From 16 May to 4 September 2000), except for the periods 8-10 June, 16-25 June, 16 July – 7 August and 23-30 August.
1999	From 20 May to 22 September 1999, off-shore trough along different parts of west coast (surface and lower levels), persisted on most of the days except from 12 to 14 and from 16 to 26 August.
1998	From 16 June to 30 September, off-shore trough along different parts of west coast (surface and lower levels) persisted on most of the days except on 11 – 15 June, 18 – 19 July and 9 – 10 September.
1997	During 8 June to 1 October 1997, the off-shore trough along different parts of the west coast (surface and in lower levels) persisted on most of the days.
1996	Off-shore trough along west coast (surface and lower levels) persisted on most of the days.
1995	During 10 June to 17 September 1995, the off-shore trough along most parts of the west coast (surface and lower levels) persisted on most of the days.
1994	Off-shore trough along west coast (surface and lower levels) persisted on most of the days during June to September.

4.6. *Upper level troughs*

During the season, 8 mid and upper tropospheric westerlies (3 each in June and August and 2 in September) formed. Details are given in Tables 3 to 6.

4.7. *Eastward moving circulations/western disturbances*

During the season 5 (1 in June and 4 in September) eastward moving circulations/western disturbances formed. Details are given in Tables 3 to 6.

5. Extra Indian systems

5.1. *Cross equatorial flow*

5.1.1. *Along the equator*

In general the cross equatorial flow very weak than normal over Arabian Sea and Bay of Bengal, *i.e.*, within $\pm$ 5° Latitude of the equator. Ship data was meagre along the equator.

5.1.2. *Over the Arabian Sea*

In June, the surface wind was more than normal to the north of 18° N by 5 – 10 kt, but it was less than normal to the south of 18° N by about 5 – 10 kt. The ship data was meagre over northern parts of Arabian Sea.

In July, the surface wind was nearly normal.

In August, surface wind was more than normal by 5 – 10 kt.

In September, surface wind was less than normal by about 5 kt or so.

5.1.3. *Over the Bay of Bengal*

The surface wind was more than normal by 5 – 10 kt, in June, August and September and nearly normal in July. The ship data was meagre over north Bay.

5.1.4. *Mid latitude troughs*

During the season, 20 upper air westerly troughs (13 at 500 hPa level and 7 at 300 hPa level) moved eastwards across 30° N Latitude. Monthwise break-up is given below :

Levels	*June*	*July*	*August*	*September*	*Total*
300 hPa	2	1	1	3	7
500 hPa	3	6	2	2	13

There were 31, 29, 17, 31 and 18 mid and upper tropospheric westerly troughs during the monsoon season of 1999, 1998, 1997, 1996 and 1995 respectively.

5.2. *Systems in west Pacific Ocean/south China Sea*

During June to September 2000, there were 18 disturbances (tropical depression stage and above) *viz.* 6 tropical depression, 5 tropical storms and 7 typhoons. No super typhoon formed during the season. The monthwise break-up of these systems is shown below :

Month	*Tropical depression*	*Tropical storm*	*Typhoons*	*Total*
June	1*	0	0	1
July	3	3	2	8
August	2	2	2	6
September	0	0	3	3
Total	6	5	7	18

* Period 21 May to 1 June.

5.3. *Systems in southern hemisphere*

5.3.1. *Tropical storms*

No weather systems (TD, TS or Typhoon) formed over south Indian Ocean during June to September 2000.

5.3.2. *Mid and upper tropospheric westerly troughs over Indian Ocean*

During the season 17 upper air troughs in westerlies moved across Indian Ocean from west to east to the north of Lat.30° S. Based on INSAT full disc pictures, the monthwise break-up is given below:

Month	*June*	*July*	*August*	*September*	*Total*
Upper air troughs	3	4	4	6	17

13 troughs in mid and upper tropospheric westerlies in 1999, 23 in 1998, 9 in 1997, 36 in 1996 and 11 in 1995 moved across 30° S in the southern hemisphere.

5.3.3. *Mascarene High*

The intensity of Mascarene High at 30° S/ 60° E was above normal by 2 hPa in June, normal in August and below normal in July (-2 hPa) and September (-1 hPa). The high was in normal position (30° S/60° E).

Month	*Pressure (hPa)*	*Departure (hPa)*
June	1026	+ 2
July	1023	- 2
August	1025	0
September	1023	- 1

For the sake of ready comparison, the position and intensity of Mascarene High in the last five years are given below :

Year	*Mascarene High*
1995	The intensity of Mascarene high was 1-2 hPa above normal in July, August and September (normal intensity is 1024 hPa). In June, the Mascarene high had normal intensity. The Mascarene high was east of normal position (30° S /60° E) by 7° to 10° in June, 8° to 10° in July and August and about 2° in September.
1996	The intensity of Mascarene high was normal or near normal in June, July and August. Its intensity was 2 hPa below normal (1022 hPa) in September. In June, the Mascarene high moved about 8° to west and about 18° to east of its normal position (30° S/60° E) and in September, about 12° to east and 12° west of its normal position. On an average, in July it shifted by 4° to 5° to west and in August by 15° to east of its normal position.
1997	The intensity of Mascarene high was above normal (1024 hPa). It was above normal by 4 hPa in June and 3 hPa in August during July and in September, it was 1 hPa above normal. The normal value of pressure during June to September is 1024 hPa.
1998	The intensity of Mascarene high during June to September 1998 (at 30° S/60° E) was slightly below normal (-1 hPa) during June and August, above normal (+3 hPa) in July and nearly normal in September 1998.
1999	The intensity of Mascarene High was slightly below normal (-1 hPa) (normal value of Mascarene High in 1024 hPa) during June, slightly above normal (+1 hPa) in July, normal in August and again slightly above normal (+1 hPa) in September.

5.3.4. *Australian High*

The intensity of Australian high pressure area at 30° S/140° E was more than normal (4 hPa and more) during all the four months of southwest monsoon and the departure was highest (+ 8 hPa) during June. The position of the high was around (30° S/140° E). The monthwise details are given below :

Month	*Pressure (hPa)*	*Departure (hPa)*
June	1029	+ 8
July	1024	+ 4
August	1024	+ 4
September	1024	+ 5

Details of the intensity and the positions of Australian high for the years 1995 to 1999 are given below :

Year	*Australian High*
1995	The normal intensity of Australian high is around 1020 hPa near Lat. 28° – 29° S. The intensity of Australian high was above normal by 3 hPa in June, 5 hPa in August and 6 hPa in September. It was normal in July *i.e.*, 1020 hPa. Australian high was 4° S of normal position (28° S) in June. While it was near normal position in July, August and September.
1996	The normal intensity of Australian high is around 1019-1020 hPa near Lat. 28°–29° S. The intensity of Australian high was below normal by 2-3 hPa in June, July, and August and by 5 hPa in September. The Australian high was near normal position in June, August and September, while it was 2° to 3° north of its normal position in July.
1997	During June to September, the Australian high was very intense compared to the normal values in all the months. It was above normal by 7 hPa in June, 10 hPa in July, 4 hPa in August and 4 hPa in September. 1024 hPa is the normal pressure value during June to August and 1018 hPa in September.
1998	The intensity of Australian high during June to September 1998 (at 30o S/140o E) was normal during July to September but was below normal by 1 hPa in June.
1999	The intensity of Australian High was above normal during June to September. The departure was +5 hPa in June, +8 hPa in July, +10 hPa in August and +7 hPa in September.

6. Semi-permanent systems

6.1. *Heat low*

The heat low over west Rajasthan and adjoining Pakistan on the sea level chart formed on 1 June and remained more or less over the same area till 30 September.

The lowest & second lowest observed pressure values of the heat low were :

June	989.0 on 13, 14, 16 & 25 and 990.0 on 1, 15, 22 & 23
July	989.0 on 7 and 990.0 on 6, 13 & 18
August	990.0 on 30 and 991.0 on 31
September	992.0 on 1 and 994.0 on 7

Details of lowest observed isobaric values of the heat low during past 5 years are given below :

Month/ Year	*1995*	*1996*	*1997*	*1998*	*1999*
June	-	995.0 hPa (7^{th})	986.0 hPa (25^{th})	987.5 hPa (21^{st})	990.0 hPa (23^{rd})
July	989.0 hPa (2^{nd})	990 hPa (11^{th})	986.8 hPa (6^{th})	985.6 hPa (12^{th})	988.0 hPa (2^{nd})
August	991.0 hPa (13^{th})	991 hPa (5^{th})	990.5 hPa (4^{th})	990.7 hPa (4^{th})	988.5 hPa (6^{th})
September	-	995.0 hPa (8^{th} & 14^{th})	996.8 hPa (2^{nd})	993.9 hPa (3^{rd})	994.0 (17^{th})

6.2. *Axis of the monsoon trough*

Monsoon trough was established on 2 July and was to the south of its normal position which runs from Ganganagar to Calcutta through Allahabad. Western end of the monsoon trough was in its near normal position and the eastern end was about 5° south of the normal position upto 05 July owing to the formation of two low pressure systems over west central Bay. Thereafter monsoon trough remained in a near normal position upto 30 July. It moved northwards and lay close to the foothills of Himalayas upto 4 August during which period the country as a whole experienced subdued rainfall activity. From 6 to 10 of August, western end of the monsoon trough was slightly to the north of its normal position and eastern end was to the south. Further, it remained either in the normal or to the south of normal upto 19 August. Because of the formation of a depression over west central Bay, the position of the monsoon trough was very much to the south upto 26 August. Again it was seen in its near normal position upto 10 September and there after it lay much north of its normal position for three days. Gradually it came back to its near normal position and became less marked on 22 September. For ready comparison, the positions of monsoon trough in the past five years are given below :

Year	*1995*	*1996*	*1997*	*1998*	*1999*
Axis of Monsoon Trough	Established on 20 June. Less marked on 6 September. Break on 4 and 5 July and 12 to 15 August	Established on 8 July. Less marked on 6 September. Break from 1 to 7 July and on 8 August	Established 25 June. Less marked on 6 September. Break on 10 July, 9 and 15 August	Established on 21 Jun Less marked on 23 September. Break from 16 to 26 July and 20 to 26 August	Established on 10 June. Less marked on 26 September.

6.3. *Tibetan Anticyclone/High*

Tibetan Anticyclone was established at 300 and 200 hPa levels on 5 June. During the past 10 years, in 1999 Tibetan Anticyclone appeared on 10 June which is almost similar to the year 2000. Most of the days in June, it was south of its normal position.

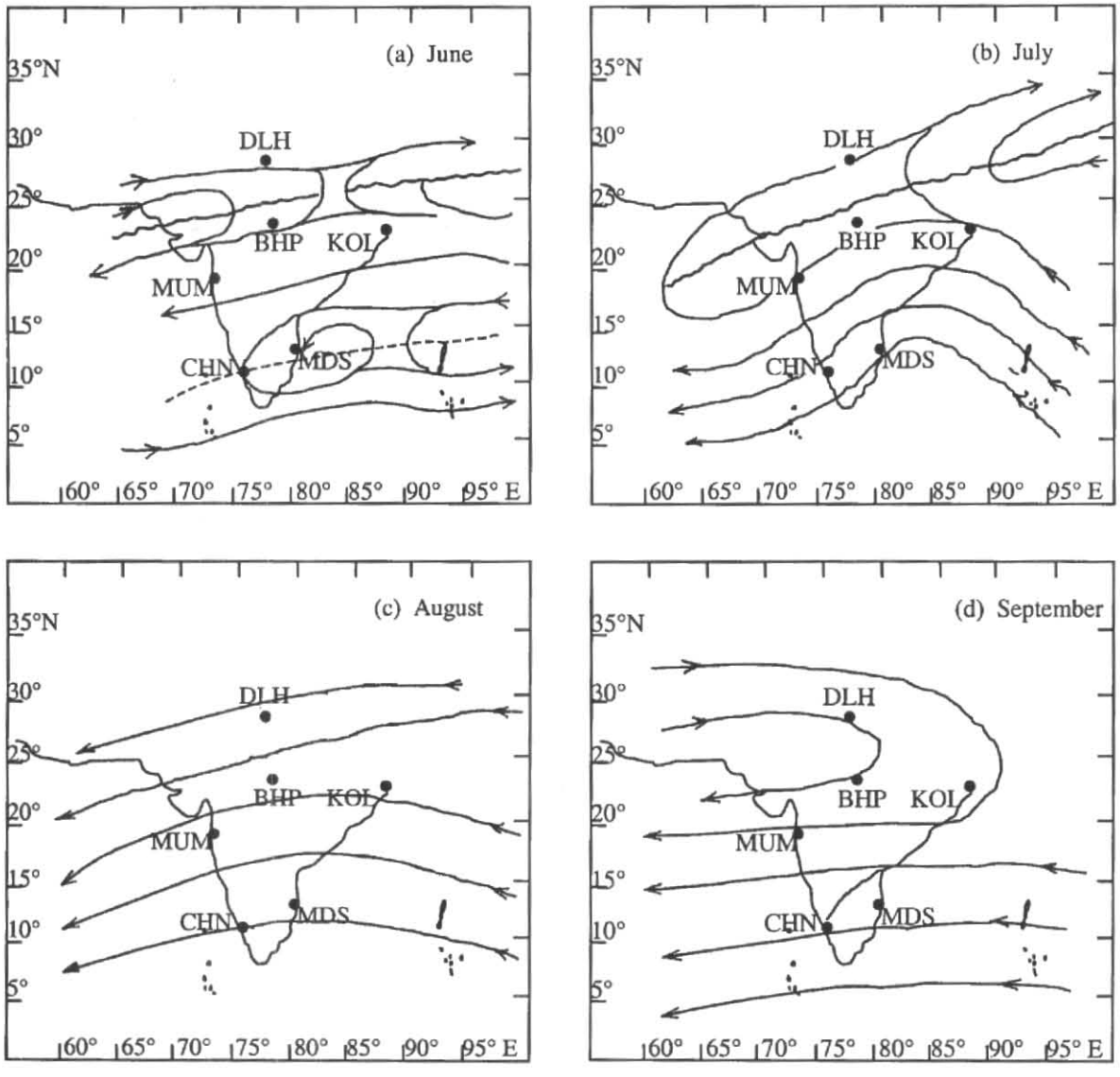
In July, the 300 hPa position was to the west of the normal and at 200 hPa it was in its normal position. The 300 hPa position in August was to the south, at 200 hPa it was normal. In September at both the levels it was to the southeast of the normal position. In the past five years, the details of the Tibetan Anticyclone is given below :

Year	*1995*	*1996*	*1997*	*1998*	*1999*
Tibetan Anti-cyclone	Appeared in last week of June. Less marked in 2nd week of September	Appeared in 3rd week of June . Less marked in 2nd week of September	Appeared in Last week of June. Less marked on 17 September	Appeared on 13 June. Less marked on 27 September	Appeared on 10 June. Seen on most of the days during July, August & September

6.4. *Sub-Tropical Westerly Jet (STWJ)*

STWJ was seen over Srinagar on 5 June, 24 June and on 16 July and over Delhi on 10 June. It then shifted northwards and reappeared over Srinagar, Delhi, Gorakhpur & Guwahati in the last week of September. The days Sub-tropical westerly jet was observed in the past five years are given below :

Year	*1995*	*1996*	*1997*	*1998*	*1999*
STWJ	Not seen	Seen till 1st week of June and 2nd fortnight of September	Seen till first fortnight of June and last week of September	Seen only in first week of June	Seen only till 12 June

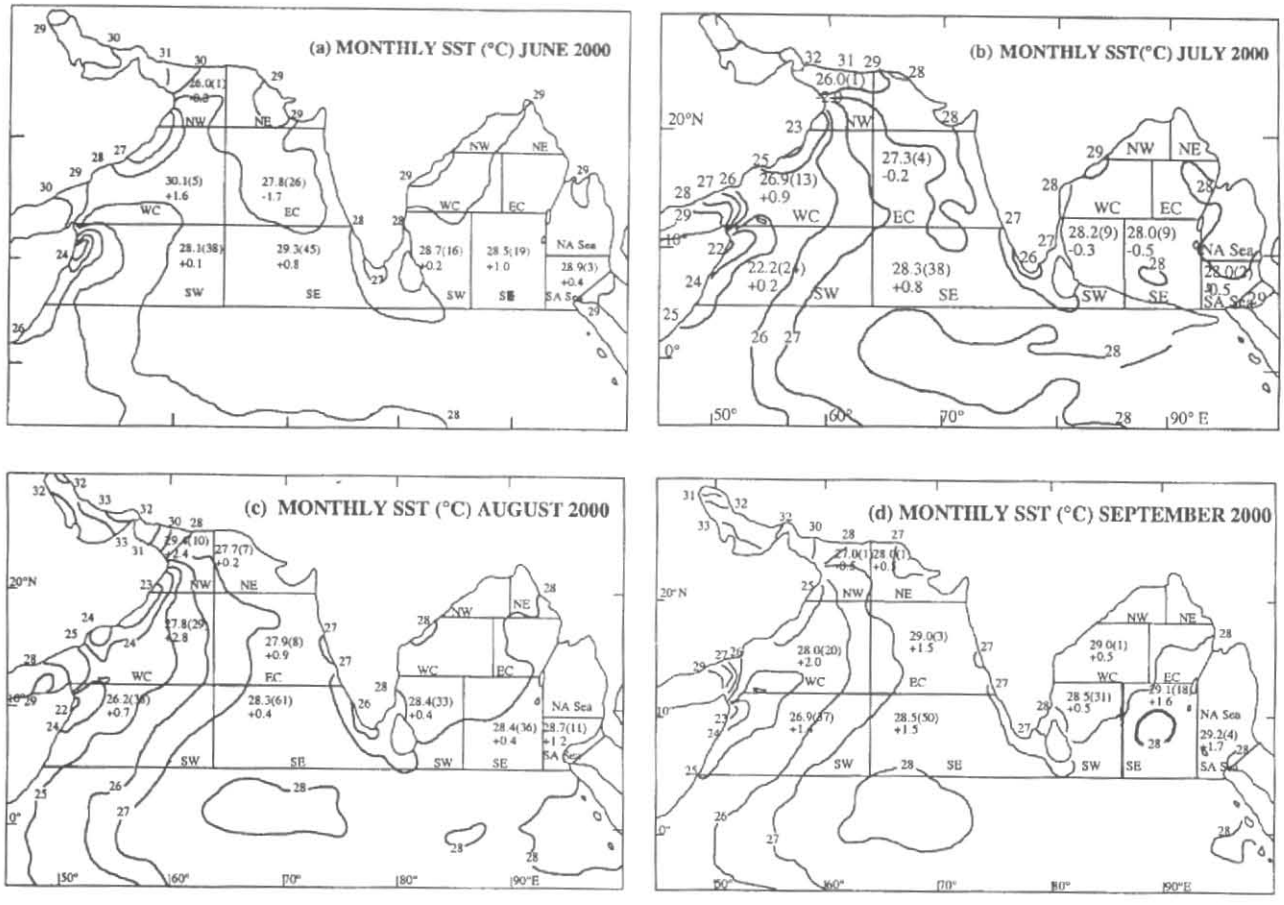


Figs. 10(a-d). Anomalous wind flow during monsoon 2000 at 30 hPa

6.5. *Tropical Easterly Jet (TEJ)*

TEJ was observed over Minicoy from 4 June to 24 September and was also seen on 29 September. The maximum wind observed was 155 kt at 177 hPa level at 1200 UTC of 6 September. It was seen over Thiruvananthapuram from 1 June to 20 September and maximum wind was 115 kt at 1200 UTC of 22 June. Over Madras also it appeared on 1 June and was seen upto 21 September. Maximum wind observed was 100 kt at 0000 UTC of 3 & 4 August.

Over Port Blair TEJ appeared on 8 June and was seen upto 25 June. Further, it was seen on most of the days upto 16 September. The maximum wind observed was 100 kt at 0000 UTC of 28 July. TEJ made its first appearance over Mumbai on 6 June. Again it was seen during the periods 9–21 June, 29 June–3 July and from



Figs. 11(a-d). Mean monthly (June-September 2000) SST anomalies (°C) of Indian seas during southwest monsoon

27 July to 8 September. Maximum wind speed observed was 115 knots at 0000 UTC of 31 July. Details of TEJ in the last five years are as follows :

Year	*1995*	*1996*	*1997*	*1998*	*1999*
TEJ	Appeared on 8 June. Less marked on 6 September. Max. wind 115 kt over MNC at 126 hPa on 27 June	Appeared on 11 June. Less marked on 27 September. Max. wind 110 kt over MDS at 109 hPa on 14 July	Appeared on 14 June. Less marked on 9 September. Max. wind 115 kt at 114 hPa on 25 July	Appeared from 1st week of June till the end of September. Max. wind 150 kt over MNC at 103 hPa on 5 August	Appeared on 3 June till the end of September. Maximum wind 140 kt at 141 hPa on 28 July

7. Sea surface temperature (SST)

In the Figs. 11 (a-d) the monthly mean SST values alongwith the anomalies in NW, NE, WC, EC, SW, SE blocks of both the seas and also for North Andaman and South Andaman seas, for months June, July, August and September are given. The normal values for each block for calculating the anomalies have been estimated from the isopleths of normal values given in the publication "Climatic Atlas of the Indian Ocean, Part I" by Stephan Hastenrath and Peter J. Lamb. One more map (Fig.12) is also included which gives the four months SST anomalies in each block. In all the above cases, if the number of observations in each block is less than 10, the mean and anomaly are not considered for this report.

The mean monthly SSTs as compared to their normals indicate that the South Arabian Sea and South Bay of Bengal were consistently warmer than normal during the whole monsoon season. The monthly patterns are given below :

7.1. *June*

South and west central Arabian Sea were warmer by 1 to 1.6° C than normal, the maximum positive anomaly being 1.6° C in WC block. East central and north Arabian

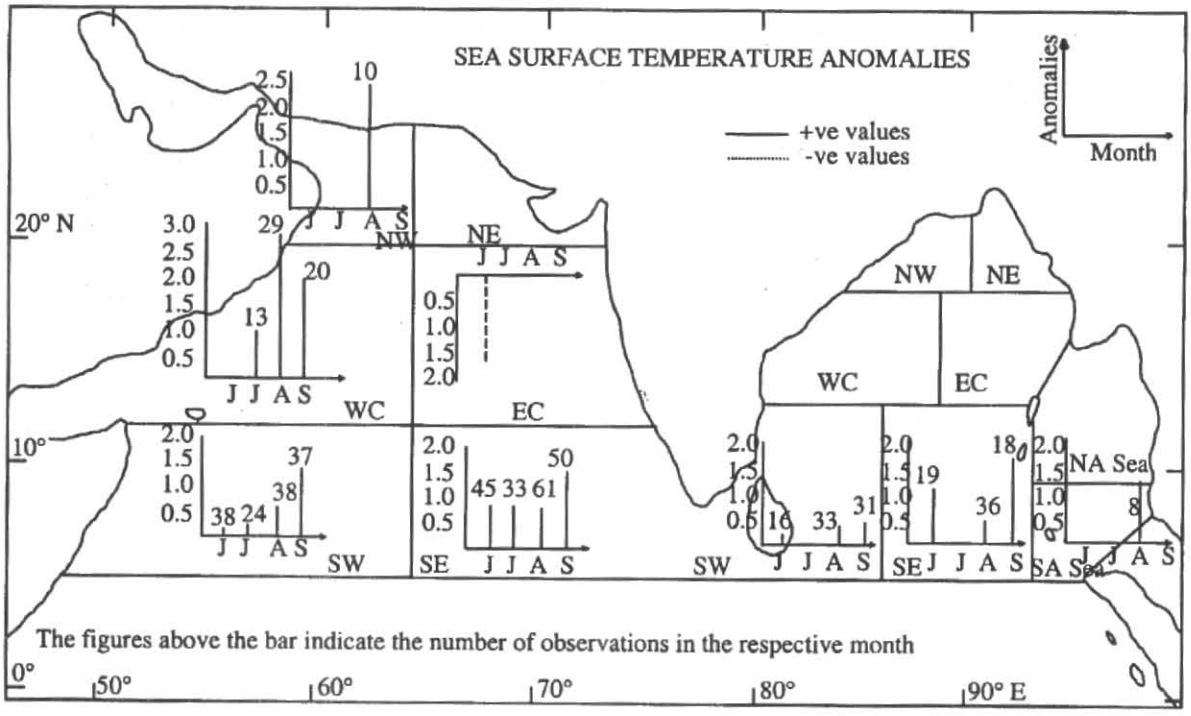


Fig. 12. Sea surface temperature anomalies

Sea were cooler by –0.3 to –1.7° C than normal (the highest negative anomaly was –1.7° C).

South Bay of Bengal was warmer by 0.2 to 1.0° C than normal, the maximum positive anomaly was +1.0° C in SE block.

7.2. *July*

The entire Arabian Sea was warmer by 0.2 to 0.9° C except NW and EC block which were cooler by –0.2° C than normal.

The Bay of Bengal was cooler by –0.3 to –0.5° C.

7.3. *August*

NW, WC and South Arabian Sea were warmer than normal, the maximum positive anomaly of +2.8° C was observed in WC block.

In the Bay sides, South Bay and South Andaman Sea were warmer than normal and the maximum positive anomaly of +1.2°C was observed over South Andaman Sea.

7.4. *September*

WC and South Arabian Sea were warmer than normal, the maximum positive anomaly of +2.0° C was found over WC Arabian Sea. South Arabian Sea also had anomaly greater than +1.0° C.

In Bay, South Bay was warmer than normal and the maximum anomaly of +1.6° C was observed over SE block.

8. Other features

8.1. *Weekly upper wind anomalies in monsoon 2000*

Using weekly wind vector anomalies at three standard levels *i.e.* 850 hPa, 500 hPa and 200 hPa representing lower, middle and upper tropospheric levels respectively, the main anomalous circulation features of Monsoon 2000 are given in Table 8 and are discussed below :

8.1.1. *June wind anomaly features*

During the first week, the lower tropospheric monsoon flow was stronger than normal and upper

TABLE 8

Main features of weekly wind anomalies (during June to September 2000)

Week ending	850 (hPa)	500 (hPa)	200 (hPa)	Remarks
			June	
6 Jun	A trough extending from NW India to Central west Central Bay	A E-W oriented ridge between 23-25°N	A E-W ridge between 25°N-22°N	The lower tropospheric anomalous flow mainly over the peninsular over the southernmost peninsula.The upper tropospheric easterlies are near normal
13 Jun	Mainly westerly flow over most of the parts of the country	A weak N-S trough over central parts of the Peninsula	A E-W ridge between 27°N-21°N	The lower tropospheric anomalous flow mainly cyclonic over most parts of the country. The upper tropospheric easterlies over Peninsula are stronger than normal
20 Jun	A N-S ridge from J&K to N. Maharashtra	A E-W trough from N. Maharashtra to N. Bay	A E-W ridge between 25°N-27°N	The lower tropospheric wind anomalies are mainly Northerlies. The upper tropospheric easterlies over Peninsula are near normal
27 Jun	A N-S ridge extends from J&K to N. Maharashtra	A N-S ridge over central India along ~78°E	A E-W ridge along ~25°N	The lower tropospheric westerlies are weaker than normal. The upper tropospheric easterlies over Peninsula are slightly stronger than normal
			July	
4 Jul	A trough from N-W India to West central Bay	A E-W trough over the southern Peninsula along ~15°N	A E-W ridge along ~27°N	The lower tropospheric anomalous flow over Peninsula is cyclonic and that over N & NE India is anticyclonic
11 Jul	A cycir over central Bay off N. Andhra and Orissa coast. A N-S ridge from J&K to Konkan & Goa	A E-W trough along ~15°N. A E-W ridge between 25°N - 27°N	A E-W ridge between 27°-30°N	The lower tropospheric anamalous flow over Peninsula is cyclonic and that over N & NE India is anticyclonic
18 Jul	A trough from N-W India to N. Bay	A E-W trough from Gujarat coast to N. Bay	A E-W ridge along ~29°N	The lower tropospheric westerlies are stronger than normal and the upper tropospheric easterlies are near normal
25 Jul	A trough from NW – NE India	A E-W trough from W. Rajasthan to NE India	A E-W ridge along ~29°N	The lower tropospheric anomalous flow over Peninsula is mainly anticyclonic and that over N & NE India is cyclonic
			August	
1Aug	A N-S ridge from J&K to Konkan and Goa	A E-W trough from Gujarat region to N. Bay. A E-W ridge from N. Maharashtra to S. Andhra	A E-W ridge along ~31°N	Mainly anomalous anticyclonic flow over entire troposphere
8 Aug	A N-S ridge from J&K to Konkan and Goa	A E-W ridge from NW India to N. Bay	A E-W ridge along ~27°N	Mainly anomalous anticyclonic flow over entire troposphere
15 Aug	A E-W trough from NW India to NE India	A N-S trough across the Peninsula along ~78°E	A E-W ridge along ~28°N	Mainly anomalous anticyclonic flow in the lower troposphere
22 Aug	A trough from plains of East U.P. to N. Bay	A E-W trough from W. Rajasthan to Coastal Orissa	A E-W ridge along ~28°N	Both the lower tropospheric westerlies and upper tropospheric easterlies over southern Peninsula weaker than normal
29 Aug	A E-W trough from Gujarat region to a cycir over Orissa and adjoining region	A E-W trough from S. Maharashtra coast to Andhra coast	A E-W ridge along ~28°N	The lower tropospheric westerlies stronger than normal
			September	
5 Sep	A N-S ridge from J&K to Konkan & Goa	A cycir over Gangetic W. Bengal and neighbourhood	A E-W ridge between 31°N -28°N	The lower tropospheric anomalous flow over most parts of country except NE India is anticyclonic
12 Sep	A N-S ridge from J&K to Konkan and Goa	A cycir over Gangetic W. Bengal and neighbourhood	A E-W ridge along ~27°N	The lower tropospheric anomalous flow over most parts of country except NE India is anticyclonic
19 Sep	A cycir over Bihar with trough from this system extending southwards to S. Kerala coast	An anticyclonic circulation over NW India	A E-W ridge along ~24°N	Both the lower tropospheric westerlies and upper tropospheric easterlies weaker than normal
26 Sep	A E-W trough over southern most Peninsula and anticyclonic circulation over NW India	A E-W ridge along ~20°N	A E-W ridge along ~20°N	Both the lower tropospheric westerlies and upper tropospheric easterlies weaker than normal

TABLE 9

Zonal wind anomalies (June – September 2000)

Week ending dates	6 Jun	13 Jun	20 Jun	27 Jun	4 Jul	11 Jul	18 Jul	25 Jul	1 Aug	8 Aug	15 Aug	22 Aug	29 Aug	5 Sep	12 Sep	19 Sep	26 Sep
TRIVANDRUM (TRV)																	
850	13.3	10.3	1.2	-3.7	9.9	7.7	7.0	-9.5	-6.3	-13.6	-2.5	4.7	13.7	-1.6	-6.1	-7.3	-12.0
500	12.2	2.8	-1.7	-8.2	1.5	1.7	4.5	-5.9	-13.6	-8.0	-9.8	9.1	10.3	8.5	1.2	-8.4	-9.0
200	4.7	-1.3	-31.6	-2.5	7.5	-8.8	-5.4	-7.5	8.6	8.1	-0.9	-3.3	-5.6	-12.0	-9.9	8.6	8.9
MADRAS (MDS)																	
850	5.5	10.3	0.3	-2.8	8.8	7.7	9.2	-9.5	-12.4	-9.2	2.5	10.9	24.0	7.2	-3.4	-7.2	-15.5
500	-4.6	1.0	4.9	-9.1	-0.4	-1.2	8.4	-0.3	-16.1	-18.0	-10.7	1.4	9.6	11.6	3.7	-11.3	-18.0
200	-5.4	-17.9	-5.6	-12.1	13.3	-8.7	3.7	-5.3	-12.2	0.5	4.1	8.3	4.7	-5.9	6.8	10.1	8.1
BOMBAY (BMB)																	
850	-13.3	-1.4	0.5	3.1	-3.7	–	–	5.5	-9.0	-8.2	1.0	4.4	-3.9	11.7	7.4	-3.1	-9.2
500	-7.6	1.0	-3.0	2.0	-9.0	–	–	–	-2.9	-6.7	-2.6	-7.4	-9.1	6.1	-2.8	-2.9	-0.4
200	-7.3	-9.1	-11.9	-11.5	-7.3	–	–	–	-1.9	5.2	-8.1	-9.9	7.5	-2.9	7.7	-0.8	4.1
NAGPUR (NGP)																	
850	0.4	4.5	6.3	4.2	-11.4	-6.4	16.1	11.4	-2.2	-3.9	2.4	9.1	-16.9	14.6	9.0	-4.8	-3.0
500	-12.3	4.5	0.2	4.0	-18.0	-11.5	-2.2	5.5	3.0	-3.0	5.6	-1.9	-21.2	5.1	11.2	0.5	4.1
200	-8.8	-10.7	-35.4	-6.6	-20.6	-10.2	-6.4	11.9	-5.3	1.8	-4.6	-18.9	-14.1	-19.7	-29.5	-39.8	-16.2

Note : 1. Easterly anomalies (-ve) at 850 hPa means that westerlies are weaker than normal.

2. Westerly anomalies (+ve) at 200 hPa means that easterlies are weaker than normal.

3. A station reporting ' – ' means no data.

tropospheric easterlies were near normal, indicating stronger than normal monsoon circulation. In the second week, though the lower tropospheric anomalies flow was cyclonic over most parts of the peninsula, an anomalous anticyclonic circulation started appearing over southern-most peninsula. In the next two weeks, a N-S ridge extending from Jammu & Kashmir to north Maharashtra was observed. This resulted in weaker than normal lower tropospheric monsoon flow. However, during most period of the month, the upper tropospheric easterlies were stronger than or near normal.

8.1.2. *July wind anomaly features*

During first two weeks, the lower tropospheric anomalous flow over peninsula was cyclonic and that over northern parts of the country was anticyclonic. The upper tropospheric easterlies over peninsula was weaker than normal. Both these resulted in weakening of monsoon circulation and limiting its influence only over peninsular India. In the subsequent weeks the trough in the lower tropospheric levels moved northward closer to foot hills of Himalayas. In association with this, the E-W ridge at 200 hPa also was north of its normal position. As a result during the last fortnight of the month, the lower tropospheric anomalous flow over the peninsula was anticyclonic and that over north and northeast India was cyclonic.

8.1.3. *August wind anomaly features*

During the week ending 8 August 2000, strong westerlies at 850 hPa extended upto northern India and an anomalous lower tropospheric anticyclonic flow was found over most parts of the country. In the next two weeks, a weak E-W trough was observed over N. India, but the lower tropospheric anomalous flow was mainly anticyclonic. In the last part of the month due to a cyclonic circulation over Orissa, an E-W trough appeared across peninsula and the lower tropospheric westerlies were stronger than normal. However, the upper tropospheric easterlies over peninsula were weaker than normal.

8.1.4. *September wind anomaly features*

In the first two weeks, once again the lower tropospheric anomalous flow became anticyclonic and lower tropospheric westerlies extended upto north India. The upper tropospheric anticyclone also was north of its normal position. In the subsequent weeks an E-W ridge over 200 hPa showed southward movement. An E-W trough appeared in the lower tropospheric levels. This indicated the gradual withdrawal of monsoon circulation. In the last two weeks, both the lower tropospheric westerlies and upper tropospheric easterlies over peninsula were weaker than normal.

Weekly wind anomaly values at three levels (850, 500 and 200 hPa) for a few representative stations over India are given in Table 9.

8.2. *Stratospheric features*

Stratospheric winds at 30 hPa and 10 hPa have been analysed based on balloon data received from Balasore till September 2000 upto 10 hPa level and RS data for 30 hPa level till September 2000. Rocket sonde data from Thumba and Balasore have already been discontinued since September 1993 and March 1995 respectively. Upper wind data from R.S., stations are not available at 10 hPa level. Circulation patterns during monsoon 2000 are given below :

Wind components at Balasore

The monthly means of zonal winds were easterly during June, July, August and September. The winds were below 19 year normal (1979-97) at 10 hPa level.

	June	*July*	*August*	*September*
Monthly means of zonal wind	−18.0	−27.0	−21.0	Flight not reached upto 10 hPa level
Normals of monthly means of zonal wind speed (1979-97)	−21.4	−27.7	−27.7	−21.2

Meridional winds were southerly in June and July and northerly in August while the normal meridional wind was northerly during June and August and southerly in July and September. In July winds were below normal while in August the winds were above normal.

	June	*July*	*August*	*September*
Monthly means of meridional wind	3.0	0.5	−5.5	Flight not reached upto 10 hPa level
Normals of monthly means of meridional wind speed (1979-97)	−0.3	1.0	−1.1	0.1

8.2.1. *Winds at 10 hPa*

The wind data of all available RS/ RW stations over the country have been analysed during the monsoon period-2000. Based on the available data it may be noted that on an average over the country, the wind was mainly easterly through out the season. Wind speed at 10 hPa level recorded at different stations along with the dates are given below :

June

During the month the strength of the wind varied between 10 to 70 mps. Wind recorded by Santacruz was 29 mps on 01; Lucknow was 32 mps on 17, 15 mps on 25; Bangalore was 70 mps on 13, 34 mps on 16, 81 mps on 24; Jagdalpur 28 mps on 16; Jodhpur was 25 mps on 17; Siliguri was 10 mps on 12; Raipur was 30 mps on 30; Calcutta was 25 mps on 15; Port Blair was 44 mps on 8, 40 mps on 16, 41 mps on 24; Chennai 39 mps on 23; Nagpur was 39 mps on 12, 33 mps on 15 and 40 mps on 16; Hyderabad was 34 mps on 20; Gorakhpur was 10 mps on 11; Patiala was 17 mps on 16, 15 mps on 20, 15 mps on 22 and 22 mps on 26.

July

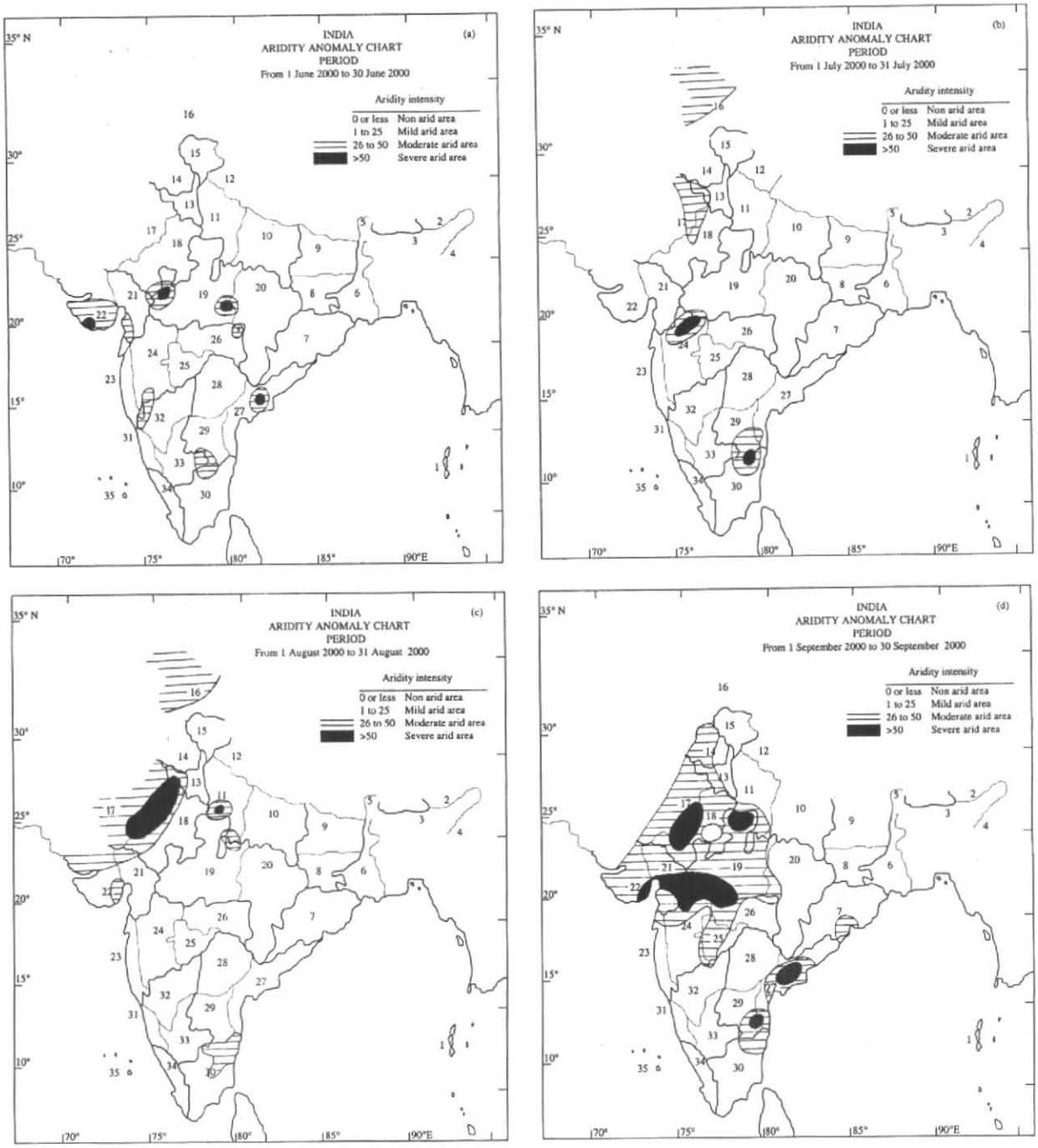
During the month the strength of the wind varied between 17 to 67 mps. Wind recorded by Hyderabad was 30 mps on 3, 33 mps on 4, 57 mps on 21, 37 mps on 22, 46 mps on 23 and 38 mps on 25; Port Blair was 26 mps on 2, 30 mps on 6, 28 mps on 9; Trivandrum was 39 mps on 14; Siliguri was 27 mps on 10; Bangalore was 55 mps on 1, 61 mps on 3, 67 mps on 5, 37 mps on 6, 39 mps on 7, 53 mps on 8, 32 mps on 11, 43 mps on 12, 41 mps on 13 and 49 mps on 14; Guwahati was 30 mps on 7, 17 mps on 11, 47 mps on 27, 41 mps on 30; Chennai was 40 mps on 7, 38 mps on 27; Lucknow was 22 mps on 1; Minicoy 38 mps on 27, 26 mps on 28, 45 mps on 29, 40 mps on 31.

August

During the month the strength of the wind varied from 7 to 63 mps. Wind recorded by Minicoy was 55 mps on 11, 53 mps on 15, 7 mps on 20, 63 mps on 23, 52 mps on 27; Port Blair was 41 mps on 4; Guwahati was 28 mps on 15; Karaikal was 47 mps on 21, Trivandrum was 53 mps on 13, 54 mps on 27, Bangalore was 44 mps on 4; Chennai was 37 mps on 8; Lucknow was 16 mps on 24, Gorakhpur was 31 mps on 3, 28 mps on 13, 24 mps on 19; Patiala was 19 mps on 25.

September

During the month the strength of the wind varied from 7 to 54 mps. Wind recorded by Chennai was 7 mps



Figs. 13 (a-d). Aridity anomaly chart-Drought research unit-Pune

on 2, 37 mps on 17, 46 mps on 28, 28 mps on 29; Minicoy was 54 mps on 4, 51 mps on 11, 28 mps on 15; Nagpur was 23 mps on 18, 29 mps on 21; Gorakhpur was 10 mps on 24, 13 mps on 25, 5 mps on 30; Trivandrum was 41 mps on 28; Lucknow was 9 mps on 21.

8.2.2. *Winds at 30 hPa*

Figs. 10 (a-d) depicts the monthly anomalous wind flow during Monsoon 2000 at 30 hPa level. The

anomalous wind flow has been calculated from real time data and 30 years normals (1967-96).

At 30 hPa level, an anomalous cyclonic circulation was observed at 30 hPa level, off Tamil Nadu coast in June only. An anomalous anticyclonic circulation was noticed in the northern part of the country during June, July and September at the same level. During July, the anomalous ridge line passed through Ahmedabad, Guna, Gangtok and then eastward, while the ridge line passed through Jaisalmer, Agra, Gorakhpur and eastward during September. During August, the anomalous wind was mainly easterly.

8.3. *Aridity conditions during monsoon 2000*

Aridity Index (AI) is computed based on Thornthwaite's formula :

$$AI = \frac{PE - AE}{PE} \times 100$$

Where, PE is potential evapotranspiration *i.e.* combined loss of water vapour to atmosphere in the form of evaporation from soil, water surfaces and transpiration from the plants, when the supply of water is unlimited. This is the water need of the plants. AE denotes the actual evapotranspiration and PE – AE denotes the water deficiency. PE is computed by Penman's modified equation and AE is obtained from the water balance procedure which takes into account the water holding capacity of the soil.

The difference between actual aridity for the month and normal aridity *i.e.* the aridity anomaly is worked out. The aridity anomalies have been classified into the following classes:

Anomaly	*Class*
Zero or less	Non arid
1 to 25	Mild arid
26 to 50	Moderate arid
more than 50	Severe arid

Aridity anomaly maps for June, July, August and September are given in Figs. 13(a-d) respectively.

Small moderate to severe arid areas were noticed in central and southern parts of the country, during June. In July, moderate arid areas in northwestern, western and southern parts of the country are noticed along with a small severe arid area in western parts of the country. Moderate and severe arid areas have increased in northwestern parts of the country in August and moderate arid areas have persisted in southeastern parts of the country in lower latitudes. In September, moderate to severe arid areas have increased to a large extent in northwestern, central and southeastern parts of the country.

9. Significant spells of heavy rains

During monsoon, the spatial distribution of heavy (atleast one station in the sub-division reported rainfall during past 24 hours ≥ 6.5 cm) and very heavy (atleast one station in the sub-division reported rainfall during past 24 hours ≥ 12.5 cm) rainfall is given in Table 10. The table also indicates the activity of monsoon and sub-divisionwise extent of rainfall in number of days like widespread (more than 75% stations of a sub-division reporting rainfall at least 2.5 mms) and fairly widespread (51 to 75% stations of a sub-division reporting rainfall at least 2.5 mms). Monthwise description is given below :

9.1. *Heavy rainfall during June*

During the month, very heavy rainfall occurred on 7 to 8 days in Assam & Meghalaya, Sub-Himalayan West Bengal & Sikkim and coastal & south interior Karnataka; on 4 to 6 days in Himachal Pradesh, Konkan & Goa and Madhya Maharashtra and on 1 to 3 days in Arunachal Pradesh, Orissa, Bihar Plains, east Uttar Pradesh, plains of west Uttar Pradesh, Haryana, Punjab, Vidarbha, Telangana, north interior Karnataka and Kerala. Heavy rainfall also occurred on 9 to 12 days in Orissa, Konkan & Goa and coastal Karnataka; on 4 to 8 in Assam & Meghalaya, Sub-Himalayan West Bengal & Sikkim, Bihar Plains, Himachal Pradesh and south interior Karnataka and on 1 to 3 days in Andaman & Nicobar Islands Arunachal Pradesh, Gangetic West Bengal, east Uttar Pradesh, plains of west Uttar Pradesh, Haryana, Punjab, east Rajasthan, east Madhya Pradesh, Gujarat Region, Madhya Maharashtra, Marathwada, Vidarbha, Telangana, Rayalaseema, Tamil Nadu, north interior Karnataka and Kerala.

9.2. *Heavy rainfall during July*

During the month, very heavy rainfall occurred on 7 to 9 days in Sub-Himalayan West Bengal & Sikkim, Konkan & Goa coastal Karnataka; on 4 to 6 days in Gangetic West Bengal, Orissa, Himachal Pradesh, east Rajasthan, Gujarat Region, Madhya Maharashtra, Vidarbha and south interior Karnataka and on 1 to 3 days in Arunachal Pradesh, Bihar Plains, east Uttar Pradesh, plains of west Uttar Pradesh, Hills of west Uttar Pradesh, Haryana, Punjab, Jammu & Kashmir, west Rajasthan, west Madhya Pradesh, north interior Karnataka and

TABLE 10

Statistics of spatial rainfall distribution
(No. of days for monsoon season 2000 as a whole with heavy to very heavy rainfall)

S. No.	Sub–division	Vig.	Act.	V. Heavy	Heavy	W/Fw
1.	Andaman & Nicobar Islands	-	-	-	5	48
2.	Arunachal Pradesh	6	30	4	16	33
3.	Assam & Meghalaya	-	20	21	30	34
4.	Naga., Mani., Mizo. & Trip.	-	13	1	2	51
5.	S.H.W.B. & Sikkim	6	24	20	25	51
6.	Gangetic West Bengal	6	23	11	11	20
7.	Orissa	1	3	8	36	44
8.	Bihar Plateau	1	2	-	3	40
9.	Bihar Plains	-	4	8	19	35
10.	East Uttar Pradesh	10	10	12	17	10
11.	Plains of west Uttar Pradesh	6	16	9	11	3
12.	Hills of west Uttar Pradesh	11	26	3	12	22
13.	Haryana	3	5	5	7	4
14.	Punjab	1	5	3	14	1
15.	Himachal Pradesh	1	17	13	35	23
16.	Jammu & Kashmir	2	3	1	3	5
17.	West Rajasthan	-	-	1	-	9
18.	East Rajasthan	-	-	4	4	12
19.	West Madhya Pradesh	2	5	1	8	12
20.	East Madhya Pradesh	3	14	1	6	16
21.	Gujarat Region	1	6	6	9	8
22.	Saurashtra & Kutch	2	4	-	4	3
23.	Konkan & Goa	4	16	22	27	53
24.	Madhya Maharashtra	4	14	16	13	16
25.	Marathwada	11	10	3	6	12
26.	Vidarbha	-	2	2	4	27
27.	Coastal Andhra Pradesh	5	15	2	1	8
28.	Telangana	8	13	4	5	10
29.	Rayalaseema	8	6	-	1	7
30.	Tamil Nadu & Pondicherry	-	-	2	13	2
31.	Coastal Karnataka	1	27	19	22	55
32.	North interior Karnataka	9	13	5	11	3
33.	South interior Karnataka	4	21	22	23	10
34.	Kerala	3	20	9	12	49
35.	Lakshadweep	-	-	-	-	24

Vig. = Vigorous (Rainfall in the sub-division is fairly widespread or widespread and the average rainfall received in a sub-division is more than 4 times the normal with atleast 2 stations reporting 8 cms in the west coast and 5 cms elsewhere)

Act. = Active(Rainfall in the sub-division is fairly widespread or widespread and the average rainfall received in a sub-division is 1.5 to 4 times the normal with atleast 2 stations reporting 5 cms in the west coast and 3 cms elsewhere)

V. Heavy = Very heavy rainfall (rainfall recorded more than 12.5 cms)

Heavy = Heavy rainfall (rainfall recorded more than 6.5 cms)

W/Fw = At most places (more than 75% stations of a sub-division reporting rainfall at least 2.5 mms) and or at many places (51% to 75% stations of a sub-division reporting rainfall at least 2.5 mms).

Kerala. Heavy rain also occurred on 16 days in Himachal Pradesh, on 7 to 10 days in Orissa, Punjab, west Madhya Pradesh and Konkan & Goa; on 4 to 6 days in Assam & Meghalaya, Sub-Himalayan West Bengal & Sikkim, Gangetic West Bengal, Bihar Plains, east Uttar Pradesh and coastal and north interior Karnataka and on 1 to 3 days in Arunachal Pradesh, Bihar Plateau, plains of west Uttar Pradesh, Hills of west Uttar Pradesh, Haryana, Jammu & Kashmir, east Rajasthan, east Madhya Pradesh, Gujarat Region, Saurashtra & Kutch, Madhya Maharashtra, Marathwada, Tamil Nadu, south interior Karnataka and Kerala.

9.3. *Heavy rainfall during August*

During the month, very heavy rainfall occurred on 7 to 10 days in Assam & Meghalaya, Konkan & Goa, Madhya Maharashtra, and south interior Karnataka; on 4 to 6 days in east Uttar Pradesh, plains of west Uttar Pradesh and Himachal Pradesh and on 1 to 3 days in

TABLE 11

Principle amounts of rainfall during June – September 2000

Date (1)	June (2)	July (3)	August (4)	September (5)
1	Aurangabad 9, Guwahati 8	Kokrajhar 11, Basar, Barobisha & Talasari 10 each, Sankalan & Umbergaon 9 each, Mathabhanga, Nagrota Surian, Vengurla & Vadakara 8 each, Balachaur, Panjim, Dapoli, Gaganbavada, Ahmednagar, Asti, Hakimpet, Mangalore & Shirali 7 each	Shillong 12, Matunga 10, Beki Road Bridge & Kokrajhar 9 each, Kamtaul 8, Puthimari, Barobisha, Berhampore, Ayodhya & Kakardharighat 7 each	Diamond Harbour & Chatnag 16 each, Hanuman Setu 13, Ayodhya 11, Amraghat 10, Varanasi & Ghamroor 9 each, Canning Town, Uluberia, Mukerian & Jogindernagar 8 each, Darjeeling, Berhampore, Marora, Nawashahar, Nagrota Surian, Una, Malwan & Chandgad 7 each
2	Jalpaiguri & Karwar 10 each, Honavar 9, Vengurla & Shirali 8 each, Doddaballapura & Kottayam 7 each	Domohani & Birpur 26 each, Mathabhanga & Galgalia 14 each, Jalpaiguri 12, Taibpur 11, Cooch Behar, Khagaria & Kochi 9 each, Salumber, Bhilsi, Harij & Alibag 7 each	Beki Road Bridge 21, Sonbarsa 16, Matunga 15, Kokrajhar 13, Chepan 12, Beki Mathanguri & Dharmapuri 10 each, Agartala, Chottabekra, Banbasa, Kangra & Bangalore 9 each, Shillong, Domohani & Jalpaiguri 8 each, Sevoke & Triveni 7 each	Japla 13, Darjeeling & Malda 9 each, Kursela, Colgaon, Indrapuri, Chatnag & Chandradeepghat 8 each, Gaya & Ayodhya 7 each
3	Honavar 9, Car Nicobar, Tilpara Barrage & Osmanabad 7 each	Cooch Behar 19, Vapi 11, Valsad & Surat 10 each, A.I.E NH X-ing, Barobisha, Navsari & Ratnagiri 9 each, Panjim & Nizamsagar 8 each, Goalpara, Mathabhanga, Mahuva, Paleru Bridge & Darsi 7 each	Agartala 17, Beki Mathanguri 12, Baghdogra 10, Bhalukpong 9, Tezu & Matunga 7 each	Jaunpur 16, Varanasi 10, Mirzapur 8, Kundapura & Ankola 7 each
4	Nil	Silvasa 26, Mumbai 24 Barobhisa 19, Ratnagiri 18, Vapi & Nanipalsan 17 each, Chepan, Madhuban, Dharampur & Gandevi 16 each, Chikhli, Sihor & Rajkot 15 each, Bardoli, Daman, Bana & Harnai 14 each, Koil Kuntla 13, Khambalia & Alagadda 11 each, Umrala 10, NH-31, Alibag 9, Domohani, Valsad, Dahanu & Alur 8 each, Gajoldoba, Lucknow, Umbergaon, Veraval, Bhavnagar & New Kandla 7 each	Nagarkata 32, Diana 29, Murti 21,Gajaldoba 17, Manas NH X-ing & Barobisha 14 each, Champasarai & Chepan 11 each, Beki Road Bridge 9, Karimganj 8, Madakasira 7	Amraghat 12, North Lakhimpur 9, Chouldhowaghat 7
5	Panjim 9, Port Blair & Punalur 8 each, Digha 7	North Lakhimpur & Shirali 18 each, Manavdar 17, Keshod, Alibag & Honavar 13 each, Ranavar & Veraval 12 each, Karwar 11, Kokrajhar, Diana, Vengurla & Agumbe 10 each, Hasimara, Mandvi, Broach, Porbandar, Devgad & Panjim 9 each, Beki Road Bridge 8, Bardoli, Valod, Viramgam, Mehsana, Visnagar & Bhakudar 7 each	Bandipura 14, Galgalia & Bhadravati 9 each, Channarayapatna 8, Dhubri, Cooch Behar, Champasarai, Berhampur, K. R. Sagara, K. R. Nagara, Tarikere, Palya & Minicoy 7 each	Dhollabazar 17, Passighat 10, Hamirpur & Kathua 7 each
6	Honavar 29, Kumta 21, Karwar 19, Sandheads 17, Panjim 13, Dharamtul & Mandvi 12 each, Eturnagaram 11, Ukai & Medak 10 each, Balasore, Gopalpur, Ratnagiri, Visakhapatnam & Tuni 9 each, Valsad & Talguppa 8 each, Goalpara, Digha, Alibag, Mangalore, Gulbarga & Kannur 7 each	Mathabhanga 32, Jalpaiguri 23, Cooch Behar 20, Murti & Domohani 19 each, Champasarai 18, Baghdogra, Gajoldoba & Panjim 17 each, Karwar 16, Mekhliganj, Nagarkata & Alagadda 15 each, Silvasa 14, Hasimara, Chepan, Vapi & Ratnagiri 13 each, Mangrol, Dahanu, Vengurla, Darsi, Tenali & Pradattur 11 each, Khonsa, Bhadrachalam & Vempalli 10 each, Darjeeling, Regoli, Umbergaon, Kalyanpur, Porbandar, Lakhapat, Ankola & Shirali 9 each,	Chikkodi 14, Kadiri 10, Savanur 9, Alagadda & Yadagiri 8 each, Udayagiri, Cuddapah & Yelburga 7 each	Dehra Dun 9, Varanasi, Rudraprayag & Mahuwa 8 each, Hasimara, Uttarkashi & Marora 7 each

TABLE 11 (*Contd.*)

(1)	(2)	(3)	(4)	(5)
		Kakrahi & Naliya 8each, Dhubri, Barobhisa, Sevoke, Bansi, Manki & Subramanya 7 each		
7	Vadakara 16, Mudibidere, Ankola & Kalasa 12 each, Mudigere 11, Mangalore 8, Gheropara, Tantloi, Kozhikode & Kottayam 7 each	Panjim 25, Karwar 20, Dahanu 18, Kakrahi & Umbergaon 16 each, Mangalore & Ankola 12 each, Bansi, Dehra Dun, Valsad, Avanigadda, Eturnagaram & Kunnavaram 11 each, Gorakhpur, Kaikalur, Panambur & Kumta 10 each, Chanpatia, Bridghat, Sharadanagar, Marora, Dharampur & Choriyasi Gandevi 9 each, Basua, Narasapur & Kudulu 8 each, Satna, Pardi, Kamrej, Perur & Honavar 7 each	Kherunighat 12, Maya Bandar 10, Amraghat & Srinivasapura 9 each, Bokajan, Chottabekra & Chitradurga 7 each	Matunga 11, Amraghat 9, Jai Bharali 8, Karimganj 7
8	Cherrapunji 23, Poladpur 21, Cooch Behar & Vythiri 19 each, Mathabhanga 18, Guhla & Patiala 16 each, Jalpaiguri, Kakrahi, Chandigarh & Ratnagiri 13 each, Thodupuzha 12, Bansi, Shimla & Kollur 11 each, Jabalpur & Chimur 10 each, Ambala & Bharatpur 9 each, Bareilly, Nanded, Parner & Punalur 8 each, Dhari, Soegaon, Uppinangady, Sringeri, Talaguppa & Kozhikode 7 each	Vapi 23, Daman 20, Vengurla & Kota 19 each, Alibag 18, Mumbai 17, Shirali & Agumbe 16 each, NH-31, Panjim, Udupi & Karwar 15 each, Valsad, Jurala Project & Honavar 13 each, Mangalore & Panambur 11 each, Diana, Nagrakata, Ratnagiri & Kunnavaram 9 each, Sapotra, Silvasa, Botad, Bhira, Mahabaleshwar & Medikeri 8 each, Hasimara, Jalpaiguri, Rampurhat, Dehragopipur, Shimla, Kalishil, Dahanu & Koida 7 each	Amraghat 15, Basti & Chalakudy 13 each, Gorakhpur 12, Vyithiry 9, Turtipar, Honavar & Peermade 8 each, Maya Bandar, Dibrugarh, Bridghat, Thodupuzha, & Parambikulam 7 each	Sripalpur & Basti 10 each, Itanagar, Beki Road Bridge, Bansi, Kakrahi & Regoli 8 each, North Lakhimpur & Basua 7 each
9	Cherrapunji 25, Alibag 17, Mathanguri 16, Passighat, Bahraich & Mumbai 15 each, Ambala & Nahan 14 each, Barobisha & Chandradeepghat 13 each, Rajgarh 12, Chepan, Shivganj & Amraoti 10 each, Tezu & Jagdalpur 9 each, Kollur 8, Jasdan & Minicoy 7 each	Vapi 30, Mhasala 21, Murti 20, Nagrakata, Chikhli & Panjim 17 each, Barsar & Diana 16 each, Navsari 15, Daman & Ratnagiri 14 each, Silvasa 12, Champasarai 11, Ranibandh & Elmanchili 10 each, Baghdogra, Mumbai, Akola & Karwar 9 each, Chouldhowaghat, Hasimara, Nagrota, Surian & Bhimsagar 8 each, Jalpaiguri, Varanasi, Jammu, Surat, Alibag & Honavar 7 each	Gharmura & Kokrajhar 11 each, Port Blair 10, Karimganj 9, Matizuri, Annapurnaghat, Neamatighat, Berhampur, Katerniaghat & Banbasa 8 each, Nancowry, Nalbari, Guwahati, Dibrugarh, Goalpara, Baghdogra, Jalpaiguri, Patna, Sripalpur, Palmerganj, Baltara, Rajapur, Kodungalur & Piravom 7 each	Bahraich 17, Ayodhya 15, Kakardharighat 12, Balarampur 11, Basti 10, Sultanpur 7
10	Mangalore 11, Passighat & Mulki 9 each, Shillong & Panjim 7 each	Gandevi & Vanthli 17 each, Mangalore 14, Mahendragarh, Bhopal, Veraval & Yellapura 12 each, Mendarda, Guhagar & Kamareddy 11 each, Mathabhanga, Keonjhargarh, Diu, Panjim, Panambur, & Mudigere 10 each, Mohitnagar, Silvasa, Navsari & Mumbai 9 each, Raipur, Madhuban, Umbergaon, Junagadh, Naliya & Moregaon 8 each, Jalpaiguri, Jagadhari, Guna, Ratnagiri & Karkala 7 each	Bareilly & Banbasa 16 each, Kangra & Dharampur 15 each, Marora & Dummagudem 14 each, Ayodhya & Kaleswaram 12 each, Chiplun & Avanigadda 11 each, Cooch Behar 10, Repalle 9, Khajuraho, Nanipalsan & Mahabaleshwar 8 each, Guwahati, Khowang, Balimundali, Dehra Dun, Hoshangabad, Gandevi, Chandgad, Peddapuram, Dundigal & Bhadrachalam 7 each	Mukhlishpur 21, Chandradeepghat 18, Basti 17, Bansi 14, Regoli 13, Kakrahi 12, Asansol & Bahraich 9 each, Ayodhya 8.
11	Hasimara 36, Ratnagiri 30, Panjim 14, Beki Mathanguri & Domohani	Gaganbavada 18, Kangsabati Dam & Vapi 12 each, Chatnag, Allahabad, Silvasa & Mhasala 11	Vapi 25, Murud 18, Nizamabad 16, Jaggar Dam & Agumbe 15 each, Bareilly & Nizamsagar 14 each,	Sonbarsa 7

TABLE 11 (*Contd.*)

(1)	(2)	(3)	(4)	(5)
	12 each, Panambur 10, Mangalore 9, Maya Bandar 8	each, Kharagpur, Madhuban, Bhagamandala & Kozhikode 10 each, Midnapur, Basti, Kamardi, & Thaliparamba 9 each, Bareilly, Halena, Panjim, Perur & Belthangady 8 each, Khowong, Bhira, Koida, Puttur, Kota & Koppa 7 each	Marora, Armoor & Karimnagar 13 each, Pardi, Silvasa, Daman & Mumbai 12 each, Depalpur & Valsad 11 each, Una, Sindewahi & Honavar 10 each, Piravom 9, Dibrugarh & Madhuban 8 each, Murti, Rohtak, Kathua, Hindon, Dundigal & Karwar 7 each	
12	Kollur & Bhatkal 19 each, Cooch Behar 14, Panjim & Gadag 13 each, Barobisha, Khonsa & Bhadrachalam 12 each, Karwar & Hosanagara 10 each, Badatighat & Kollguppa 9 each, Dowliaswaram & Hyderabad 8 each, Kokrajhar, Peddapuram & Dundigal 7 each	Perur 36, Alibag & Hosanagara 20 each, Eturnagaram 18, Thane Belapur, Mahabaleshwar & Kalasa 17 each, Mumbai & Mudigere 16 each, Valparai 15, Jalalpur & Koppa 14 each, Navsari & Bhira 13 each, Dharampur, Harnai, Manki, Siddapura & Kamardi 11 each, Bhubaneswar, Vapi, Gaganbavada & Medak 10 each, Basoli, Umrer, Gadchiroli, Belthangady, Belgaum & Kozhikode 9 each, Cuttack, Bhoond, Dungala, Bardoli, Chiplun, Vengurla, Kuhi, Dundigal & Hanagal 8 each, Ukai, Panhala, Gondia, Nagpur, & Palakkad 7 each	Bhalukpong 16, Chouldhowaghat 14, Jasdan 12, Barobhisa & Lilla 11 each, Aurangabad 10, Sevoke, Modasa, Mahuva, & Pandharkawada 9 each, Annapurnaghat, Jaora, Palsana, Amreli & Mangaon 8 each, Lakhipur, Dhar, Hathmatiweir, Kinwat & Kamtee 7 each	Nil
13	Jai Bharali NT X-ing 19, Tezpur 15, Sevoke 10, Chepan 8, Kokrajhar & Champasarai 7 each	Dharampur 39, Mumbai 35, Nanipalsan 28, Vapi & Bansda 19 each, Kaprada 17, Umred 15, Daman & Kuhi 14 each, Matunga, Amraoti & Nagpur 13 each, Naharkatia & Silvasa 11 each, Darjeeling & Yeotmal 8 each, Khowang, Dibrugarh, Jhajjar & Ramgarh 7 each	Bahraich 14, Khambalia 10, Baghdogra, Haripur & Mehsana 9 each, Navasari & Dharampur 8 each, Golaghat, Karimganj, Banbasa, Vallabh Vidya Nagar & Radhanpur 7 each	Nil
14	Karimganj & Halflong 9 each, Tezu, Barobisha, Chepan, Guna & Raipur 7 each	Sanad 48, Dholka & Karjan 44 each, Bavla 38, Ahmedabad 33, Kamardi 20, Broach 18, Lakhtar 17, Wadhvan & Kollur 16 each, Rapar, Chandgad & Yellapura 15 each, Agumbe 14, Siddapura & Koppa 13 each, Mount Abu 10, Amritsar, Susner & New Kandla 9 each, Bhuj 8, Munger, Daman & Khannapura 7 each	Haripur & Jaipur 12 each, Lakkireddypally 10, Passighat, Nagarkata, Galgalia & Bundi 9 each, Dehra Dun 8, Kamtaul, Chillaghat, Hindon & Jhanjgir 7 each	Balimundali 26, Jaipur 20, Champua 11, Digha & Balasore 10 each, Diamond Harbour & Mandya 8 each, Kharidwar, Baripada & K. R. Sagara 7 each
15	Sripalpur & Patna 12 each, Jainagar & Ahirwalia 11 each, Sevoke 10, Perumbavur 7	Srirampur 21, Galgal 12, Anjar 11, Diodar & Ahwa 10 each, Bahalpur, Goalpara, Mount Abu, Bachau, Rapar, Morbi, New Kandla & Kollur 9 each, Varanasi, Kakrahi, Mukhlishpur, Chikhli, Visnagar, Bhachau, Chandgad & Mani 8 each, Khagaria, Basti, Chandradeepghat, Dharampur, Rupangarh, Lakhapat & Hosdurg 7 each	Chillaghat 24, Mathabhanga 12,. Sultanpur, Dehra dun, Kahu 11, Jaunpur 10, Dhollabazar, Dibrugarh & Tharad 9 each, Chepan 8, Khowang, Ankinghat, Banera, Kakri, Deesa, Wanakbori & Coimbatore 7 each	Bhalukpong 20, Chouldhowaghat 15, Tezpur 13, Hasimara 9, Amraghat & Chottabekra 8 each, North Lakhimpur & Valparai 7 each
16	Amraghat 33, Gohar 13, Jogindernagar 12, Bahraich, Varanasi, Marora & Sompeta 7 each	Nokah 29, Sarotary 16, Bhinmal 15, Dantiwada & Danta 14 each, Paonta, Nahan, Jammu & Pokhran 11 each, Durgapur, Basti & Sirsa 10 each, Samastipur & Haripur 9 each, Naraingarh 8, Turtipar, Dehra Dun & Banbasa 7 each	Chillaghat 25, New Delhi 23, Balarampur 13, Itanagar 11, Narela 10, Samastipur, Bahraich & Haripur 9 each, Banda & Kollur 8 each, Chouldhowaghat, Rosera, Bhatpurwaghat, Hindon, Hamirpur, Narora, Rohtak & Nagapattinam 7 each	Chouldhowaghat 15, North Lakhimpur 12, Varanasi 9, Dibrugarh, Khowong & Dhollabazar 8 each, Dhubri, Lakhipur & Mathabhanga 7 each

TABLE 11 (*Contd.*)

(1)	(2)	(3)	(4)	(5)
17	Matunga 13	Nangal Dam 15, Kahu 14, Anandpur Sahib & Dehragopipur 13 each, Ropar, Una & Ladnoo 12 each, Didwana 11, Marora & Samrala 10 each, Nalagarh 8, Kharidwar, Jhajjar, Kaithal, Ludhiana, Ajmer, Pushkar, Udaipur, Mahabaleshwar, Gadchiroli & Mul 7 each	Shahjina, Banda & Hamirpur 8 each, Basti 7.	Hasimara 21, Champasarai 19, Murti 15, Dhubri 14, Sevoke 13, Barobisha 12, Beki road Bridge 11,Jhawa & Katerniaghat 10 each, Beki Mathanguri, Bahalpur & Cooch Behar 9 each, Prodattur, Dharamapuri & Bangalore 8 each, Goalpara, Matunga, Baghdogra, Basua, Machilipatnam, Cuddapah & Palamner 7 each
18	Nil	Chandigarh & Umrer 26 each, Arjunimorgaon 25, Bhirapur 24, Dharampur 23, Jagadhari, Ambala & Derabassi 21 each, Gadchiroli 19, Kalka & Ashti 18 each, Nalagarh & Kuhi 16 each, Naraingarh & Pandharkawada 15 each, Solan & Sindewahi 14 each, Kahu & Rajgarh 13 each, Dibrugarh & Yeotmal 12 each, Nabha 11, Ropar 11, New Delhi, Shimla & Chaksu 10 each, Neamatighat 9, Banswara 8, Keonjhargarh, Thanesar, Patiala, Mahuwa & Umedsagar 7 each	Ayodhya 12, Amraghat 11, Baijnath 10, Hut Bay 9, Narayanpur, Puri, Sohagpur & Rajamundry 8 each, Fatehgarh 7	Tantloi 41, Suri 22, Tilpara Barrage 16, Asansol 15, Rangagora & Hatwara 14 each, Kashipore 13, Balasore 10, Berhampore & Hakimpet 9 each, Annapurnaghat, Karimganj Suri, Visakhapatnam & Medchal 8 each, Kailashahar, Gorakhpur, Saundatti & Gulbarga 7 each
19	Agumbe 16, Sironcha 13, Kalimpong & Chandrapur 12 each, Medikeri 10, Beki Road Bridge 7	Gondia 23, Jhansi 16, Darwah 15, Yeotmal 13, Wardha 12, Nagpur 11, Rangagora & Chandrapur 10 each, Tantloi 8, Singla Bazar, Tadong, Ranchi & Paonta 7 each	Kataula 10, North Lakhimpur & Amraghat 9 each, Guwahati, Gharmura & Haripur 8 each, Port Blair, Malda, Gangtok, Laxmangarh, Sakoli, Bhamragarh, Subramanya, Kollur & Piravom 7 each	Suri 62, Tilpara Barrage 55, Tantloi 40, Narayanpur, Kondi & Malavalli 33 each, Krishnanagar 22, Dhaniakhali & Bashirhat 17 each, Dengraparaghat 14, Harinkhola 13, Salem 9, Uluberia & Dubbak 7 each
20	Kota 18, Agumbe 14, Karkala 13, Panjim & Siddapura 11 each, Kundapura 10, Jai Bharali NT Xing & Poonampet 9 each	Sironj 19, Guna 17, Bauwer Gau, Gopo Pussa & Ganj Basoda 16 each, Vatale 13, Sibsagar & Chachaura 12 each, Jhansi 11, Bais road Garh & Jabalpur 10 each, Rudraprayag 9, Gadchiroli 8, Bhatpurwaghat, Mandi, Vidisha, Narsinghpur & Sohagpur 7 each	Dhollapur 10, Port Blair & Sepadar 9 each, Kama & Talab Shahi 8 each, Namsai, Karoli, Baseri & Bari 7 each	Narayanpur & Harinkhola 21 each, Krishnanagar 15, Sriniketan 14, Tantloi 11, Malda 10, Banbasa 7
21	Hasimara 25, Baghdogra 23, Murty 20, Bani 12, Galgalia, Hanuman Setu & Kayamkulam 10 each, Khajuraho 7	Bijolia 39, Asnawar 31, Aklera , Manohar & Thana 26 each, Chand Ka Talab 25, Jahajpur 24., Raipur, Chawli, Khanpur, Jhalarapatan & Bundi 23 each, Jhalwar 21, Kota 20, Biora, Sironj & Rajgarh 17 each, Narsinggarh 15, Bansi 13, Mandsaur & Vidisha 12 each, Munger, Chandradeepghat & Chittorgarh 11 each, Bashirhat 10, Baijnath & Nagaur 9 each, Kalna & Gorakhpur 8 each, Ranaghat, Degana, Sripalpur & Bhilwara 7 each	Khanpur 19, Domohani 10, Jalpaiguri, Harish Chand Sagar & Medikeri 9 each, Ongole & Sri Sailam 8 each, New Delhi, Bhinay, Mahabaleshwar & Darsi 7 each	Tantloi 50, Narayanpur 16, Munger 15, Suri & Khagaria 13 each, Tikarpara 11, Gheropara & Tilpara Barrage 10 each, Sriniketan & Rosera 9 each, Asansol, Kursela & Basua 8 each, Talcher & Hatidah 7 each
22	Barobisha 40, Chepan & Jalpaiguri 28 each, Cooch Behar 25, Galgalia 22, Cherrapunji, Kakrahi, 21, Taibpur 16, Itanagar & Samastipur 11 each, Beki Mathanguri 10, Tezu 9, Patna, Varanasi, Jammu, Paderu & Dummagudem 7 each	Beawar 20, Tantloi & Burdwan 18 each, Gheropara & Guda Dam 13 each, Suri, Krishnanagar & Jhajpur 12 each, Bijolia 11, Durgapur, Harinkhola & Jawaja 10 each, Haripur & Mount Abu 9 each, Nalagarh 8, Amraghat, Sriniketan, Dehra Dun & Kahu 7 each	Amraghat 16, Nandyal 11, Bhatpurwaghat 10, Bhawargarh Colony, Vapi & Madhuban 9 each, Mahabaleshwar 8, Gopalpur, Ramgarh & Shirali 7 each	Munger 33, Khagaria 25, Samastipur 20, Narayanpur 11, Shirol 9, Jhanjharpur & Tiptur 7 each

TABLE 11 (*Contd.*)

(1)	(2)	(3)	(4)	(5)
23	Cherrapunji & Roing 31 each, Malda 18, Beki Mathanguri 17, Barobisha, Chanpatia & Sonbarsa 11 each, Tezu 9, Itanagar, Guwahati & Vempalle 8 each, Shillong & Tusuma 7 each	Suri 20, Gheropara 18, Sriniketan, Tilpara Barrage & Bolpur 14 each, Burdhwan 10, Didwana 9, Canning Town & Uluberia 8 each, Kolkata 7	Sriharikota 25, Paleru Bridge, Koilkuntla & Medikeri 16 each, Nandgaon, Machilipatnam & Ongole 15 each, Bapatla & Darsi 13 each, Nandigama 11, Kailashshahar, Kavali, Nellore & Prodatur 10 each, Kankavali, Jamalamadugu, Valparai & Shimoga 9 each, Mumbai, Dundigal, Cuddapah & Gooty 8 each, Mahendragarh, Bareilly, Jammu, Gangapur, Ratnagiri & Hyderabad 7 each	Pendra, Sholapur & Belgaum 9 each, Chickmagalur 8, Siddapura, Hidkul Dam, Ajjampura, Hollenarasipura & H. D. Kote 7 each
24	Dhubri 23, Jowai 20, Roing 19, Tezu, Shillong 12, Guwahati 9, Karimganj & Munger 7 each	Lunkaransar 23, Kondi & Haripur 18 each, Krishnanagar & Nakshipura 15 each, Suri & Fazhilka 10 each, North Lakhimpur, Kataula & Ghursana 8 each, Pandoh, Sardarshahar & Vijayanagar 7 each	Dundigal 25, Hyderabad 24, Hakimpet 18, Pargi 14, Kannad, Udgir & Nizamsagar 13 each, Ambejogai & Parbhani 11 each, Bihubar, Ratnagiri, Palghar & Medak 8 each, Kaman, Malvan, Rajuri, Aurangabad & Perur Bridge 7 each	Mudhol 9, Bhalukpong 7
25	Shillong 12, Kokrajhar 11, Amraghat 8, Taibpur 7	Golaghat 27, Krishnanagar 18, Jhanjharpur 16, Shahpurkandi 13, Triveni 12, Margherita, Ranjit Sagar Dam & Basholi 11 each, Pandoh 10, Kamtaul 9, Madhopur & Patiala 8 each, Araria, Jainagar, Kataula & Patti 7 each	Guhagar 36, Palghar & Panambur 19 each, Bhagamandala 18, Dapoli & Mudibidere 16 each, Harnai & Mangalore 15 each, Ratnagiri & Udupi 14 each, Kottayam 12, Dahanu, Madapura & Kochi 11 each, Pathardi & Medak 10 each, Umbergaon & Kalyan 9 each, Mumbai, Alibag, Visakhapatnam & Honavar 8 each, Vapi, Silvasa, Lathi, Vadgaon, Valparai, Somwarpet & Ammathy 7 each	Cooch Behar 15, Dhubri 10, Tezpur & Chouldhowaghat 8 each, Sibsagar 7
26	Solan 12, Domohani 11, Beki Mathanguri, Jowai & Gokarna 8 each, Karimganj, Jalpaiguri & NH31 7 each	Korba 27, Simulia 9, Miao & Khanitar 8 each, Damoh 7	Honavar & Agumbe 17 each, Kumta & Kottayam 13 each, Nidadavole, Chinthalapudi & Koida 12 each, Vengurla & Dapoli 11 each, Siddapura 10, Jogindernagar, Harnai, Subramanya & Kochi 9 each, Mangaon, Belthangady, Dharmasthala, Karkala & Madapura 8 each, Banbasa, Ratnagiri, Panjim, Bhira, Madhira, Karwar & Alapuzha 7 each	Karimganj 16, Chalakkudy 12, Minicoy 10, Passighat, Vita & Arasalur 8 each, Murti, Hasimara & Chitradurga 7 each
27	Rangagora 11, Rajapur 10, Sundernagar, Baijnath, Bhatkal & Konni 8 each, Mahendragarh, Shimla & Agumbe 7 each	Katra 12, Biswan & Baijnath 10 each, Churk, Unnao & Jogindernagar 9 each, Nadaun 8, Lucknow & Mandi 7 each	Gaganbavada 14, Partur 13, Jalpaiguri & Dapoli 11 each, Gharmura & Nalbari 9 each, Galgalia, Nadaun, Sindi & Medikeri 8 each, Matunga, Baghdogra, Malwan & Akola 7 each	Koderu 8, Mancherial 7
28	Jogindernagar 13, Mangalore 12, Amraghat, Chottabekra, Taibpur & Puttur 11 each, NH-31 & Agumbe 10 each, Galgalia, Kangra, Panambur & Mulki 9 each, Jalpaiguri, Khadda, Baijnath, Elmanchili & Udupi 8 each, Nagarkata, Gajoldoba, Kathua, Jagdalpur & Mangalore 7 each	Kathua 37, Baijnath 15, Katra 11, Narsinghpur 10, Kataula, Paonta, Ghamroor, Mandi & Udhampur 8 each, Narora, Kotdwar, Kangra & Guler 7 each	Kaleshwaram 22, Dapoli 21, Harnai & Madangad 18 each, Mahabaleshwar 17, Lalbegiaghat 16, Chiplun 15, Panjim & Mancherial 14 each, Poladpur 13, Nagrota, Surian & Panvel 11 each, Ramgundam 10, Nalbari, Alibag & Murbad 9 each, Thane, Nanded & Hingoli 8 each, Matunga, Mumbai, Ahmednagar, Shevgaon, Khandar, Purna, Jagityal & Kollur 7 each	Punalur 20, Alapuzha 10, Haveri 9, Tadong, Hosanagara 8

TABLE 11 (*Contd.*)

(1)	(2)	(3)	(4)	(5)
29	Pathri 10, Tezpur, Kathua, Thane & Gaganbavda 9 each, Katra & Jagdalpur 8 each, Ratnagiri & Mangalore 7 each	Champasarai 19, Bakani 9, North Lakhimpur, Gajoldoba & Dasuya 8 each, Tezu & Galgalia 7 each	Baijnath 20, Wada 18, Amraghat 16, Jogindernagar, Madhuban, Jawahar & Mahabaleshwar 13 each, Songadh 12, Nagrakata, Domohani, Bareilly & Madangad 11 each, Murti, Saulighat, Chiplun & Igatpuri 10 each, Gajoldoba, Banbasa, Nanipalsan, Bhira, Dapoli, Bhadrawati & Arjunimorgaon 9 each, Shahjina, Hamirpur, Eturnagaram & Perur 8 each, Birdeghat, Chillaghat, Pandoh, Silvasa, Alibag & Sakoli 7 each	Hut Bay 7
30	Nagarkata 17, Bhatkal 15, Murti, Jalpaiguri, Domohani & Udupi 13 each, Kota 12, Jogindernagar & Mulki 11 each, Dharavi 10, Hingoli, Kurnool & Mangalore 9 each, Vengurla & Karwar 8 each, Naraingarh, Pandoh, Gohar, Nadaun, Malvan, Jalgaon & Alapuzha 7 each	Dehra Dun 19, Marora 12, Araria 9, Kunda 8, Gyanpur, Nagina & Lansdown 7 each	Lucknow 25, Hanuman Setu 14, Darjeeling, Basti, Chandradeepghat 11, Patna, Bani 10, Sripalpur 9, Chanpatia, Raebarely 8, Khanitar, Rewaghat, Marora & Ankola 7 each	Nil
31	-	Nadaun 12, Barobisha 11, Triveni 10, Mathanguri, Jalpaiguri, Sevoke, Anandpur, Taibpur & Basti 9 each, Chepan, Munger, Dhengraghat, Gazhiabad & Mandi 8 each, Domohani, Banbasa & Kolar 7 each	Hardwar 23, Marora 12, Chatnag 11, Raebarely, Lucknow, Bahraich, Banbasa & Gaganbawda 10 each, Bhatpurwaghat 9, Dehra Dun & Mandi 8 each, Gorakhpur, Bareilly, Naraingarh, Pandoh, Dharampur, Sakti, Malvan & Bhagamandala 7 each	-

Nagaland, Manipur, Mizoram & Tripura, Sub-Himalayan West Bengal & Sikkim, Bihar Plains, Hills of west Uttar Pradesh, Haryana, east Madhya Pradesh, Gujarat Region, Marathwada, Vidarbha, coastal Andhra Pradesh, Telangana, Tamil Nadu, coastal & north interior Karnataka and Kerala. Heavy rain also occurred on 7 to 11 days in Assam & Meghalaya, Sub-Himalayan West Bengal & Sikkim, east Uttar Pradesh, Himachal Pradesh and south interior Karnataka; on 4 to 6 days in Andaman & Nicobar Islands, Orissa, Bihar Plains, plains of west Uttar Pradesh, Hills of west Uttar Pradesh, Gujarat Region, Konkan & Goa, Madhya Maharashtra, Marathwada, coastal Karnataka and Kerala and on 1 to 3 days in Arunachal Pradesh, Nagaland, Manipur, Mizoram & Tripura, Gangetic West Bengal, Haryana, Punjab, east Rajasthan, west Madhya Pradesh, coastal Andhra Pradesh, Tamil Nadu and north interior Karnataka.

9.4. *Heavy rainfall during September*

During the month, very heavy rainfall occurred on 3 to 5 days in Assam & Meghalaya, Gangetic West Bengal, Bihar Plains and east Uttar Pradesh and on 1 to 2 days in Sub-Himalayan West Bengal & Sikkim, Orissa, plains of west Uttar Pradesh, Hills of west Uttar Pradesh, Tamil Nadu, south interior Karnataka and Kerala. Heavy rain also occurred on 7 to 10 days in Arunachal Pradesh, Assam & Meghalaya, Orissa and south interior Karnataka; on 4 to 6 days in Sub-Himalayan West Bengal & Sikkim, Gangetic West Bengal, east Uttar Pradesh, Hills of west Uttar Pradesh, Himachal Pradesh, Tamil Nadu and north interior Karnataka and on 1 to 3 days in Bihar Plateau, Bihar Plains, plains of west Uttar Pradesh, Punjab, east Madhya Pradesh, Saurashtra & Kutch, Konkan & Goa, Madhya Maharashtra, Vidarbha Telangana, coastal Karnataka and Kerala.

10. Significant temperature during the season

Significant temperatures were noticed only in the month of June and in remaining three months of the season, the temperature were within reasonable limits.

Day temperatures were markedly above normal (departure from normal temperature is +5° C to +6° C for the regions where the normal maximum temperature is

40° C or less) on 1 day each in some parts of Saurashtra & Kutch and coastal Andhra Pradesh and were appreciably above normal (departure from normal temperature is +3° C to +4° C for the regions where the normal maximum temperature is 40° C or less) on 7 to 9 days in Jammu & Kashmir and west Rajasthan and on 1 to 4 days in Gangetic West Bengal, Orissa, Haryana, east Rajasthan, Gujarat Region, Saurashtra & Kutch and coastal Andhra Pradesh. They were generally markedly to appreciably below normal (departure from normal temperature is −5° C to −6° C, for the regions where normal minimum temperature is 10° C or more) in Bihar, east Uttar Pradesh, plains of west Uttar Pradesh, hills of west Uttar Pradesh (now Uttaranchal), Haryana and Punjab during first two weeks of the month. Highest day temperature of 46° C was recorded at Ganganagar (Rajasthan) on 2 June.

11. Disastrous weather events and damages during monsoon months

11.1. *June*

Heavy rains, lightning and floods took a toll of 174 (56 in Uttar Pradesh, 37 in Assam and adjacent states, 36 in Maharashtra, 15 in Kerala, 13 in West Bengal, 10 in Gujarat, 6 in Karnataka and 1 in Tamil Nadu) human lives. 2000 people were missing in Assam. Flood situation in Assam affected 4,82,228 people of 13 districts. Heavy rain also caused water logging and disrupted traffic in Mumbai. Widespread damage to property & Agriculture was also caused due to heavy rain in Kerala.

11.2. *July*

In all, 655 (273 in Maharashtra, 150 in Himachal Pradesh, 84 in Gujarat, 64 in Kerala, 30 in Andhra Pradesh, 15 in West Bengal, 14 in Assam & adjacent states, 13 in Madhya Pradesh and 6 each in Goa and Karnataka) people lost their lives due to heavy rains and floods. In Assam, 54,931 hectares of crop area affected. 250 houses damaged in Goa due to landslide and Konkan Railway service disrupted for 10 days.

11.3. *August*

Telangana sub-division experienced exceptionally heavy rains, especially Hyderabad city received 241.5 mm rain on 24 August 2000. 142 people died; 8,651 houses were fully damaged and 27,026 houses partially damaged. 5,368 cattle heads died and 1,77,987 hectares of paddy and other crops damaged in 4 districts of Telangana. Heavy rain also took a toll of 177 (56 in Uttar Pradesh, 36 in Assam, 39 in Kerala, 31 in Maharashtra, 6 in Himachal Pradesh, 5 in Madhya Pradesh and 4 in Karnataka) people in other parts of the country.

11.4. *September*

Heavy rains and flood took a toll of 1258 persons in West Bengal and 98 in Bihar. 8 (2 each in Assam, Maharashtra and Karnataka and 1 each in Madhya Pradesh and Kerala) people also died due to heavy rain.

12. Damages due to floods etc. during monsoon season

During the season, floods, heavy rains, landslides took a toll of 2,512 people (1,286 in West Bengal, 342 in Maharashtra, 172 in Andhra Pradesh, 156 in Himachal Pradesh, 119 in Kerala, 112 in Uttar Pradesh, 98 in Bihar, 94 in Gujarat, 89 in Assam, 19 in Madhya Pradesh, 18 in Karnataka, 6 in Goa and 1 Tamil Nadu). Road and rail traffic were also disrupted due to heavy rains in many parts of the country including cities like Mumbai and Hyderabad.

Damages due to floods and heavy rains in June, July, August and September have been discussed above in para 11.1., 11.2., 11.3. and 11.4. respectively.

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