Mausam, (1990). **41**, 3, 505-520

Weather

MONSOON SEASON (JUNE–SEPTEMBER 1989)*

1. Introduction

The year 1989 was another good monsoon year for the country followed by very good monsoon year of 1988. This was the third best monsoon year in this decade starting from 1980. In 1980, the summer monsoon rainfall for the country as a whole was 1% above normal. In other two best years of the decade the summer monsoon rainfall was +19% and +13% of the normal in 1988 and 1983 respectively. In 1989 about 77% of the area of the country received excess or normal monsoon rainfall as against 88% area of the country in 1988. There was no major floods over the known flood prone areas of the country during monsoon 1989. However, there was severe flood on one occasion in Maharashtra in the month of July. Over the areas where the seasonal rainfall was deficient the rainfall deficiency was not very significant except on a small pocket covering parts of east Rajasthan, northwest Madhya Pradesh and adjoining parts of Haryana including Delhi where the seasonal rainfall deficiency was quite large.

Monthly and seasonal rainfall statistics for June to September 1989 have been given in Table 1. Seasonal rainfall departures analysed on the basis of individual station's rainfall are shown in Fig. 1.

For classification of the short period as well as the long period rainfall distribution the following norms have been followed :

Classification	*Percentage departure of rainfall from the normal*	
	Monthly	*Seasonal*
(*i*) Excess (E)	20 or more	10 or more
(*ii*) Normal (N)	+ 19 to — 19	10 to — 10
(*iii*) Deficient (D)	— 20 to — 59	
(*iv*) Scanty (Sc)	— 60 or less	

2. Chief features of the season

2.1. *Advance of southwest monsoon*

Southwest monsoon set in over Kerala on 3 June. The onset was in association with a shallow trough in the low level and it was not in association with any vortex.

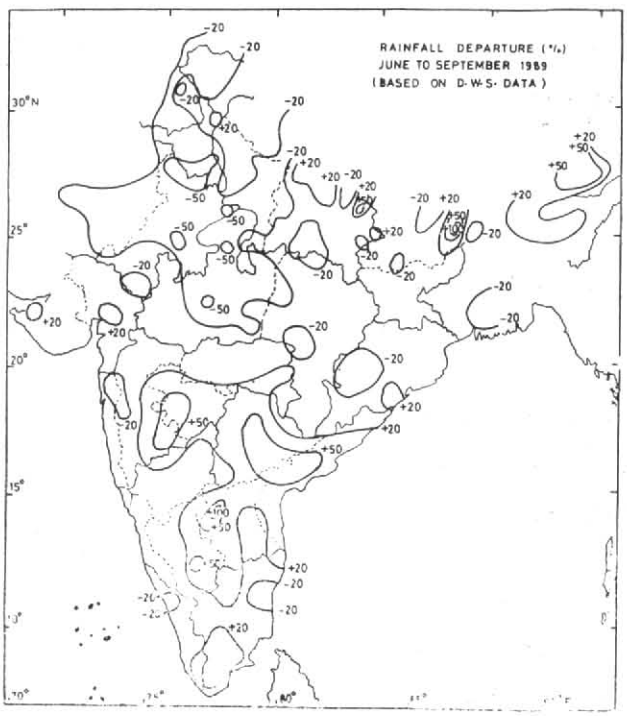

Fig. 1. Percentage rainfall departure for the period 1 June to 30 September 1989 based on D.S.W. data

The Arabian Sea branch of the monsoon current advanced steadily northwards up to south Gujarat by 10 June and covered most of the areas of Gujarat State by 11 June. The Bay branch of the monsoon current advanced over Assam and adjacent States on 6 June. Thereafter, it stalled there for about a week. The second phase of the advance over the northern plains commenced on 13 June and it covered the northern parts of the Peninsular India and the northern plains up to the eastern parts of west Uttar Pradesh by 23 June. The third phase of the advance commenced on 29 June and it covered the remaining parts of the country by 2 July. The onset of monsoon in various parts of the country is shown in Fig. 2.

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TABLE 1

Sub-divisional means of rainfall (mm) in each month and during the season as a whole—June to September 1989 (Based on D.W.S. data)

Sub-divisions	Jun		Jul		Aug		Sep		Season (Jun-Sep)		
	Actual	Dep.%	Actual	Dep. %	Actual	Dep. %	Actual	Dep.%	Actual	Normal	Dep. %
(1) Andaman & Nicobar Islands	447	—9	385	+11	305	—17	222	—45	1359	1611	—16
(2) Arunachal Pradesh	358	—40	1064	+45	491	—7	345	+23	2258	1849	+22
(3) Assam & Meghalaya	573	—1	644	+35	459	—4	509	+56	2184	1857	+18
(4) Naga., Mani., Mizoram	417	—9	257	—24	291	+4	183	—21	1148	1231	—7
(5) S.H.W.B. & Sikkim	497	—7	545	—10	352	—30	591	+45	1985	2050	—3
(6) G. West Bengal	317	—27	260	—19	228	—25	227	—7	1032	1105	—7
(7) Orissa	310	+45	247	—32	375	+7	206	—17	1146	1181	—3
(8) Bihar Plateau	189	+4	359	+3	228	—30	191	—14	968	1077	—10
(9) Bihar Plains	132	—22	460	+46	210	—33	266	+19	1067	1020	+5
(10) East Uttar Pradesh	144	—42	320	+5	181	—39	227	+15	872	902	—3
(11) Plains — West U.P.	92	+13	125	—53	232	—12	159	—10	607	784	—23
(12) Hills — West U.P.	174	+9	290	—26	386	—18	237	+17	1087	1222	—11
(13) Har., Chandi. & Delhi	71	+41	77	—55	167	—1	39	—64	355	501	—29
(14) Punjab	66	+57	164	—11	163	0	24	—75	418	488	—14
(15) Himachal Pradesh	97	0	266	—26	323	—19	41	—65	728	976	—25
(16) Jammu & Kashmir	53	—14	295	+41	123	—29	69	—41	539	561	—4
(17) West Rajasthan	37	+41	59	—43	88	—17	42	—30	226	295	—23
(18) East Rajasthan	82	+46	79	—66	183	—21	48	—64	392	650	—40
(19) West Madhya Pradesh	129	+9	170	—48	334	+12	96	—49	729	930	—21
(20) East Madhya Pradesh	206	+11	275	—26	301	—21	180	—20	963	1167	—18
(21) Gujarat Reg., Daman, Dadra & Nagar Haveli	117	—15	462	+3	436	+42	91	—53	1106	1088	+2
(22) Sau., Kutch & Diu	174	+117	249	+4	60	—52	57	—35	540	532	+1
(23) Konkan & Goa	641	—5	1041	—6	659	—7	279	—22	2619	2852	—8
(24) Madhya Maharashtra	150	—1	300	+5	191	+1	205	+24	846	790	+7
(25) Marathwada	145	—1	432	+116	172	—9	217	+21	967	714	+35
(26) Vidarbha	191	+19	243	—22	361	+26	159	—22	954	963	—1
(27) Coastal Andhra Pradesh	140	+26	332	+95	219	+35	182	+5	872	615	+42
(28) Telangana	196	+45	468	+96	213	—1	213	+11	1090	782	+39
(29) Rayalaseema	63	+4	259	+201	39	—62	196	+46	557	383	+45
(30) T. Nadu & Pondi.	53	+5	132	+72	51	—47	126	+25	362	324	+12
(31) Coastal Karnataka	974	+12	847	—28	858	+24	278	—10	2957	3037	—3
(32) N.I. Karnataka	98	—1	229	159	71	—42	215	+42	613	519	+18
(33) S.I. Karnataka	176	+14	337	+13	191	—2	161	+14	866	788	+10
(34) Kerala	737	+7	536	—29	395	—19	282	+37	1951	2132	—8
(35) Lakshadweep	460	+50	417	+48	143	—27	190	+18	1209	943	+28

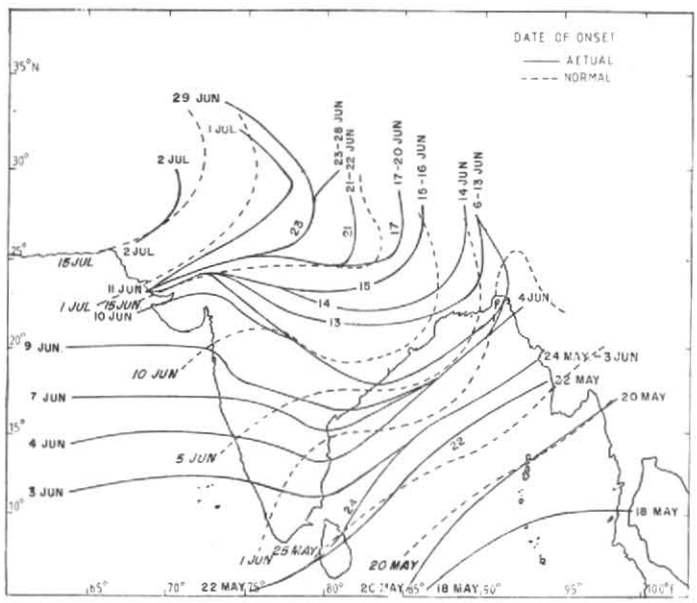

Fig. 2. Actual and normal dates of onset of southwest monsoon 1989 over India

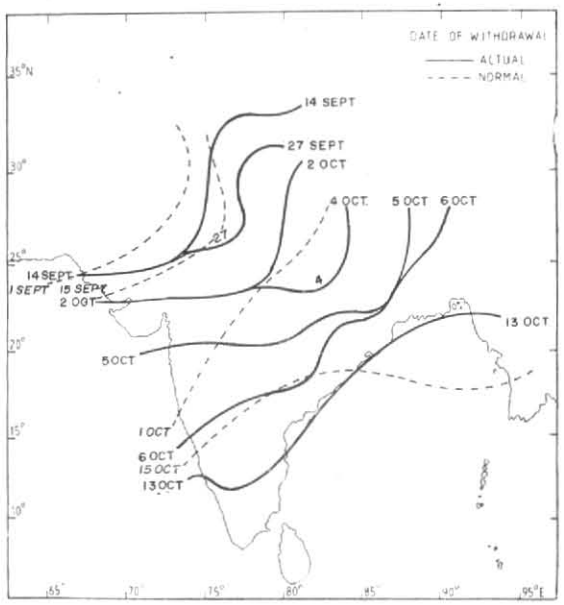

Fig. 3. Actual and normal dates of withdrawal of southwest monsoon 1989 over India

The onset of monsoon over south Kerala was on 3 June as against its normal date on 1 June. However, its advance over the Peninsula and the northern India was either in time or early. It advanced over Gujarat early by about a week and that over the western parts of Rajasthan by about two weeks.

2.2. *Weekly performance of the monsoon*

During the 17 weeks period (1 June to 27 September 1989) of the southwest monsoon season, twenty two sub-divisions received excess or normal rainfall for 8 to 11 weeks. Of these twenty two sub-divisions, seven were in the north India, thirteen were in the Peninsular India and the other two were Andaman & Nicobar Islands and Lakshadweep.

Monsoon activity over the country was the weakest during the week 7 to 13 September, when only 3 met. sub-divisions received excess or normal rainfall. The rainfall was deficient over 19 sub-divisions and scanty over 10 sub-divisions and there was no rain over 3 sub-divisions in the week. The next low activity period was observed during 3 to 9 August. During this week, 8 sub-divisions received normal or excess rainfall. Rainfall during the week was deficient in 12 and scanty in 15 sub-divisions. Monsoon rainfall during the weeks 22–28 Jun, 6–12 Jul, 27 Jul–2 Aug and 31 Aug–6 Sep were below normal. During these weeks rainfall was excess or normal over 12 to 14 sub-divisions and was scanty or deficient over 21 to 23 sub-divisions.

The weekly rainfall activity picked up during the weeks, 13–19 July, 20–26 July, 17–23 August, 24–30 August and 21–27 September when the weekly rainfall was either excess or normal in 19 to 24 sub-divisions. Rainfall during the first two weeks of June was exceptionally good, though monsoon did not cover the entire country by that time. During those periods more than half the number of sub-divisions of the country received excess or normal rainfall. Scanty rainfall occurred for three consecutive weeks in Bihar plains, Haryana, Jammu & Kashmir, Saurashtra & Kutch (twice) and in north interior Karnataka. Week by week rainfall performance of the 1989 southwest monsoon has been shown in Fig. 4.

2.3. *Monthly performance of monsoon*

Though the southwest monsoon did not advance over northwest India in the month of June, the rainfall over these areas was either normal or excess in June. Out of the 35 met. sub-divisions only two received deficient rainfall and the rest received excess or normal rainfall in June 1989. July is the month, when the country received the maximum amount of rainfall of the season. During this month rainfall was scanty over one sub-division, *i.e.*, east Rajasthan, and was deficient over 12 sub-divisions. Out of these deficient sub-divisions it was largely deficient (with 40% or more negative departure) over plains of west Uttar Pradesh, Haryana, west Madhya Pradesh and west Rajasthan. Over the other eight sub-divisions the rainfall was marginally deficient. Twenty-two sub-divisions received excess or normal rainfall during this month, of which largely excess rainfall (more than +50%) occurred over Marathwada, Andhra Pradesh, Tamil Nadu and north interior Karnataka. Departures were as large as +201% over Rayalaseema and +116% over Marathwada. The cumulative rainfall for June *plus* July, however, was deficient over six sub-divisions. Those sub-divisions were plains of west Uttar Pradesh, Haryana, Himachal Pradesh, Rajasthan and west Madhya Pradesh. The

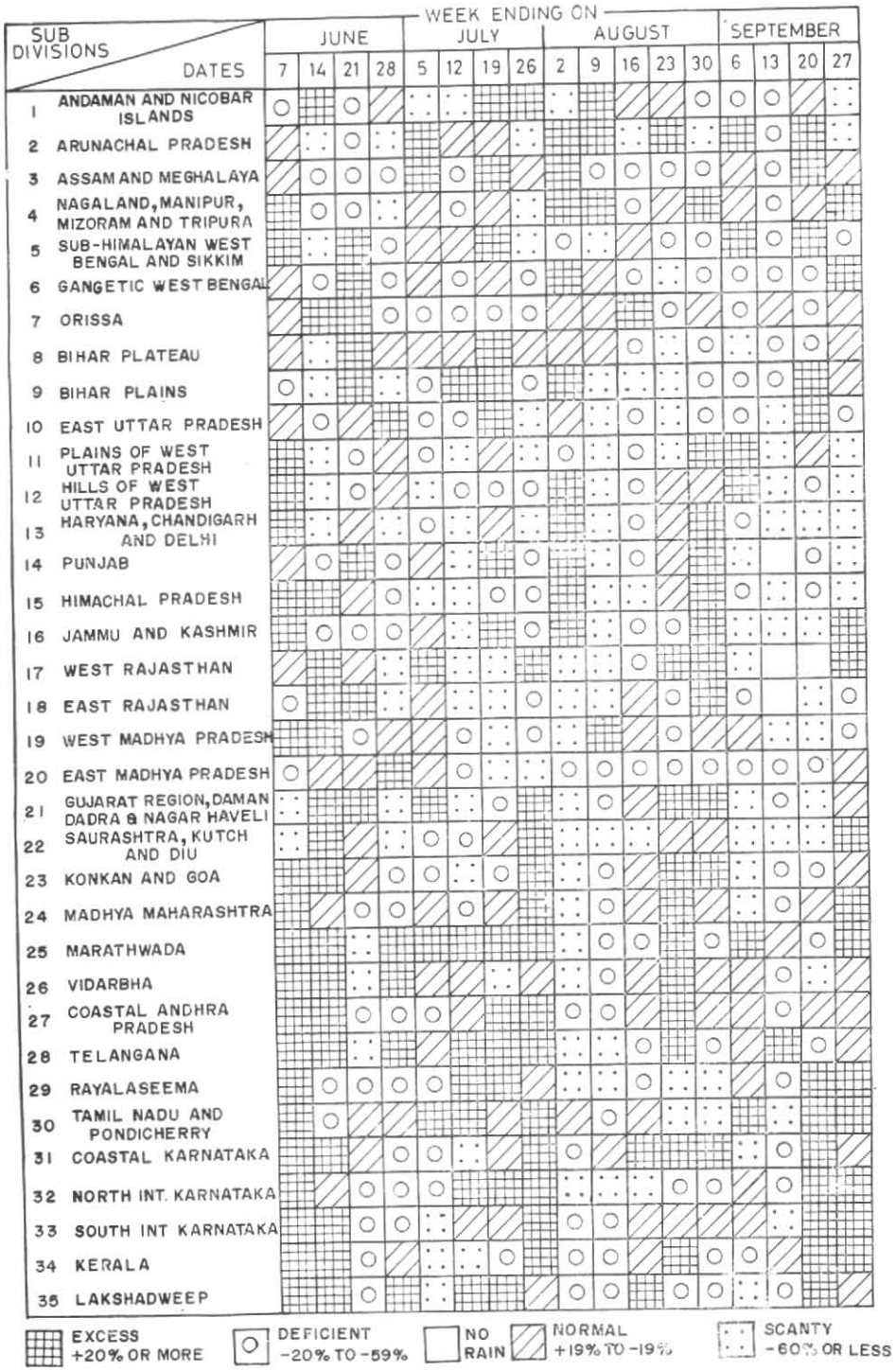

Fig. 4. Performance of week by week southwest monsoon season (June-September 1989) rainfall over the 35 Met. Sub-division of India

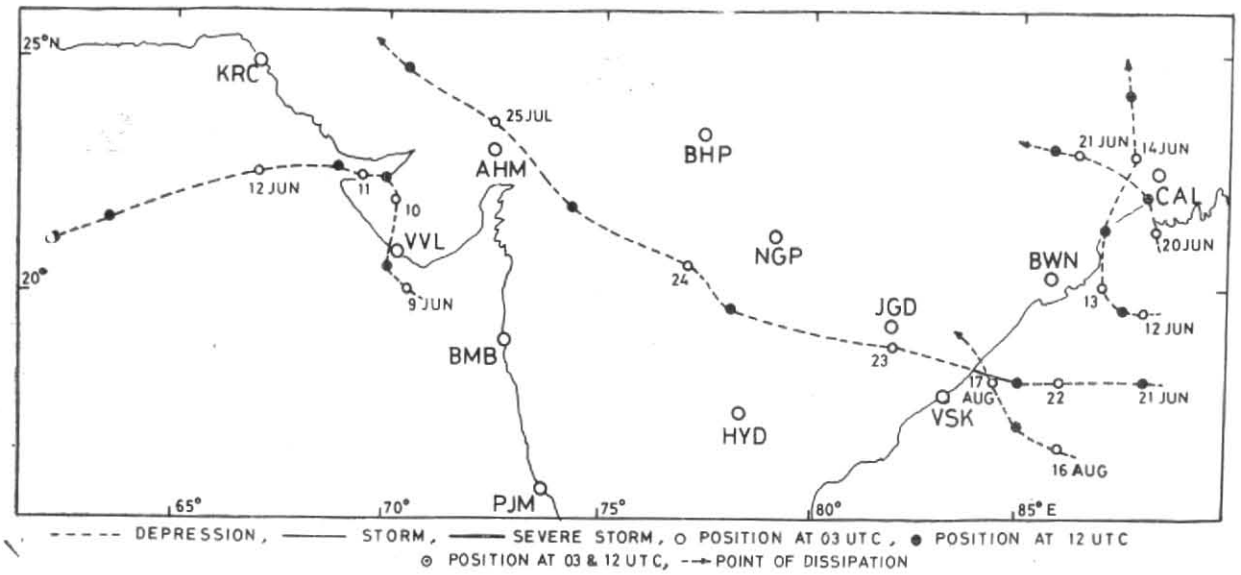

Fig. 5. Tracks of depressions/cyclonic storms formed during southwest monsoon season (June-September 1989) over Bay of Bengal and Arabian Sea

deficiency over east Rajasthan was quite large (dep. —40% or less). August is the month, which received the second highest rainfall of the season after July. During this month, one sub-division received scanty rainfall, while it was deficient over twelve sub-divisions. During this month rainfall was scanty over Rayalaseema. Amongst the deficient sub-divisions was deficient by —40% or more over Saurashtra & Kutch and Tamil Nadu. Twenty-two sub-divisions received excess or normal rainfall during this month. However, the cumulative rainfall from June to August remained deficient over four sub-divisions. Those sub-divisions were plains of west Uttar Pradesh, Himachal Pradesh and Rajasthan. The range of deficiency over those sub-divisions was between —20% and —33% from the normal. In the month of September, when the withdrawal phase of monsoon from northwest India and neighbourhood commenced, the monsoon activity over northwest and central India was quite subdued. During this month rainfall was scanty over Haryana, Punjab, Himachal Pradesh and east Rajasthan and was deficient over 10 sub-divisions. The rainfall deficiency was as large as —40% or more over Andaman & Nicobar Islands, Jammu & Kashmir, west Madhya Pradesh and Gujarat region. Rainfall was excess or normal over twenty-one sub-divisions during the month. The subdued rainfall activity over Haryana and west Madhya Pradesh during September caused deficiency in the seasonal rainfall in these two sub-divisions.

2.4. *Seasonal performance of monsoon*

Of the 35 met. sub-divisions of the country the seasonal rainfall was excess in five, normal in twenty-four and deficient in six sub-divisions (Table 1). Of these 5 excess sub-divisions four were in the Peninsular India and the other one was Lakshadweep. The six deficient sub-divisions were mostly in northwest India. Out of these six sub-divisions five had marginally deficient (—22 to —29% dep.) rainfall. However, the deficiency was quite large over east Rajasthan, where the seasonal rainfall departure from the normal was —40%. During this monsoon season there was no sub-division which received scanty rainfall. Another significant feature of the seasonal rainfall was that all the five deficient sub-divisions of northwest and central India were contiguous.

2.5. *Storms and depressions*

During the season five intense systems developed in the Indian seas. Of these five intense systems, three developed during the month of June, namely, a deep depression and a depression over the Bay of Bengal and a deep depression over the Arabian Sea. Thereafter, a cyclonic storm formed during July and a deep depression formed during the month of August over the Bay of Bengal. The depression in the month of June advanced the southwest monsoon over the western and the eastern parts of the country. The tropical storm in June formed at somewhat southerly latitude and moved across the north Peninsula to Saurashtra & Kutch and neighbourhood causing unprecedented heavy rainfall in parts of Andhra Pradesh and Maharashtra. The depression in August system also developed in a southerly latitude and had a short life span. The tracks of these systems have been shown in Fig. 5.

2.6. *Withdrawal of the southwest monsoon*

The withdrawal phase of the southwest monsoon commenced in the mid-September and was complete outside Tamil Nadu and Kerala on 13 October.

On 14 September, monsoon withdrew from Jammu & Kashmir, western parts of Punjab and west Rajasthan. Thereafter, it further withdrew from Himachal Pradesh, Haryana, northeast Rajasthan and the eastern parts of Punjab on 27 September. During October, the withdrawal was rather fast. On 2 October, it withdrew from west Uttar Pradesh, northwest Madhya Pradesh, southeast Rajasthan and north Gujarat State. By 6 October monsoon withdrew from the most parts of the country outside West Bengal & Sikkim, Orissa, northeastern States and south Peninsula and on 13 October

TABLE 2

Details of weather systems responsible for the advance of southwest monsoon during 1989

Weather system	Period	Place of first location	Direction of movement	Place of dissipation	Remarks
		June 1989			
Low pressure area/depressions etc					
(1) Deep depression	9th-13th evening	Northeast and adjoining east central Arabian Sea off south Gujarat coast	Initially N'ly & then W'ly	Northwest Arabian Sea off Arabian coast	Appeared as a cyclonic circulation in the lower and middle tropospheric levels on 5th over east central Arabian Sea off Goa-Karnataka coast
(2) Do.	13th-14th	Northwest Bay and adjoining coastal Orissa	Initially N'ly & then NW'ly	Bihar and neighbourhood	Appeared as a low pressure area with associated cyclonic circulation up to mid-tropospheric levels of 11th over northwest Bay
(3) Depression	20th-21st evening	Northwest Bay off north Orissa-West Bengal coast	NW'ly	Bihar plateau and neighbourhood. Remnant became less marked over central parts of Uttar Pradesh on 25th	Appeared as a cyclonic circulation in the lower and mid-tropospheric levels on 17th over north Bay
(4) Well marked low pressure area	27th-30th	Northwest Bay	Westerly	West Madhya Pradesh	Appeared as a cyclonic circulation in the mid-tropospheric levels over northwest and adjoining northeast Bay on 26th
		July 1989			
Cyclonic circulation					
(1) Lower levels	30 Jun-2 Jul	Punjab & neighbourhood	Easterly	Himachal Pradesh and neighbourhood	

the monsoon withdrew from the entire country outside Tamil Nadu and Kerala. The withdrawal of the southwest monsoon has been shown in Fig. 3.

2.7. *Characteristic features of the season*

All the monsoon depressions initially appeared as upper air disturbances. They could be located first as circulations in the lower and middle tropospheric levels, which subsequently developed on the sea level as intense systems. Also all the low pressure areas that formed during August, & one that formed in the last week of June, initially appeared as upper air disturbances. During July a cyclonic storm (14-19 July) formed over southeast Bay, an area where monsoon disturbances seldom develop during this month. This cyclonic storm/deep depression also travelled as far west as Saurashtra and neighbourhood. The track of this system was through a southerly latitudes than normal one. In August, also two low pressure areas followed somewhat southerly tracks.

During this monsoon season, typical 'break' monsoon conditions were not observed though rainfall was meagre in the country on some of the weeks. The seasonal rainfall was not scanty in any of the 35 sub-divisions. The onset of monsoon over Kerala was without any significant features like any low pressure area or cyclonic vortex.

3. Significant monthly features

3.1. *June*

During June 1989, the seasonal trough at 0.9 km a.s.l. appeared over the plains of north India in the last week. During the rest of the month it was not well defined or was absent.

3.1.1. *Features heralding the advance of southwest monsoon during June*

Southwest monsoon advanced over Kerala on 3 June. The advance took place without the presence of any 'onset vortex'. Two deep depressions : one over the Arabian Sea and the other over the Bay of Bengal, and another depression and a well marked low pressure area over the Bay during this month helped in advancing the monsoon over the country. The details of the synoptic features, which were responsible for the advance of the southwest monsoon over the country, have been given in Table 2. Datewise advance of the monsoon has also been shown in Fig. 2.

3.1.2. *Other synoptic features of the month*

The trough on sea level chart off west coast extending from south Gujarat to Kerala was observed on most of the days during 8 to 28 June. The other synoptic features of the month have been given in Table 3.

TABLE 3

Details of weather systems during June 1989

Weather system	Period	Place of first location	Direction of movement	Place of dissipation	Remarks
(A) Cyclonic circulation					
(1) Lower & middle tropospheric levels	5th-11th	Southwest Bay off Tamil Nadu-Sri Lanka coasts	Northerly	—	Merged with circulation of the depression over northwest Bay & neighbourhood
(2) Do. (bet. 1.5 & 5.8 km asl)	20th-22nd	Gujarat and adjoining Gulf of Cambay	—	*In situ*	
(3) Do. (bet. 1.5 & 5.8 km asl)	29 Jun even.-1 Jul	East central Arabian Sea off Maharashtra coast	Northerly	South Gujarat-north Maharashtra coasts	
(B) Western disturbance					
(1) Upper air system	6th-7th	North Pakistan & adjoining Jammu & Kashmir	Easterly	Moved away across Jammu & Kashmir and neighbourhood	
(2) Do.	10th-12th	Jammu & Kashmir and neighbourhood	Do.	Do.	
(3) Do.	14th-18th	North Pakistan & neighbourhood	Do.	Do.	
(4) Do.	19th-21st	North Pakistan & adjoining Jammu & Kashmir	Do.	Do.	
(C) Induced cyclonic circulation					
(1) Lower tropospheric levels	6th-9th	Punjab & adjoining Pakistan	Quasi-stationary	Punjab & neighbourhood	
(2) Do.	14th-18th	Punjab & neighbourhood	Easterly	Become unimportant over Western Himalayas of Himachal Pradesh & adjoining Uttar Pradesh	

3.1.3. *Monsoon activity during the month*

Over the northwest India, where the southwest monsoon advanced during the month of July, the rainfall activity was sporadic except in west Uttar Pradesh. Rainfall occurred almost at all the places or at many places on 11 days over hills of west Uttar Pradesh; on 5 days over plains of west Uttar Pradesh and on 1 to 2 days over Haryana, Punjab, Himachal Pradesh, Jammu & Kashmir and east Rajasthan during the month. Monsoon rainfall activity was rather good over northeastern States, West Bengal & Sikkim, Orissa, Konkan & Goa, Marathwada, coastal Andhra Pradesh, Telangana and coastal Karnataka.

It was active to vigorous on 10 days over Konkan & Goa and was so on 5 to 7 days over the rest of the aforesaid sub-divisions. It was also active to vigorous on 3 to 4 days in Bihar plateau, Gujarat region, Vidarbha and Kerala and was so on 1 to 2 days in Bihar plains, Saurashtra & Kutch, Madhya Maharashtra and south interior Karnataka. There was no active monsoon days over east Uttar Pradesh, Madhya Pradesh and north interior Karnataka during the month. However, rain or thundershowers occurred almost at all the places or at many places on 12 days over east Madhya Pradesh and on 4 to 8 days over east Uttar Pradesh, west Madhya Pradesh and north interior Karnataka. They were so on 22 to 24 days over Andaman & Nicobar Islands, coastal Karnataka, Kerala and Lakshadweep; on 11 to 16 days over Assam & adjacent States, Sub-Himalayan West Bengal & Sikkim and Konkan & Goa; on 5 to 10 days over Gangetic West Bengal, Madhya Maharashtra and Marathwada and on 1 to 4 days over Orissa, Bihar, Gujarat, Vidarbha, Telangana, Rayalaseema and south interior Karnataka. Rain or thundershowers occurred either at a few places or at one or two places on all the 30 days of the month over Tamil Nadu.

3.1.4. *Month's rainfall*

The month's rainfall was either excess or normal over 33 met. sub-divisions and deficient over two. It was excess in Gangetic West Bengal, Orissa, east Uttar Pradesh, Haryana, Punjab, Rajasthan, Saurashtra & Kutch, coastal Andhra Pradesh, Telangana and Lakshadweep; normal in Andaman & Nicobar Islands, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Sub-Himalayan West Bengal & Sikkim, Bihar plateau, west Uttar Pradesh, Himachal Pradesh, Jammu &

Kashmir, Madhya Pradesh, Gujarat region, Maharashtra, Rayalaseema, Tamil Nadu, Karnataka and Kerala and was deficient in Arunachal Pradesh and Bihar plains.

The significant amounts (cm) of rainfall during the month are given below :

1st : Nancowry 8.

2nd : Tumkur 10, Mulki 9, Kasargode & Mancompu 8 each, Hanamkonda, Hasan & Sirailla 7 each.

3rd : Cooch Behar 16, Sudhagad 8, Aminidivi, Belgaum AP, Hosur, Kanakpura & Rupsi 7 each.

4th : Rajapur 9, Devgad, Ratnagiri & Tiruvalla 8 each, Dumka, Hosdurg, Jat & Udipi 7 each.

5th : Cherrapunji 26, Dummagudam 16, Kayamkulam 10, Jogipet & Paviambur 9 each, Majbat 8, Jainagar 7.

6th : Hosdurg 33, Mulki 26, Kasargode 18, Cherrapunji 17, Kunnamkulam 16, Panambur 13, Kozhikode 12, Gangpur 11, Alleppey & Mangalore AP 10 each, Agartala AP 9, Cochin AP & Devgad 8 each, Bhagamandala & Trivandrum 7 each.

7th : Karwar 26, Shirali 25, Agumbe 15, Cannanore & Gaganbavda 11 each, Kasargode 10, Belgaum & Kailashahar 9 each, Panjim, Ratnagiri & Wardha 8 each, Guwahati AP & Vidisha 7 each.

8th : Karwar & Mangalore 16 each, Devgad & Panjim 14 each, Bhatkal & Hosdurg 10 each, Kasargode 9, Shahpur & Rupsi 8 each, Silchar 7.

9th : Agumbe 20, Shirali 19, Mangalore AP, Ratnagiri & Rupai 12 each, Palankonde 11, Hosenagar & Kasargode 10 each, Cooch Behar & Tuni 8 each, Gaganbavda & Karwar 7 each.

10th : Kumte 20, Bhatkal 15, Keonjhargarh & Vengurla 10 each, Kasargode 9, Porbandar 8, Banswada, Kisarganj, Sirailla & Veraval 7 each.

11th : Porbandar 26, Bhira 11, Agumbe & Dwarka 9 each, Bhuj, Bombay AP & Cannanore 7 each.

12th : Quilandy 14, Agumbe 13, Gaganbavda & Kozhikode 11 each, Kailashahar, Karkala & Rajapur 9 each, Okha 8.

13th : Gopalpur 31, Berhampur 20, Agumbe 14, Peermade 11, Tekkali 10, Warud 9, north Lakhimpur 7.

14th : Rajghat 18, Bhubaneshwar 14, Puri 14, Idikki & Peermade 13 each, Raipur 11, Midnapore 10, Tadong & Sandheads 8 each, Bhira & Kisanganj 7 each.

15th : Cherrapunji 41, Purnea 32, Katihar 19, Jamgiri 13, Rupsi 12, Jalpaiguri 11, Balurghat & Telkoi 10 each.

16th : Cherrapunji 43, Jalpaiguri 13, Agumbe & Shillong 11 each, Bhagmandala & Kundapur 10 each, Mangalore AP 9, Bhavnagar & Purnea 8 each, Mannarghat 7.

17th : Dungarwadi 18, Diamond Harbour 12, Bombay 11, Akbarpur 7.

18th : Bantwal 15, Puri 14, Udupi 13, Agumbe, Jalpaiguri & Talchar 12 each, Joginder-nagar & Mangalore AP 11 each, Baghdogra & Kasargode 10 each, Long Island & Thakurganj 8 each.

19th : Tukania 8, Gaganbavda & Tensa 7 each.

20th : Rajghat 18, Jaipur & Midnapore 13 each, Digha 10, Balasore 9, Bankura & Pattambi 8 each.

21st : Balasore & Simdega 9 each, Punalur 8, Contai, Purulia & Ranchi AP 7 each.

22nd : Ratnagiri 25, Tensa & Udgir 11 each, Chalisgaon, Katghora & Vengurla 10 each, Pendra 8, Belthangady, Bhagmandala, Car Nicobar & Daltonganj 7 each.

23rd : Panna 20, Khajuraho 16, Ora & Satna 13 each, Peermade 12, Cannanore & Lansdowne 9 each, Vengurla 8, Amravati & Parbhani 7 each.

24th : Cherrapunji & Cooch Behar 15 each, Agumbe 11, Rupsi 9, Pilibhit, Thakurganj & Trivandrum AP 7 each.

25th : Cherrapunji 14, Pasighat 10, Jalpaiguri 9, Fatehpur 7.

26th : Mankapure 12, Kheri Lakhimpur 8, Chandanpur & Tiruvella 7 each.

27th : Ponnani 11, Trichur 9, Chiplun 8, Asifabad & Jaypore 7 each.

28th : Kinwat 39, Ratnagiri 16, Luxhettipet 13, Utnoor 12, Long Island 10, Wardha 9, Biloli, Nagpur AP & Pattambi 8 each, Raipur 7.

29th : Hingoli & Kinwat 18 each, Gaganbavda & Pasighat 15 each, Nanded 11, Chiplun & Bodhan 10 each, Yeotmal 9, Buldhana & Jalgaon 8 each, Agumbe, Harnai & North Lakhimpur 7 each.

30th : Pasighat 23, Alibag & Baghdogra 17 each, Bombay AP 10, Agumbe & Baijnath 9 each, Karwar & Yellapur 7 each.

3.1.5. *Temperature*

During this month, though monsoon did not advance over northwest India, the days were comparatively cooler than the normal ones. As much as —8 C° to —10°C below normal day temperatures were recorded on 4 days each at several places in Haryana and Punjab. Day temperatures were —5 °C to —7° C below normal on 3 to 6 days in plains of west Uttar Pradesh, Haryana, Punjab and Jammu & Kashmir and were appreciably below normal on 6 to 7 days in plains of west **Uttar**

TABLE 4

Details of weather systems during July 1989

Weather system	Period	Place of first location	Direction of movement	Place of dissipation	Remarks
(A) Low pressure area/depression etc					
(1) Low pressure area	13th-16th	East Uttar Pradesh	Westerly	Southwest Uttar Pradesh and neighbourhood	
(2) Well marked low pressure area	14th-19th	Southeast Bay & adjoining Andaman Sea	WNW'ly to NW'ly	Saurashtra & neighbourhood	Associated cyclonic circulation extended up to middle tropospheric levels
(3) Cyclonic storm	22nd-26th	West central & adjoining northwest Bay	W to NW'ly	Southern parts of Rajasthan & neighbourhood. The remnants became unimportant over the same area on 27th	Appeared as a low pressure area on 20th with associated cyclonic circulation up to 7.6 km a.s.l. over central and adjoining north Bay
(4) Low pressure area	25th-31st	North Bay	N'ly to E'ly	Nagaland	Associated circulation extended up to middle tropospheric levels
(B) Cyclonic circulation					
(1) Lower & middle tropospheric levels	6th-9th	Coastal Andhra Pradesh & neighbourhood	NW'ly	Northwest Madhya Pradesh and neighbourhood	
(2) Lower tropospheric levels	9th-11th	Gujarat & neighbourhood	Quasi-stationary	Saurashtra & Kutch	
(3) Lower & middle tropospheric levels	10th-12th	South Tamil Nadu & neighbourhood	—	*In situ*	
(4) Lower levels	13th-15th	Punjab and neighbourhood	Easterly	Himachal Pradesh	
(5) Lower levels	15th-17th	Northwest Rajasthan and neighbourhood	—	*In situ*	
(C) Western disturbance					
(1) Upper air system in the lower and middle tropospheric levels	2nd-7th	North Pakistan and adjoining Jammu & Kashmir	Easterly	Moved away across Jammu & Kashmir and neighbourhood	

Pradesh, Punjab, Jammu & Kashmir and east Rajasthan and on 3 to 4 days in Haryana, Himachal Pradesh and Madhya Pradesh during the month.

3.1.6. *Disastrous weather events and damages*

According to press reports a cloud burst on 4th claimed four lives in the outskirts of Srinagar city. Seven people were washed away in a flash flood at Jeahalli in Karnataka on 5th. Severe thunderstorms hit several villages along Lucknow-Sultanpur road in Uttar Pradesh on 10th. It claimed the lives of nine persons. In the third week of this month floods and landslides took a toll of sixteen lives and rendered thousands homeless in Arunachal Pradesh.

During the second fortnight floods affected Darnang, Kamrup, Barpeta, Sonitpur, Jorhat and Dhubri districts of Assam. Flood waters of the river *Dhansiri* submerged 30 villages in Dalgaon circle of the State in the 3rd week.

Floods damaged about 35 houses and affected 5,500 hectares of cropped land in Assam during the month.

3.2. *July*

3.2.1. *Synoptic feature of the month*

During July 1989, the seasonal trough at 0.9 km a.s.l. was not well defined. In the last week, the trough at 0.9 km a.s.l. became marked over northern parts of the Peninsula in association with the cyclonic storm/deep depression that moved across the Peninsular India. The trough on sea level chart off and along the west coast of India was not observed during the first fortnight of the month. However, it appeared for most of the days during the later half of the month.

The other synoptic features of the month are given in Table 4.

3.2.2. *Monsoon activity during the month*

During the first twelve days of the month, there was very little monsoon activity over east Uttar Pradesh and

hills of west Uttar Pradesh, Haryana, Punjab, Himachal Pradesh and Jammu & Kashmir. Plains of west Uttar Pradesh and Rajasthan had no active monsoon days throughout the month, while in Madhya Pradesh monsoon became active only on 21st and 22nd. However, the monsoon activity was rather well distributed during the month over the other sub-divisions of India. Monsoon was active to vigorous on 7 to 12 days in Assam & adjacent States, West Bengal & Sikkim, Bihar plains, Jammu & Kashmir, Marathwada, Andhra Pradesh, south interior Karnataka and Kerala; on 3 to 6 days in Orissa, Bihar plateau, east Uttar Pradesh, Punjab, Himachal Pradesh, Gujarat, Konkan & Goa, Madhya Maharashtra, Vidarbha, coastal and north interior Karnataka and was so on 1 to 2 days in hills of west Uttar Pradesh and Haryana. Rainfall occurred almost at all the places or at many places on 18 to 26 days over east Madhya Pradesh, Gujarat region, Konkan & Goa and coastal Karnataka; on 10 to 15 days over Andaman & Nicobar Islands, Arunachal Pradesh, Assam & Meghalaya, Sub-Himalayan West Bengal & Sikkim, Orissa, east Uttar Pradesh and hills of west Uttar Pradesh, west Madhya Pradesh, Kerala and Lakshadweep; on 6 days over east Rajasthan and on 1 to 3 days over west Rajasthan and Tamil Nadu. Though Tamil Nadu has recorded rainy days all the days of the month, the rainfall generally occurred at one or two places on most of the occasions.

3.2.3. *Month's rainfall*

Month's rainfall was normal or excess over 22 met. sub-divisions and was deficient or scanty over thirteen. It was excess in Arunachal Pradesh, Assam & Meghalaya, Bihar plains, Jammu & Kashmir, Marathwada, in 3 sub-divisions of Andhra Pradesh, Tamil Nadu, north interior Karnataka and Lakshadweep, normal in Andaman & Nicobar Islands, West Bengal & Sikkim, Bihar plateau, east Uttar Pradesh, Punjab, Gujarat, Konkan & Goa, Madhya Maharashtra and south interior Karnataka; deficient in Nagaland, Manipur, Mizoram & Tripura, Orissa, west Uttar Pradesh, Haryana, Himachal Pradesh, west Rajasthan, Madhya Pradesh, Vidarbha, coastal Karnataka and Kerala and was scanty in east Rajasthan.

The significant amounts (cm) of rainfall during the month are given below :

1st : Cherrapunji 25, Pasighat 19, Lonavala 15, Bombay AP 10, Katihar & Yellapur 9 each, Chhatarpur, Mancompu & Pilibhit 7 each.

2nd : Cherrapunji 35, Raipur 19, Mangalore AP 18, Karkala 16, Kasargode & Shillong 14 each, Cooch Behar & Nowgong 13 each, Pasighat 11, Veraval 9, Sambalpur & Gangtok 7 each.

3rd : Cherrapunji 32, Kancheepuram 13, North Lakhimpur 12, Shillong 11, Bhagalpur & Tikamgarh 9 each, Muzaffarpur 7.

4th : North Lakhimpur 28, Shillong 13, Bhira 11, Sonagadh 10, Berhampore & Sudhagad 7 each.

5th : Shillong 16, Dindigul, Midnapore & Salem 7 each.

6th : Thakurganj 12, Mahabubabad 10, Bhadrachalam, Jeypore & Katihar 9 each, Jalpaiguri 8, Madras, Malda & Wardha 7 each.

7th : Chittoor 10, Katihar, K.G. Field & Raigarh 9 each, Harur 8, Nancowry 7.

8th : Tarana 11, V.V. Nagar 9, Haldwani & Rentachintala 8 each, Bhira & Medak 7 each.

9th : Hardwar 15, Dharavi 13, Ratnagiri 9, Bombay AP & Chittoor 8 each, Parkal 7.

10th : Cherrapunji 30, Lansdowne 12, Beed 11, Rupsi 10, Kurnool 9, Honavar & Pasighat 7 each.

11th : Cherrapunji 36, Tezu 12, Pasighat 11.

12th : Ambikapur & Buxar 15 each, Daltonganj 13, Chamrajnagar, Kottayam & Cooch Behar 10 each, Dharmapuri, Jharsuguda & Minicoy 9 each, Vellore & Medak 7 each.

13th : Karimganj 21, Nurpur & Sringeri 16 each, Buxer & Varanasi 13 each, Jammu 12, Shirali 10, Nizamabad 9, Hassan, Jalpaiguri, Jogindernagar & Karwar 8 each, Anantpur, Nowgong & Orai 7 each.

14th : Bansgaon 29, Turtipur 21, Triveni 14, Sultanpur 12, Gurdaspur 10, Cooch Behar, Gorakhpur & Sagar Island 9 each, Purnea, Ranchi & Varanasi 8 each, Ambala & Kathua 7 each.

15th : Katerniaghat 27, Bahraich 20, Harnai 16, Thakurganj 15, Jalpaiguri 11, Cuttack, Gorakhpur & Ratnagiri 9 each, Dehra Dun, Nancowry, Bapatla & Jammu 7 each.

16th : Cooch Behar 16, Ongole 14, Kavali 13, Nandyal 12, Agathi 11, Cuddapah, Tezu & Varanasi 10 each, Anantpur 9, Solapur 8.

17th : Bhatkal, Mannarghat & Osmanabad 18 each, Agathi 15, Anantpur & Honavar 11 each, Hyderabad AP 10, Bidar AP & Panjim 9 each, Alleppey 8, Aurangabad AP & Kottayam 7 each.

18th : Rupsi 34, Cherrapunji 32, Cooch Behar 17, Jalpaiguri & Peermade 12 each, Bhagamandala & Mangalore AP 10 each, Bombay 9, Amrali & Cannanore 8 each, Ahmedabad 7.

19th : Ballia 11, Hut Bay & Veraval 9 each, Chapra 7.

20th : Car Nicobar 14, Udupi 8, Idikki, Karkala & Peermade 7 each.

21st : Car Nicobar 16, Hanamkonda, Munner 12 each, Bhira 10, Madikeri, Mukteshwar & Thakurganj 9 each, Bikaner & Gondia 8 each, Bhagamandala & Bhilwara 7 each.

22nd : Munnar 20, Dhulia & Ratnagiri 16 each, Bhagamandala 13, Karwar, Peermade & Vengurla 11 each, Dalhousie& Panjim 10 each, Bombay, Car Nicobar & Rawat Bhata 9 each, Kalingapatnam 8.

23rd : Koderu 42, Nidadevolu 39, Bhagamandala & Kakinada 30 each, Khammam 25, Dhulia, Narsapur & Ratnagiri 24 each, Harnai 21, Kothagudam 20, Machilipatnam 16, Mangalore AP 12, Bombay 7.

24th : Bhira 71, Beed 35, Parbhani 23, Munnar 22, Dhulia & Ratnagiri 20 each, Bombay 18, Medak 16, Hyderabad 14, Nanded 13, Bhavnagar 11, Panjim 10, Aurangabad AP & Pune 9 each, Belgaum 8.

25th : Chikhali 42, Sandheads 31, Valsad 30, Munnar 24, Bhira 22, Bombay 19, Navasari 17, Madikeri & Veraval 13 each, Surat 12, Baroda 8, Akola & Dohad 7 each.

26th : Naliya 20, Bhira 11, Belthangady & Dharmsala 10 each, Mangalore AP 8, Madikeri & Okha 7 each.

27th : Rangali 29, Bhira 16, Bhagamandala 13, Cochin AP 11, Paradip 10, Dhanbad, Dharmsala, Kottayam & Madikeri 9 each, Pasighat & Puri 8 each.

28th : Sandheads 31, Balasore & Itanagar 20 each, Jammu AP 16, Pasighat 15, Bhira 12, Midnapore 11, Tezpur 10, Jharsuguda & Peermade 9 each, Contai, Guwahati & Raigad 8 each, Ramagundam 7.

29th : Sriniketan 27, Hardwar & Roorkee 18 each, Panagarh 16, Tezpur 15, Shillong 13, Berhampore, Gorakhpur & Jamshedpur 9 each, Guwahati & Itanagar 8 each, Ambala, Pendra & Silchar 7 each.

30th : Jogindernagar 25, Shillong 20, Dehra Dun 18, Jammu 17, Imphal 16, Dharmsala & Roorkee 15 each, Shimla 13, Amritsar 12, Aijwal & Chandigarh 8 each.

31st : Jogindernagar 27, Dalhousie 15, Bansgaon 10, Hardwar 8, Bhagalpur & Katra 7 each.

3.2.4. *Disastrous weather events and damages*

Heavy rain caused floods in Arunachal Pradesh, Assam, Andhra Pradesh and Maharashtra during the month. In Assam, *Brahmaputra* and its tributaries were in floods almost throughout the month. During the last week floods disrupted road communications in five districts of the State. National Highway No. 36 remained under water for some time and a bridge over the river *Barapar* was washed away. Floods/heavy rain claimed 4 lives in the State during the month. During the last week of the month floods/heavy rain also claimed 24 lives in Arunachal Pradesh. A RCC bridge on the river *Kameng* near Tippi was washed away by floods. The storm/deep depression in the last week caused very severe flood in Maharashtra and in some parts of Andhra Pradesh. The system caused unprecedented heavy rainfall in these two States. In Andhra Pradesh river *Godavari* and its tributaries were in spate. High floods occurred in lower Krishna basin. Heavy rain caused breach in irrigation tanks in West Godavari and Krishna districts causing severe floods. Yeluru town was submerged. Apart from extensive damages to crops and properties, the calamity claimed 140 lives in the State. The system left a trail of death and devastation in western Maharashtra. High winds accompanied with heavy rain and flash floods in tributaries took a toll of 916 lives in the State, while quite a large number of persons including fishermen were reported missing. About 14212 cattle heads were perished and 99283 houses were damaged totally or partially in the State in this calamity. Raigad district was the worst affected followed by Beed district. 35 villages in Beed and Nanded and Raigad were marooned. Pen village that used to supply the Ganesh idol in the whole of Maharashtra was almost washed out by flash floods. In a tiny hamlet called Bhaje near Carla caves a landslide on 23rd night crushed 40 members of a marriage party to death. Bombay city remained cut off from the rest of the country for a day or two. Road and rail communications in several parts of the State remained dislocated. Damage to road, buildings and power stations in rural areas was estimated over Rs. 91 crores in Maharashtra. Landslides, heavy rain and strong winds between 21st and 24th also claimed 16 lives in Kerala and caused floods in the river *Hemavati*, which inundated large areas of paddy field in Hassan district of Karnataka.

3.3. *August*

3.3.1. *Synoptic features of the month*

The trough at sea level off and along west coast was absent during the month. The seasonal trough at 0.9 km a. s.l. over the plains of north India was also ill-defined during the first half of the month. During the second half of the month it was observed on most of the days to the east of Long. 78° E and about 3 to 5 degrees south of its normal position.

The other synoptic features of the month are given in Table 5.

3.3.2. *Monsoon activity during the month*

Monsoon activity during the month was weak over Bihar plains, west Rajasthan, Saurashtra & Kutch, Rayalaseema and north interior Karnataka. Monsoon was active on 1st over Bihar plains and on 31st over north interior Karnataka. There were no active monsoon days over the other aforesaid met. sub-divisions. However, monsoon activity was well distributed in time over the Peninsular India. Monsoon was active to vigorous on 8 to 13 days in Madhya Pradesh, Konkan & Goa, Telangana and coastal Karnataka and was on 3 to 7 days in Assam & adjacent States, West Bengal & Sikkim, Orissa, Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, Jammu & Kashmir, east Rajasthan, Gujarat region, Madhya Maharashtra, Marathwada, Vidarbha, coastal Andhra Pradesh, south interior Karnataka and Kerala. Rainfall occurred almost at all the places or at many places on 20 days over Andaman & Nicobar Islands and on 10 days over Lakshadweep area. It occurred at one or two places over Tamil Nadu during the month.

TABLE 5

Details of weather systems during August 1989

Weather system	Period	Place of first location	Direction of movement	Place of dissipation	Remarks
(A) Low pressure area/depression etc					
(1) Well marked low pressure area	2nd-8th	North Bay & neighbourhood	Westerly	Central parts of Madhya Pradesh & adjoining Vidarbha. The remnant became unimportant over north Madhya Pradesh & adjoining south Uttar Pradesh on 10th	Appeared as a cyclonic circulation in the lower levels over north Bay & neighbourhood on 1st
(2) Low pressure area	11th-17th	Northwest Bay	WNW'ly	Central parts of Rajasthan	Appeared as a cyclonic circulation in the lower & middle tropospheric levels over northwest Bay on 10th
(3) Deep depression	16th evening-17th evening	West central & adjoining northwest Bay off north Andhra coast	Do.	North coastal Andhra Pradesh neighbourhood. The remnants became less marked over central parts of Rajasthan on 21st	Appeared as a cyclonic circulation in the lower & middle tropospheric levels over west central & adjoining northwest Bay on 15th
(4) Low pressure area	22nd-28th	West central Bay	NW'ly	North Rajasthan & adjoining Haryana and Punjab	Appeared as a cyclonic circulation in the middle tropospheric levels over west central and adjoining northwest Bay on 20th evening
(5) Do.	28 Aug even.-4 Sep	Northwest Bay & neighbourhood	WNW'ly	*Lay over east Madhya Pradesh on 31 August	Seen on 20th morning as a cyclonic circulation up to 4.5 km a.s.l. over the same area
(B) Cyclonic circulation					
(1) Middle tropospheric levels	14th-16th	South Gujarat and neighbourhood	—	*In situ*	
(2) Lower & middle tropospheric levels	20th-24th	Gujarat	—	*In situ*	
(3) Lower levels	22nd-24th	North Pakistan and adjoining Punjab	Quasi-stationary	Punjab and adjoining north Pakistan	
(C) Western disturbance					
(1) Upper air system	31 Jul-3 Aug	North Pakistan & adjoining Jammu & Kashmir	Easterly	Moved away across Jammu & Kashmir and neighbourhood	
(2) Do.	5th 9th	Southeast Afghanistan & adjoining north Pakistan	Do.	Do.	
(3) Do.	11th-14th	North Pakistan and neighbourhood	Do.	Do.	
(4) Do.	29 Aug-1 Sep	Central Pakistan and adjoining northwest Rajasthan	ENE'ly	Became unimportant over Himachal Pradesh and neighbourhood	

3.3.3. *Month's rainfall*

Month's rainfall was excess or normal over 22 met. sub-divisions and was deficient or scanty over 13. It was excess in Gujarat region, Vidarbha, coastal Andhra Pradesh and coastal Karnataka; normal in Andaman & Nicobar Islands, Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Orissa, west Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, west Rajasthan, west Madhya Pradesh, Konkan & Goa, Madhya Maharashtra, Marathwada, Telangana, south interior Karnataka and Kerala; deficient in West Bengal & Sikkim, Bihar, east Uttar Pradesh, Jammu & Kashmir, east Rajasthan, east Madhya Pradesh, Saurashtra & Kutch, Tamil Nadu, north interior Karnataka and Lakshadweep and was scanty in Rayalaseema.

The significant amounts (cm) of rainfall during the month are given below :

1st : Dengraghat 21, Dalhousie 14, Sandheads 10, Kathua & Malda 9 each, Batala, Dharamsala, Diamond Harbour & Jalandhar 8 each, Durgachak 7.

2nd : Baijnath 25, Sandheads 22, Kasauli 21, Ambala 15, Patiala 14, Chandigarh 8, Uluberia 7.

3rd : Sandheads 13, Thakurmunda 12, Ghatshila 9, Madhupur 8, Sriniketan 7.

4th : Keonjhargarh 21, Bhagamandala & Sulya 14 each, Panambur 11, Honavar, Panjim & Purlia 9 each, Baripade, Itanagar & Uluberia 8 each.

5th : Kasargode 21, Panambur 16, Bhagamandala 14, Narsinghpur 11, Rajnandgaon 10, Cannanore & Honavar 9 each, Long Island & Lumding 7 each.

6th : Narsinghpur 19, Jabalpur 12, Munnar 10, Kailashahar 8.

7th : Raisen 10, Hoshangabad 9, Bhopal & Port Blair 8 each.

8th : North Lakhimpur 12, Ahwa 11, Baripada, Muradabad & Vidisha 9 each, Guna 8.

9th : Seoni 9, Amraghat 7.

10th: Minicoy 9, Damoh, Jharsuguda AP & Madurai AP 7 each.

11th: Karimganj 19, Bahraich 11, Allahabad 10, Panambur & Thenmala 9 each, Bhavanipatna 8, Katra & Kundapur 7 each.

12th: Karimganj 22, Silchar 13, Bhagamandala & Vidisha 10 each, Mathura 9, Bhira, Panambur & Phulbani 8 each, Karkala & Medikeri 7 each.

13th: Kasauli 12, Bhira & Bombay 10 each, Buxar 7.

14th: Hut Bay 14, Neemuch 11, Gwalior & Satna 8 each, Bhira & Rawat Bhata 7 each.

15th: Hasimara 25, Sulya 10, Datia 9, Chittorgarh & Kasargode 8 each, Panambur 7.

16th: Jharsuguda AP 17, Shirali 10, Bhagamandala 8, Cooch Behar, Gopalpur, Mangalore AP & Puri 7 each.

17th: Thakurganj 19, Parbhani 18, Munnar 12, Kailashahar & Visakhapatnam 8 each, Kozhikode & Ratnagiri 7 each.

18th: Mulug 17, Munnar 16, Bhagamandala 9, Karkala & Ratnagiri 8 each, Hoshiarpur, Mangalore AP & Tezu 7 each.

19th: Sudhagad 13, Pasighat 11, Jalgaon, Munnar, Tezu & Yeotmal 9 each, Akola, Nanded & Udupi 8 each, Bhira 7.

20th: Bhira 22, Nahan 11, Sonagadh 10, Kasauli 9, Pasighat 8, Nandurbar 7.

21st: Bhira 15, Idar 13, Forbesganj & Colaghat 10 each, Bansgaon 9, Ahmedabad 8, Bhuj AP & Seoni 7 each.

22nd: Dessa 19, Kangra 14, Dehra Dun 13, Ahmedabad & Patna AP 11 each, Dharamsala, Gangtok, Gondia, Jhansi & Satna 7 each.

23rd: Voderu 16, Sironcha 11, Rawat Bhata 10, Karimnagar 8, Ajmer, Bhira, Kasauli & Satna 7 each.

24th: Bhira 23, Shirali 9, Honavar & Udaipur AP 8 each, Koppa & Sikandrabad 7 each.

25th: Karimganj 19, Panambur 12, Bhagamandala, Panjim & Raigarh 10 each, Sikandrabad 9, Bhira & Gondia 8 each, Bharatpur, Bombay, Jalore, Kasauli & Sagar 7 each.

26th: Bhira 12, Bhopal & Neemuch 7 each.

27th: Jaipur AP 16, Bhilwara 11, Agra 9, Bhira & Chittorgarh 8 each, Jogindernagar 7.

28th: Patiala 16, Chandigarh & Katra 13 each, Kheri 12, Ambala & Roorkee 11 each, Jogindernagar 10, Daltonganj & Idar 9 each, Bhuj AP 8, Puri 7.

29th: Bhira & Namakkal 10 each, Buxar 9, Navsari 8.

30th: Madurai AP 11, Mulug 9, Bhira & Jagdalpur 8 each, Khammam, Midnapore & Sudhagad 7 each.

31st: Parbhani 16, Koderu 15, Chandrapur & Nanded 10 each, Pusad 8, Jarsuguda, Sangareddy & Wardha 7 each.

3.3.4. *Disastrous weather events and damages*

During the first week of August, southern parts of Assam and some parts of Gangetic West Bengal were under high floods. Road communications in Silchar district remained cut off for several days. In Hoogly and Burdwan districts of West Bengal about 5 lakhs people were affected by floods. Also, flood waters submerged 173 villages in Burdwan district of the State where 5 people lost their lives in the calamity. Heavy rain during the first week of the month, also caused floods in the rivers *Baitarani, Subarnarekha* and *Budhabalang* in Orissa affecting about 4 lakhs population in Balasore, Cuttack, Mayurbhanj and Keonjhar districts of the States. Standing crops in large tract of low lying riverine area were damaged.

3.4. *September*

3.4..1 *Synoptic features of the month*

During September, the sea level trough off and along west coast of India was not observed except in the

TABLE 6

Details of weather systems during September 1989

Weather system	Period	Place of first location	Direction of movement	Place of dissipation	Remarks
(A) Lopar/depression etc					
(1) Lopar*	28 Aug-4 Sep	Lay on 1st over southern parts of U.P. and adjoining north M.P.	NW'ly	Haryana and neighbourhood	
(2) Lopar	7th-17th	North Bay and adjoining land areas	WNW'ly	Plains of W. U.P. and adjoining NW M.P. and E. Rajasthan. Associated cyclonic circulation became less marked on 19th evening over Haryana and neighbourhood	Associated cyclonic circulation extended upto middle tropospheric levels
(3) Lopar	21st-25th	East central Arabian Sea off south Maharashtra coast	Northerly	East central Arabian Sea off Maharashtra and adjoining south Gujarat coast	Associated cyclonic circulation extended up to lower tropospheric levels
(4) Lopar	25 Sep-1 Oct	North Bay and adjoining Bangladesh and Gangetic West Bengal	WNW'ly	East Uttar Pradesh and adjoining west Uttar Pradesh	Associated cyclonic circulation extended up to mid-tropospheric levels
(B) Cyclonic circulation					
(1) Lower tropospheric levels	4 even-5 even	Saurashtra and neighbourhood	—	*In situ*	
(2) Lower and middle tropospheric levels	11th-15th	Saurashtra & Kutch and neighbourhood	Easterly	Do.	
(3) Lower levels	12th-14th	Punjab and adjoining north Pakistan	Do.	H. P.	
(4) Lower tropospheric levels	16th-21st	West central and adjoining northwest Bay	SW'ly to NW'ly	Merged with the circulation of the lopar over east central Arabian Sea	Moved across north Tamil Nadu and neighbourhood
(5) Do.	16th-18th	East central and adjoining southeast Arabian Sea off south Maharashtra-Karnataka coasts	—	*In situ*	
(6) Do.	21st-26th	South Tamil Nadu	Quasi-stationary	South Tamil Nadu and adjoining Kerala	
(7) Do.	28 Sep-3 Oct	East central Arabian Sea off Maharashtra coast	—	*In situ*	
(C) Western disturbance					
(1) Upper air system	23rd-26th	North Pakistan and adjoining Punjab and Haryana	E'ly	Moved away across Jammu & Kashmir and neighbourhood	
(2) Do.	26th-28th	Northwest Rajasthan and adjoining Punjab and Haryana	NE'ly	Do.	

last week off south Maharashtra-Karnataka coast. The seasonal trough at 0.9 km a.s.l. across the plains of north India was not also well defined. However, on a few occasions north-south trough at this level was observed over northeast India.

The other synoptic features of the month have been given in Table 6.

3.4.2. *Withdrawal of southwest monsoon*

The withdrawal phase of the southwest monsoon commenced from the middle of this month. It withdrew from northwest India by 27 September and from central India and Bihar by 5 October. The withdrawal of the southwest monsoon from the entire country outside Tamil Nadu and Kerala was complete by 13 October. Datewise withdrawal is shown in Fig. 3.

3.4.3. *Monsoon activity during the month*

Monsoon activity during the month was mainly confined to northeast and Peninsular India. The monsoon activities were well distributed over northeast India during the month. The active spell of rains occurred mostly after 10th of this month over the Peninsular India. Monsoon was active to vigorous on 10 to 13 days in Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, West Bengal & Sikkim, Bihar plains, Madhya Maharashtra and interior Karnataka; on 5 to 8 days in Orissa, Bihar plateau, Konkan & Goa, Marathwada, Telangana, Rayalaseema and Kerala and was so on 2 to 4 days in Uttar Pradesh, Jammu & Kashmir, Madhya Pradesh, Vidarbha, coastal Andhra Pradash and coastal Karnataka. There was no active monsoon day over Haryana, Punjab, Himachal Pradesh, Rajasthan and Gujarat. However, rainfall occurred at one or two places or at a few places in these sub-divisions outside west Rajasthan on many days. Rainfall occurred almost at all the places or at many places on 10 days in Andaman & Nicobar Islands; on 12 days in Lakshadweep and on 2 days in Tamil Nadu. However, Tamil Nadu received rainfall at one or two places or at a few places during the remaining days of the month.

3.4.4. *Month's rainfall*

Rainfall during the month was excess or normal over 21 sub-divisions and was deficient or scanty over 14 sub-divisions.

It was excess in Arunachal Pradesh, Assam & Meghalaya, Sub-Himalyan West Bengal & Sikkim Madhya Maharashtra, Marathwada, Rayalaseema, Tamil Nadu, north interior Karnataka and Kerala; normal in Gangetic West Bengal, Orissa, Bihar, Uttar Pradesh, coastal Andhra Pradesh, Telangana, coastal & south interior Karnataka and Lakshadweep; deficient in Andaman & Nicobar Islands, Nagaland, Manipur, Mizoram & Tripura, Jammu & Kashmir, west Rajasthan, Madhya Pradesh, Gujarat, Konkan & Goa and Vidarbha and scanty in Haryana, Punjab, Himachal Pradesh and east Rajasthan.

The significant amounts (cm) of rainfall during the month are given below :

1st : Bijnor 26, Ujjain 15, Dhar 12, Nowgong 9, Gwalior & Mathura 7 each.

2nd: Roorkee 21, Meerut 16, Agra 14, New Delhi & Pasighat 7 each.

3rd : Hardwar 17, Lansdowne 12, Usilampatti 11, Bijnor & Patiala 9 each, Jalpaiguri 9, Cooch Behar & Roorkee 7 each.

4th : Tezu 18, Nagamangala 13, Jalpaiguri & Purnea 8 each, Begalkota 7.

5th : Pasighat & Tezu 11 each, Malda 8, Jalpaiguri 7.

7th : Palghat 11, Long Island 8, Khowong, Port Blair & Visakhapatnam 7 each.

8th : Paithan 13, Dahanu & Valsad 8 each, Trivandrum AP 7.

9th : Dhanbad 9, Angul 7.

11th: Karimaganj 20, Amraghat 11, Durgapur 10, Amreli 8, Chandrapur, Diamond Harbour, Jalpaiguri & Sangareddy 7 each.

12th: Cuttack 16, Bareilly 11, Bolangir & Silchar 9 each, Munnar & Phulbani 7 each.

13th: Rangali 9, Asansol & Punalur 8 each, Bankura 7.

14th: Bhabua 15, Dahri 10, Baripade & Bhawanipatna 9 each, Cooch Behar & Minicoy 8 each, Fatehpur 7.

15th: Purnea 24, Sultanpur 18, Rae Bareilly 9, Fatehpur 7.

16th: Agra AP & Bahraich 8 each, Bareilly 7.

17th: Jalpaiguri & Yelhanka AP 11 each, Car Nicobar 10, Dharmapuri & Itanagar 9 each, Hoskota & Vellore 8 each, Hut Bay 7.

18th: Jalpaiguri 29, Vellore 22, Domohani 21, Karimganj 19, Itanagar 14, Cooch Behar 12, Arundhutinagar & Pasighat 11 each, Mavelikara 10, Alleppey & Dibrugarh AP 9 each, North Lakhimpur 7.

19th: Jalpaiguri 19, Chargharia 17, Domohani & Thakurganj 13 each, Purnea 11, Palghat & Punalur 10 each, Bhagalpur & Karkala 9 each, Guwahati AP 8, Cudappah & Dharmapuri 7 each.

20th: Shirali 23, Bhagamangala 12, Karkala 11, Purnea 10, Goalpara 9, Belgaum AP & Gadag 8 each, Adirampattinam, Akola, Cochin AP, Cooch Behar, Jogindernagar & Panambur 7 each.

21st : Jabalpur 10, Nagarkurnool & Panjim 8 each.

22nd: Tirupattur 14, Kannad 13, Beed & Vedaranayam 11 each, Buldhana & Sriniketan 9 each, Ahwa & K. Paramathy 8 each, Adirampattinam, Alur & Kundapur 7 each.

23rd: Karimganj 13, Thakurganj 11, Ahmednagar 10, Salem 8, Pondicherry 7.

24th: Kooni 11, Triveni 10, Bellary 9, Bijapur, Umerga & Usilampatti 8 each, Kasod & Wai 7 each.

25th: Kanchipuram & Thenmala 11 each, Goalpara 10, Nizamabad 8, Idikki, Janapur & Niphad 7 each.

26th: Amraghat 11, Pandharpur 10, Thakurganj 9, Karwar & Canning Town 8 each, Pune & Vengurla 7 each.

27th: Bhimavaram 19, Umerga 14. Karwar & Narsapur 13 each, Bijapur 12, Pandharpur 11, Gulbarga 8, Asthi, Karimganj & Vijayawada AP 7 each.

28th: Chittapur 15, Ratnagiri 11, Pasighat 10, Berhampore & Visakhapatnam 8 each, Contai, Devgad & Purnea 7 each.

29th: Dengiaghat 32, Purnea 18, Karimganj 13, Dumka 12, Jojuri 9, Angul & Asansol 7 each.

30th: Tenali 19, Chatia 12, Mahoba 9, Jainagar, Malda, Samastipur & Sangamner 7 each.

3.4.5. *Disastrous weather events and damages*

During the first week of September, Assam experienced a fresh wave of flood which continued almost throughout the month. Landslides in the State took a toll of 6 human lives. During the second and third week north Bihar experienced floods. Rivers *Kosi, Kamala Balan* and *Mahananda* were in spate during this period.