MAUSAM, **70**, 3 (July 2019), 593-624

Weather in India

MONSOON SEASON (JUNE - SEPTEMBER 2018)†

1. Introduction

The rainfall over the country as a whole during the monsoon season (June-September) was 91% of its long period average (LPA) thus categorized as a normal monsoon. Seasonal rainfall over Central India (93% of LPA) Northwest India (98% of LPA) and South Peninsula (98% of LPA) regions were normal while East and Northeast Region remained *deficient* at 75% of LPA and this region remained *deficient* throughout the monsoon months. The seasonal rainfall for East and Northeast India remained to be the second lowest season rainfall ever received by the region with lowest during 2013 (73% of LPA). Out of the total 36 meteorological subdivisions, 24 subdivisions constituting 70% of the total area of the country received *normal* seasonal rainfall, Kerala subdivision received *excess* rainfall (1% of the total area) and 11 subdivisions (29% of the total area) received *deficient* seasonal rainfall. Monthly rainfall over the country was normal from June to August but *deficient* in September (77% of LPA). Southwest monsoon reached parts of southeast Bay of Bengal, south Andaman Sea and Nicobar Islands on 25th May (5 days later than its normal date). It advanced over Kerala on 29th May, 3 days ahead of the normal schedule and covered the entire country by 29th June (a fortnight earlier than the normal date). Monsoon withdrawal was delayed and commenced from parts of northwest India on 29th September (with a delay of nearly a month). It withdrew from more parts of northwest India and adjoining central India by 1st October and by 5th from remaining Central India and all of northeastern states and on 6th from northern parts of Peninsula region. The withdrawal was delayed upto 20th over southern parts of Peninsula and it finally withdrew from the entire country on 21st October.

2. Various aspects of southwest Monsoon 2018

2.1. *Onset and advance*

Fig. 1 shows the isochrones of advance of monsoon over the country.

In view of strengthening and deepening of cross equatorial flow and enhanced cloudiness and rainfall,

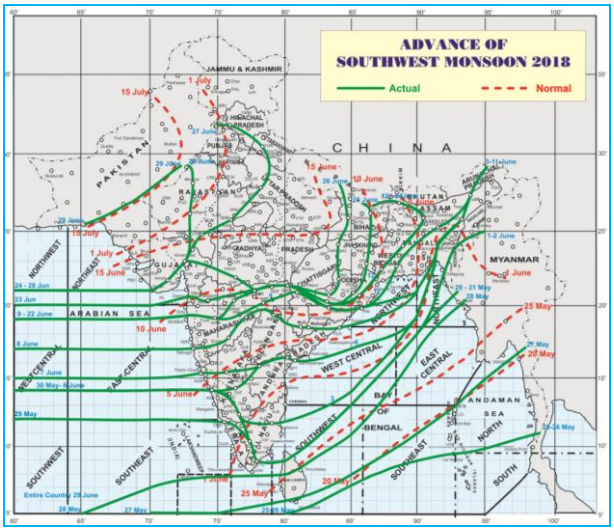

Fig. 1. Isochrones of advance of SW monsoon 2018

Southwest monsoon advanced over south Andaman Sea and parts of southeast Bay of Bengal on 25th May, five days later than its normal date. The development of a well-marked low pressure area over southeast Arabian Sea off Kerala-Karnataka coasts on 28th May and a Deep Depression over northeast and adjoining Eastcentral Bay of Bengal on 29th May resulted in strengthening the Cross Equatorial Flow (CEF) and advance of the onset over Kerala relatively faster on 29th May (3 days ahead of its normal date). The Southwest Monsoon covered some parts of central Arabian Sea, remaining parts of Kerala, most parts of Coastal Karnataka and some parts of South Interior Karnataka and some more parts of interior Tamil Nadu On 30th May, some more parts of northeast Bay of Bengal and some parts of Mizoram and Manipur on 1st June and into remaining parts of Nagaland, Manipur, Mizoram & Tripura and parts of Assam and Arunachal Pradesh on 3rd June. More parts of south Peninsula upto southern parts of Karnataka and Andhra Pradesh were covered by 6th June. Further progress in the Arabian Sea branch caused the Southwest monsoon to enter into southern parts of Maharashtra and entire Telangana on 8th June. In a steady progress, the southwest monsoon advanced into most parts of northeast India and also covered parts of West Bengal, Odisha and Chhattisgarh during 9-12 June. Thereafter, monsoon flow pattern weakened in general and this resulted in a 'hiatus' in the

* *Definitions of terms in italics other than subtitles are given in Appendix.*

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TABLE 1

Rainfall figures (mm) for each month and season as a whole (June-September 2018)

S. No.	Meteorological Sub-divisions	June			July			August			September			Monsoon		
		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	518.4	438.6	18%	239.1	407.7	-41%	415.7	403.8	3%	395.9	432.4	-8%	1569.2	1682.5	-7%
2.	Arunachal Pradesh	320.7	500.4	-36%	341.7	536.1	-36%	247.3	359.9	-31%	288.8	371.6	-22%	1198.5	1768.0	-32%
3.	Assam & Meghalaya	367.6	502.3	-27%	357.0	553.9	-36%	286.4	410.3	-30%	289.2	326.3	-11%	1320.7	1792.8	-26%
4.	Naga, Mani, Mizo and Tri.	355.1	412.1	-14%	359.8	415.0	-13%	316.2	380.1	-17%	147.4	289.7	-49%	1215.6	1496.9	-19%
5.	S. H. W. B. & Sikkim	404.9	485.2	-17%	503.7	615.8	-18%	406.5	495.2	-18%	453.3	410.0	11%	1768.3	2006.2	-12%
6.	Gangetic West Bengal	223.4	244.4	-9%	321.2	331.7	-3%	234.1	312.3	-25%	180.6	279.5	-35%	959.2	1167.9	-18%
7.	Odisha	155.3	214.1	-27%	434.7	337.0	29%	413.8	362.1	14%	286.3	236.7	21%	1290.1	1149.9	12%
8.	Jharkhand	128.0	197.5	-35%	275.5	334.6	-18%	235.1	315.8	-26%	146.4	244.0	-40%	785.0	1091.9	-28%
9.	Bihar	100.3	168.5	-40%	291.5	343.5	-15%	266.3	291.6	-9%	112.8	224.0	-50%	770.8	1027.6	-25%
10.	East Uttar Pradesh	43.1	107.8	-60%	286.3	298.0	-4%	312.6	294.5	6%	116.4	197.3	-41%	758.5	897.6	-15%
11.	West Uttar Pradesh	37.1	71.1	-48%	319.1	258.2	24%	262.7	291.6	-10%	157.1	148.5	6%	776.1	769.4	1%
12.	Uttarakhand	162.7	167.8	-3%	384.2	428.1	-10%	444.3	426.3	4%	205.0	206.9	-1%	1196.1	1229.1	-3%
13.	Haryana, Chandigarh & Delhi	70.9	45.9	54%	159.0	165.8	-4%	82.4	173.6	-53%	131.2	81.0	62%	443.3	466.3	-5%
14.	Punjab	95.5	44.4	115%	166.2	186.0	-11%	105.3	170.4	-38%	202.1	91.1	122%	569.1	491.9	16%
15.	Himachal Pradesh	120.0	95.4	26%	240.1	306.9	-22%	297.0	283.0	5%	269.8	140.0	93%	926.9	825.3	12%
16.	Jammu & Kashmir	105.9	64.1	65%	149.9	192.4	-22%	221.5	186.0	19%	111.9	92.1	22%	589.1	534.6	10%
17.	West Rajasthan	52.9	29.9	77%	88.9	102.7	-13%	40.4	89.3	-55%	19.5	41.3	-53%	201.8	263.2	-23%
18.	East Rajasthan	102.4	62.5	64%	233.3	225.2	4%	157.0	228.4	-31%	142.7	99.7	43%	635.3	615.8	3%
19.	West Madhya Pradesh	134.1	105.4	27%	307.1	291.6	5%	233.2	308.7	-24%	163.2	170.4	-4%	837.6	876.1	-4%
20.	East Madhya Pradesh	113.3	133.7	-15%	358.9	347.8	3%	295.5	369.7	-20%	151.4	200.0	-24%	919.1	1051.2	-13%
21.	Gujarat Region	90.1	130.8	-31%	377.4	341.2	11%	181.4	282.7	-36%	46.9	160.0	-71%	695.8	914.7	-24%
22.	Saurashtra & Kutch	10.2	86.9	-88%	219.2	188.5	16%	72.3	126.1	-43%	14.3	76.0	-81%	316.0	477.5	-34%
23.	Konkan & Goa	994.7	698.1	42%	1221.9	1111.0	10%	541.7	760.2	-29%	120.2	345.4	-65%	2878.4	2914.7	-1%
24.	Madhya Maharashtra	159.1	145.6	9%	265.8	242.2	10%	183.4	189.1	-3%	52.1	152.4	-66%	660.3	729.3	-9%
25.	Marathwada	190.4	143.3	33%	113.2	187.2	-40%	202.3	188.2	7%	32.1	164.2	-80%	538.1	682.9	-21%
26.	Vidarbha	196.8	168.0	17%	336.7	311.9	8%	258.0	305.7	-16%	84.0	169.0	-50%	875.4	954.6	-8%
27.	Chattisgarh	159.3	185.5	-14%	381.6	377.5	1%	419.5	374.8	12%	143.8	215.5	-33%	1104.1	1153.3	-4%
28.	Coastal Andhra Pradesh	108.8	103.9	5%	178.2	160.4	11%	205.4	157.7	30%	94.5	159.1	-41%	586.9	581.1	1%
29.	Telangana	165.5	136.2	22%	197.0	240.9	-18%	288.8	220.7	31%	81.6	161.4	-49%	732.9	759.2	-3%
30.	Rayalaseema	65.1	67.7	-4%	32.9	94.2	-65%	53.0	103.3	-49%	102.2	133.1	-23%	253.1	398.3	-36%
31.	Tamil Nadu & Puducherry	50.8	46.0	10%	60.6	68.0	-11%	73.6	87.4	-16%	105.7	115.8	-9%	290.7	317.2	-8%
32.	Coastal Karnataka	1011.2	867.7	17%	1034.6	1159.7	-11%	925.1	755.5	22%	89.3	300.9	-70%	3060.2	3083.8	-1%
33.	North Interior Karnataka	107.8	104.6	3%	89.4	135.0	-34%	89.5	120.4	-26%	69.8	146.0	-52%	356.5	506.0	-30%
34.	South interior Karnataka	181.2	141.5	28%	197.5	216.1	-9%	200.2	161.4	24%	106.7	141.0	-24%	685.6	660.0	4%
35.	Kerala	750.0	649.8	15%	858.0	726.1	18%	822.4	419.5	96%	85.6	244.2	-65%	2516.1	2039.6	23%
36.	Lakshadweep	203.2	330.2	-38%	139.7	287.7	-51%	124.4	217.5	-43%	74.4	163.1	-54%	541.7	998.5	-46%

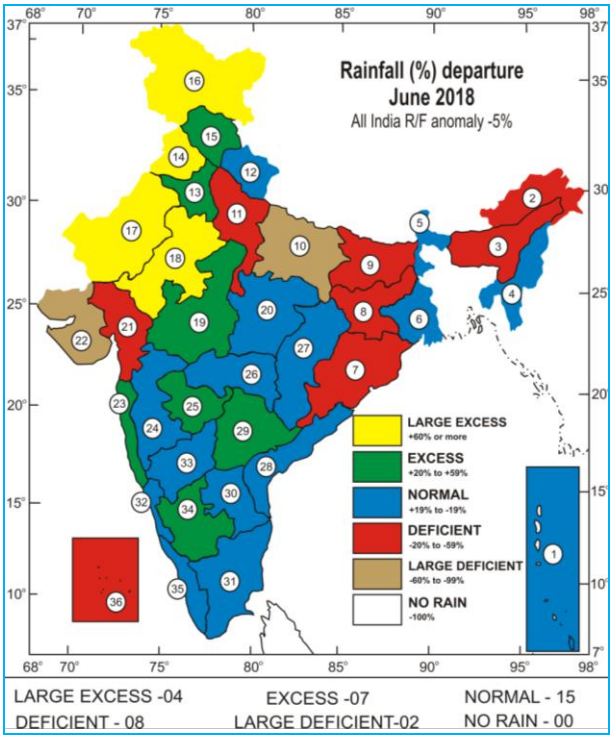

Fig. 2. Rainfall for the month of June 2018 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	18	**7**	-27	**13**	54	**19**	27	**25**	33	**31**	10
2	-36	**8**	-35	**14**	115	**20**	-15	**26**	17	**32**	17
3	-27	**9**	-40	**15**	26	**21**	-31	**27**	-14	**33**	3
4	-14	**10**	-60	**16**	65	**22**	-88	**28**	5	**34**	28
5	-17	**11**	-48	**17**	77	**23**	42	**29**	22	**35**	15
6	-9	**12**	-3	**18**	64	**24**	9	**30**	-4	**36**	-38

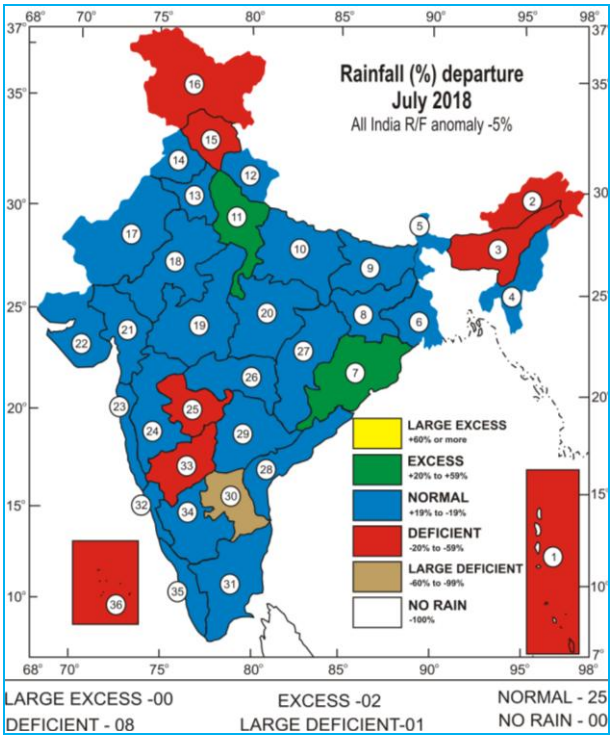

Fig. 3. Rainfall for the month of July 2018 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	-41	**7**	29	**13**	-4	**19**	5	**25**	-40	**31**	-11
2	-36	**8**	-18	**14**	-11	**20**	3	**26**	8	**32**	-11
3	-36	**9**	-15	**15**	-22	**21**	11	**27**	1	**33**	-34
4	-13	**10**	-4	**16**	-22	**22**	16	**28**	11	**34**	-9
5	-18	**11**	24	**17**	-13	**23**	10	**29**	-18	**35**	18
6	-3	**12**	-10	**18**	4	**24**	10	**30**	-65	**36**	-51

advance of southwest monsoon during 13-22 June. This period was characterized by the shifting of the active convection zone over to the Pacific Ocean, which in turn led to enhanced cyclogenesis and channeling of cross equatorial flow towards that region. After the hiatus, monsoon gradually progressed into more parts of Maharashtra, Gujarat, Madhya Pradesh and West Bengal on 23-24 June. It further advanced into some more parts of Odisha, most parts of West Bengal and some parts of Bihar and Jharkhand on 25th June. It further advanced into more parts of Odisha, remaining parts of West Bengal and most parts of Bihar and Jharkhand on 26th June and into some more parts of Gujarat region, some parts of East Rajasthan, remaining parts of Maharashtra, Chhattisgarh, Odisha, Bihar and Jharkhand, entire Madhya Pradesh and East Uttar Pradesh, most parts of West Uttar Pradesh, Uttarakhand & Himachal Pradesh, entire Jammu & Kashmir and some parts of Punjab on 27th June. It then advanced into some more parts of Gujarat Region, most parts of East Rajasthan, some parts of West Rajasthan, entire Haryana, Chandigarh & Delhi and remaining parts of West Uttar Pradesh, Uttarakhand, Himachal Pradesh and Punjab on 28th June. It further advanced into remaining parts of Gujarat State, Rajasthan and North Arabian Sea and thus the Southwest Monsoon covered the entire country on 29th June, 2018, two weeks earlier than the normal date of 15th July. In the recent past, the years 2015 and 2013 had also witnessed rapid advance of southwest monsoon when it covered the entire country on 26th June & 16th June respectively.

2.2. *Monthly rainfall distribution*

Figs. 2-5 show the monthly spatial distribution of rainfall.

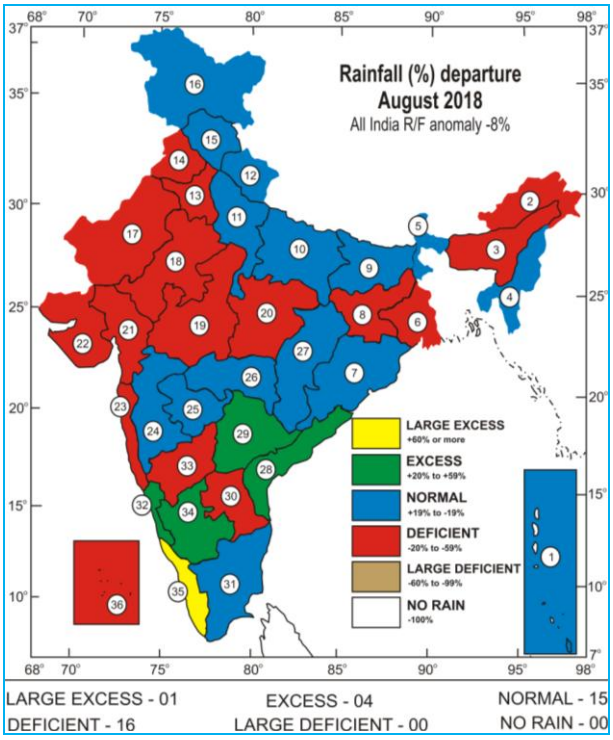

Fig. 4. Rainfall for the month of August 2018 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	3	**7**	14	**13**	-53	**19**	-24	**25**	7	**31**	-16
2	-31	**8**	-26	**14**	-38	**20**	-20	**26**	-16	**32**	22
3	-30	**9**	-9	**15**	5	**21**	-36	**27**	12	**33**	-26
4	-17	**10**	6	**16**	19	**22**	-43	**28**	30	**34**	24
5	-18	**11**	-10	**17**	-55	**23**	-29	**29**	31	**35**	96
6	-25	**12**	4	**18**	-31	**24**	-3	**30**	-49	**36**	-43

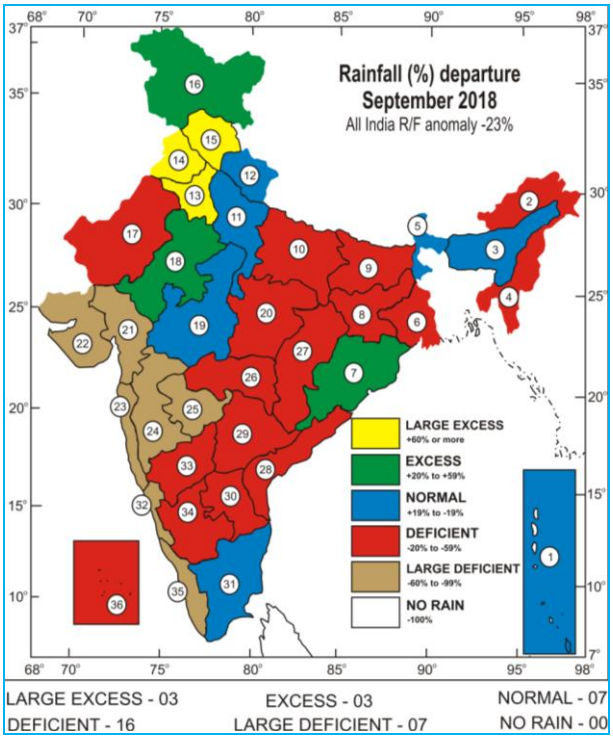

Fig. 5. Rainfall for the month of September 2018 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	-8	**7**	21	**13**	62	**19**	-4	**25**	-80	**31**	-9
2	-22	**8**	-40	**14**	122	**20**	-24	**26**	-50	**32**	-70
3	-11	**9**	-49	**15**	93	**21**	-71	**27**	-33	**33**	-52
4	-49	**10**	-41	**16**	22	**22**	-81	**28**	-41	**34**	-24
5	11	**11**	6	**17**	-53	**23**	-65	**29**	-49	**35**	-65
6	-35	**12**	-1	**18**	43	**24**	-66	**30**	-23	**36**	-54

In June, 4 subdivisions received *large excess*, 7 subdivisions received *excess* rainfall, 15 subdivisions received *normal* rainfall and 8 subdivisions received *deficient* rainfall. The *large excess* divisions are Punjab, Jammu & Kashmir and both divisions of Rajasthan, all from the Northwest region. Out of the 7 *excess* subdivisions, 3 were from Central India, 2 each from northwestern and Peninsula parts of the country. Out of 8 deficient subdivisions, 4 were from Northeast (Bihar, Jharkhand, Assam & Meghalaya and Arunachal Pradesh), one each from South Peninsula (Lakshadweep Islands), one from Northwest (West Uttar Pradesh) and Central India (Odisha). Region-wise, all 3 other regions recorded normal rainfall except East and Northeast region (-26% of LPA) which was rainfall *deficient*.

In July, 2 subdivisions received *excess* rainfall, 25 subdivisions received *normal* rainfall and 8 subdivisions received deficient rainfall. The excess regions were west Uttar Pradesh and Odisha. Out of 8 *deficient* subdivisions majority of the subdivisions were from South Peninsula and East and Northeast regions. Rayalaseema division rainfall was *large deficient* as it received precipitation only 35% of LPA. Out of the remaining 3 deficient subdivisions, 2 subdivisions were from northern part of the country (Jammu and Kashmir and Himachal Pradesh) and Marathwada from Central India. All the regions recorded normal rainfall except east and northeast region which received only 77% of LPA and remained rainfall deficient in this month too.

In August, rainfall in 1 subdivision was *large excess*, *excess* in 4, *normal* in 15 and *deficient* in 16. Two geographical regions received *normal* rainfall (-8% of LPA in Northwest India and -10% of LPA in Central India) while south peninsula received *excess*

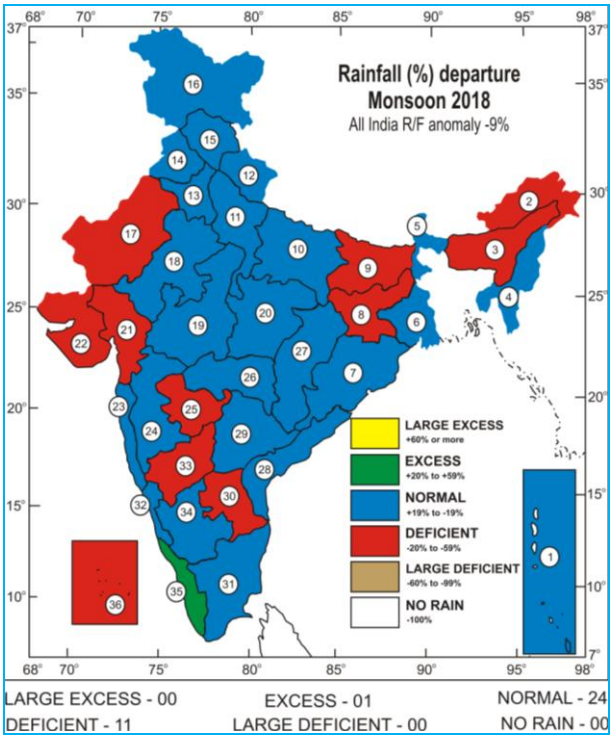

Fig. 6. Rainfall for the month of monsoon 2018 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	-7	**7**	12	**13**	-5	**19**	-4	**25**	-21	**31**	-8
2	-32	**8**	-28	**14**	16	**20**	-13	**26**	-8	**32**	-1
3	-26	**9**	-25	**15**	12	**21**	-24	**27**	-4	**33**	-30
4	-19	**10**	-15	**16**	10	**22**	-34	**28**	1	**34**	4
5	-12	**11**	1	**17**	-23	**23**	-1	**29**	-3	**35**	23
6	-18	**12**	-3	**18**	3	**24**	-9	**30**	-36	**36**	-46

rainfall (+23% of LPA). Kerala subdivision from this region received nearly double (+96% of LPA) the rainfall of its *normal* for the month. Out of the 5 *excess* subdivisions, 4 were from South Peninsula (coastal Karnataka, south interior Karnataka, Telangana and coastal Andhra Pradesh). The monthly rainfall in the East and Northeast India continued to be *deficien*t with monthly anomaly at -23%.

The rainfall in September for the country was highly *deficient* at -23% of LPA. A noticeable feature of rainfall distribution during September was only northwest subdivisions, which recorded *normal* rainfall (+9% of LPA), the remaining three regions were rainfall *deficient* with East and Northeast India, Central India and South Peninsula receiving -29% of LPA, -31% of LPA and -38% of LPA respectively. Assam and Meghalaya division rainfall was *normal* for the first time in 4 months (other 3

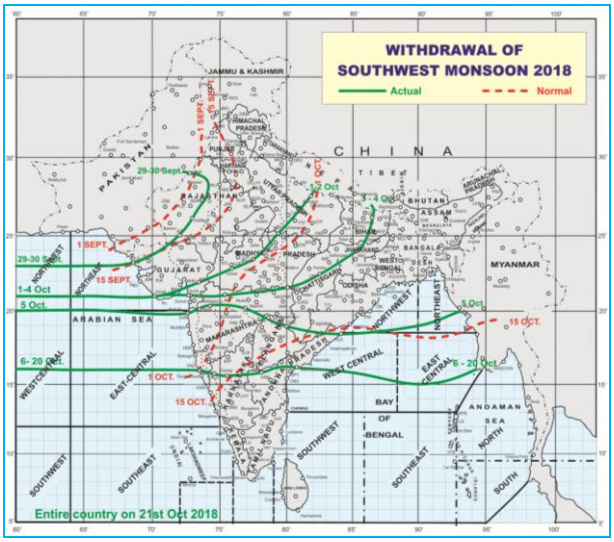

Fig. 7. Isochrones of withdrawal of SW monsoon 2018

months *deficient*). Arunachal Pradesh and Lakshadweep subdivisions remained *deficient* for all the monsoon months. Three subdivisions, all from northwest India (Punjab, Haryana, Chandigarh & Delhi subdivision and Himachal Pradesh) were *large excess*, 3 *excess* (2 from Northwest India and 1 from Central India).

7 subdivisions were *normal*, 16 subdivisions were deficient and 7 *large deficient* (5 from central India and 2 from Peninsula).

2.3. *Seasonal rainfall distribution*

Meteorological subdivision seasonal rainfall distribution in terms of percentage departures from *normal* is given in Fig. 6. Out of the total 36 meteorological subdivisions, the season rainfall was *excess* in 1 (Kerala), *normal* in 24 sub-divisions and *deficient* in 11 subdivisions, no Sub-divisions reported *Large excess and Large deficient* rainfall by the end of the season. Out of the 11 *deficient* subdivisions, 4 subdivisions were from east and northeast India, 3 each from Peninsula and central India and one (west Rajasthan) from northwest India. East & Northeast India recorded the lowest rainfall (75% of LPA), It may be noted that prior to 2018 (during 1901-2017), there were only four years, when the season rainfall over Northeast India was less than 80% of LPA and 3 of these years were from the recent 15 years (2005, 2009 & 2013) the other being 1992 (-22%of LPA). It may also be added that during 17 of the last 18 years (2001-2018), Northeast India has received season rainfall less than LPA with an exception of 2007 (110% of LPA). This indicates that the seasonal rainfall over Northeast India is passing through a below normal epoch like it was during early 1950s to mid-1980s.

TABLE 2

Representative amounts of extremely heavy rainfall during June-September 2018

Date	Some representative amounts of rainfall in cm for June, July, August and September 2018 (21 cm and above)
1 Jun	Nil
2 Jun	Nil
3 Jun	Nil
4 Jun	Nil
5 Jun	Nil
6 Jun	Nil
7 Jun	Nil
8 Jun	Umarga and Siddapura 21 each
9 Jun	Malvan 49, Vengurla 27, Bhiwandi 21
10 Jun	Devgarh 28, Ratnagiri 27, Murud 26, Rajapur 21
11 Jun	Peermade To 32, Lanja 22
12 Jun	Sabroom 27, Sakleshpura 26, Serchip (Hydro) 24
13 Jun	Ponnampet Pwd 23, Kollur and Kammardi 22 each, Sohra (earstwhile Cherrapunji) 21
14 Jun	Sohra 28, Manjeri 23, Nilambur 21
15 Jun	Kamalpur 25, Chhamonu 21
16 Jun	Nil
17 Jun	Nil
18 Jun	Murud 21
19 Jun	Nil
20 Jun	Devgarh 27
21 Jun	Rameshwaragri and Malvan 35 each, Vengurla 32, Rajapur 26, Mulki and Mapusa 22 each
22 Jun	Cooch Behar 21
23 Jun	Matheran 26, Gajoldoba 25, Karjatagri 24, Dapoliagri 23, NH31 Bridge 22, Ratnagiri 21
24 Jun	Sohra (RKM) 38, Guhagarh 25, Shriwardhan 24, Sohra and Buxaduar 23 each
25 Jun	Devgarh 27, Mumbai (SCZ) and Dahanu 23 each, Talasari, Thane and Umergam 21 each
26 Jun	Kaprada and Valsad 29 each, Pardi 24, Waghai 22, Dharampur, Dhansura and Umergam 21 each
27 Jun	Kanksa BSF 25, Birdghat 24, Gorakhpur and Kanva 23 each
28 Jun	Agumbe 30, Kollur 26, Gerusoppa 21
29 Jun	Sehore AWS 21
30 Jun	Sohra (RKM) 21
1 Jul	Gossaigaon and Domohani 23 each, Kokrajhar, Sohra (RKM) and Mohitnagar 22 each, Jalpaiguri 21
2 Jul	Kakerdarighat and Munsyari 25 each, Nighasan 24, Bhinga and Sohra 23 each, Bhinga HMO 22, Sohra (RKM) 21
3 Jul	Nil
4 Jul	Alipurduar CWC 28, Hasimara and Chepan 26 each, Kumargram, Sohra (RKM) and Sohra 23 each, Buxaduar 21
5 Jul	Jalpaiguri AWS 21
6 Jul	Ponda 21
7 Jul	Nanipalson 29, Nagpur AP 28, Hingna 27, Sulya 24, Songadh, Udupi, Puttur HMS and Wada 23 each, Bantwal, Mudubidre, Mulki, Mani and Murbad 22 each, Karkala, Lonavalaagri, Korpana and Agumbe 21 each

TABLE 2 (*Contd.*)

Date	Some representative amounts of rainfall in cm for June, July, August and September 2018 (21 cm and above)
8 Jul	Bhiwandi 38, Mulki 28, Mangaon and Kalyan 25 each, Mahad 24, Karjat Agri 23, Khalapur and Waghai 22 each, Subir 21
9 Jul	Dahanu 35, Vasai and Mhasla 23 each, Murud and Palgharagri 22 each
10 Jul	Vasai 30, Palghar Agri 29, Kapkot 28
11 Jul	Nil
12 Jul	Bardoli, Chikhli and Dharampur 21 each
13 Jul	Waghai 21
14 Jul	Kodinar 22
15 Jul	Malia 39, Brahmagiri AWS 30, Visavadar 28, Kotraguda and Kodinar 23 each, Krishnaprasad 22
16 Jul	Bhavani P. and Mahabaleshwar 30 each, Lonavala Agri 29, Matheran 26, Narla ARG 25, Talasari, Kochi AP, Kozha and Jesar 23 each, Ulhasnagar, Piravam and Igatpuri 22 each
17 Jul	Gir Gadhada 50, Una 45, Kodinar 33, Jafrabad 28, Mahabaleshwar 27, Diu 26, Sutrapada 25, Dharampur 23, Valsad 22
18 Jul	Khambhalia 41, Manavadar 28, Vansda 25, Waghai and Mangrol 21 each
19 Jul	Nil
20 Jul	Nil
21 Jul	Umerpada 32, Brahmagiri AWS 29, Puri 27, Junagarh 26, Tentulikhunti ARG, Pipili and Kesinga ARG 24 each, Kashipur 22, Narla ARG, Cuttack and Jaipatna 21 each
22 Jul	Burla ARG 62, Sambalpur 57, Birmaharajpur ARG 43, Hirakud 40, Boudhgarh 38, Atabira ARG 35, Bargarh 31, Rairakhol 30, Ullunda ARG 26, Jujumura ARG 22, Sonepur, Binika, Khairamal and Athmalik 21 each
23 Jul	Nil
24 Jul	Nil
25 Jul	Nil
26 Jul	Orai 21
27 Jul	Maithon 24, Ballabgarh 22, Gohar 21
28 Jul	Budhana and Meerath 21 each
29 Jul	Nil
30 Jul	Karhal 21
31 Jul	Nil
1 Aug	Nil
2 Aug	Nil
3 Aug	Nil
4 Aug	Nil
5 Aug	Nil
6 Aug	Bankura 35, Jhargram 27, Bankura CWC 22
7 Aug	Puri 39
8 Aug	Nil
9 Aug	Nilambur 40, Mananthavady 31, Peerumade To and Munnar KSEB 25 each, Palakkad and Myladumparaagri 21 each
10 Aug	Nil
11 Aug	Nil
12 Aug	Luxettipet and Ramagundam 27 each, Utnur and Venkatapuram 25 each, Gossaigaon and Venkatapur 23 each, Bhamragad 22, Dharmapuri 21
13 Aug	Sujanpur Tira 31, Arki 30, Nadaun 29, Gohar 26, Kollur 25, Paonta 24, Baijnath 23, Palampur and Bhoranj 21 each

TABLE 2 (*Contd.*)

Date	Some representative amounts of rainfall in cm for June, July, August and September 2018 (21 cm and above)
14 Aug	Agumbe 31, Kollur 30, Siddapura 26, Bhagamandala 25, Kota 24, Kundapur 22, Gerusoppa and Kammardi 21 each
15 Aug	Lanjigarh 28, Peerumade To and Shencottah 27 each, Madanpur Rampur and Bhagamandala 25 each, Ambadola and Narla ARG 24 each, Idukki and Agumbe 23 each, Bhavani P. and Munnar KSEB 22 each, Karipur and Medikeri 21 each
16 Aug	Bhopalpatnam 40, Peerumade To 35, Idukki and Munnar KSEB 29 each, Ponnani 27, Medikeri and Vadakara 26 each, Vellanikkara, Vadakkancherry and Enamakkal 25 each, Mannarkad, Sukma and Subramanya 24 each, Alathur, Perumpavur and Kunnamkulam 23 each, Sohra (RKM) and Chalakudi 22 each, Ottapalam and Thrithala 21 each
17 Aug	Medikeri 30, Bhikangaon and Castle Rock 23 each, Kamalpur, Shegaon, Bhagamandala, Bhabhra and Madapura 21 each
18 Aug	Nil
19 Aug	Nil
20 Aug	Koida 39, Kukunoor 29, Velairpad 28, Panposh 23, Aswaraopeta 21 each
21 Aug	Mauda 26, Navipet 21
22 Aug	Murbad 22
23 Aug	Nil
24 Aug	Rosera and Orchha 30 each, Dharmasala 29, Dharmshala AWS 28, Sohra 27, Sohra (RKM) 22
25 Aug	Bareilly and Bareilly Tehsil 21 each
26 Aug	Kannauj 24
27 Aug	Junagarh 21
28 Aug	Nil
29 Aug	Nil
30 Aug	Nil
31 Aug	Hardwar 27
1 Sep	Jajpur 23, Pattamundai and Gyanpur 21 each
2 Sep	Chanderi 29, Orchha 25, Mungaoli 21
3 Sep	Sawai Madhopur Tesil 27, Sawai Madhopur 24
4 Sep	Nil
5 Sep	Nil
6 Sep	Paradip 41, Kujanga ARG 37, Kendrapara and Marsaghai ARG 34 each, Pattamundai 31, Derabis ARG 30, Bari ARG 27, Tirtol ARG 26, Salepur ARG 25, Binjharpur ARG and Garadapur ARG 24 each, Raghunathpur ARG and Alipingal 21 each
7 Sep	Nil
8 Sep	Nil
9 Sep	Nil
10 Sep	Murti 35, Nagarkata 32, Chengmari/Diana and Hasimara 29 each, Bagrakote 28, Neora 27, Buxaduar and Gajoldoba 25 each, Salbari 24
11 Sep	Nil
12 Sep	Nil
13 Sep	Nil
14 Sep	Nil
15 Sep	Sevoke 28
16 Sep	Nil
17 Sep	Nil
18 Sep	Nil

TABLE 2 (*Contd.*)

Date	Some representative amounts of rainfall in cm for June, July, August and September 2018 (21 cm and above)
19 Sep	Nil
20 Sep	Nil
21 Sep	Jaipur 29, Malkangiri 28, Contai 25, Similiguda AWS 21
22 Sep	Khandwa 34, Hinganghat 23
23 Sep	Nil
24 Sep	Pathankot and Gurudaspur 24 each, Kapurtala 23, Beki Mathungari and TaranTaran 21 each
25 Sep	Nil
26 Sep	Panbari 23
27 Sep	Nil
28 Sep	Nil
29 Sep	Nil
30 Sep	Nil

2.4. *Withdrawal of southwest Monsoon*

Fig. 7 shows the isochrones of withdrawal of SW Monsoon.

The rainfall activity over west Rajasthan remained subdued since last week of August but the remnant low of the Cyclonic storm 'DAYE' which travelled to south Haryana and neighbourhood on 24th September and its associated cyclonic circulation extending upto 7.6 kms a.s.l. tilting south-southwestwards with height revived the monsoon in this subdivision with scattered rainfall on 1 or 2 days and isolated rainfall on a few days between 23rd to 25th September. After this there was change over in the lower tropospheric circulation pattern over the region from cyclonic to anti cyclonic leading to substantial reduction in moisture content and prevalence of dry weather indicating the beginning of the withdrawal of southwest monsoon from the region. Hence the southwest monsoon withdrew from some parts of west Rajasthan, Kutch and north Arabian Sea on 29th September. Further withdrawal was rapid when the monsoon withdrew from remaining parts of Rajasthan, entire Punjab, Haryana, Chandigarh & Delhi, Jammu & Kashmir, Himachal Pradesh, Uttarakhand and west Uttar Pradesh, some parts of east Uttar Pradesh, most Gujarat region and some more parts of north Arabian Sea on 1st October. It further withdrew from remaining parts of East Uttar Pradesh and Madhya Pradesh, some more parts of east Bihar, Chhattisgarh and extreme northern parts of Maharashtra on 3rd October, all northeastern states, most parts of Chhattisgarh, Odisha, west Bengal and remaining parts of Bihar and Jharkhand and some more parts of northern Maharashtra on 5th and from entire Maharashtra and Telangana, northern parts of coastal Andhra Pradesh and north interior Karnataka on 6th October. Thus the monsoon had withdrawn from most parts of India barring south peninsula. There was a lag in withdrawal after 6th October upto the 20th October over Peninsula, where rainfall activity continued due to the presence of an active Inter Tropical Convergence Zone (ITCZ) with embedded easterly wave perturbations. Subsequent to the equatorward shifting of the ITCZ and reduction in rainfall, the southwest monsoon withdrew from the entire country, Bay of Bengal and the Arabian Sea on 21st October, 2018.

3. Chief synoptic features of southwest Monsoon 2018

The synoptic features which affected the Indian Monsoon region during June, July, August and September are given in Tables 3 to 6 respectively.

During the season, 11 low pressure systems formed over the Indian subcontinent, 3 Low pressure areas, 2 Well marked low pressure areas, 4 Depressions, 1 Deep Depression and 1 Cyclonic Storm.

The first intense system of the season and the only intense low pressure system of the month was a Depression (10-11 June) over northeast Bay of Bengal and adjoining Bangladesh coast, the remnant cyclonic circulation moved up to south Assam and Meghalaya and neighbourhood which helped in advancing the monsoon in the northeastern states.

TABLE 3

Details of the weather systems during June 2018

S. No.	System	Duration	Place of initial location	Direction of movement	Place of Final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**)	*Depression/ Deep depression*					
1.	Depression	10 (1730 hrs IST)-11	Over northeast Bay of Bengal and adjoining Bangla Desh near Lat. 22.5° N/ Long. 91.5° E	Northeast	Lat. 23.1° N/ Long. 91.2° E	Details are given in the article Storms and Depressions over the North Indian Ocean 2018
(**B**)	*Western disturbances / Eastward moving systems*					
(*i*)	*Upper air cyclonic circulation*					
1.	Upto Mid and upper tropospheric levels	11-12	North Pakistan and adjoining Jammu and Kashmir Neighbourhood	Northeast	Jammu & Kashmir and neighbourhood	Moved away northeastwards
2.	Upto 3.1 kms a.s.l.	14-15	Eastern parts of Jammu and Kashmir and neighbourhood	Stationary	*In situ*	It became less marked on 15
3.	Upto mid and upper tropospheric levels	22-28	North Pakistan and adjoining Jammu and Kashmir neighbourhood	Northeast	Jammu & Kashmir and neighbourhood	It initially lay as a trough in mid and upper troposphere with axis at 5.8 kms a.s.l. along Long. 68° E and north of latitude 34° N. It moved away east northeast wards
(*ii*)	*As a trough*					
1.	Upto Mid tropospheric levels	15-17	Along Long. 64° E to the north of Lat. 32° N (axis at 5.8 kms a.s.l.)	East	Along Long. 76° E to the north of Lat. 32° N (axis at 5.8 kms a.s.l.)	Became less marked on 18
2.	Upto mid and upper troposphere	18-19	Along Long. 65° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	Northeast	Along Long. 72° E to the north of Lat. 32° N (axis at 5.8 kms a.s.l.)	Moved away northeastwards
3.	Do	28 Jun-2 Jul	Along Long. 64° E to the north of Lat. 28° N (axis at 5.8 kms a.s.l.)	East northeast	Along Long. 74° E to the north of Lat. 34° N (axis at 5.8 kms a.s.l.)	Moved away east northeast wards
(**C**)	*Other upper air cyclonic circulations*					
1.	Upto lower tropospheric levels	31 May-8 Jun	Northeast Rajasthan & neighbourhood	Northwest	North Madhya Pradesh and adjoining south Uttar Pradesh	Merged with the trough over NW Rajasthan to Bangladesh on 9
2.	Do	31 May	Madhya Pradesh and neighbourhood	Stationary	*In situ*	Became less marked on 1
3.	Between 4.5 and 7.6 kms a.s.l.	31 May-4 Jun	Southeast Arabian Sea and adjoining Lakshadweep	North	East central and adjoining South east Arabian sea	Merged with the east west shear zone running roughly along Lat. 12° N across peninsular India
4.	Upto 0.9 kms a.s.l.	31 May-1 Jun	Sub-Himalayan West Bengal and neighbourhood lay over west Assam and neighbourhood	Stationary	*In situ*	Became less marked on 2
5.	Upto lower tropospheric levels	1	Northeast Rajasthan and neighbourhood	Do	Do	Became less marked on 2

TABLE 3 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
6.	Upto Lower tropospheric levels	1	South Konkan and Goa and neighbourhood	Stationary	*In situ*	Became less marked on 2
7.	Do	1	North coastal Tamil Nadu and neighbourhood	Do	Do	Became less marked on 2
8.	Upto 1.5 kms a.s.l.	2-3	South Bihar and adjoining Jharkhand	North	Bihar and neighbourhood	Merged with the east west trough from Punjab to Gangetic West Bengal extending upto 1.5 kms a.s.l. on 4
9.	Upto mid tropospheric levels	2-4	Sub-Himalayan West Bengal and adjoining Bihar	South	Bangladesh and adjoining West Bengal	Became less marked on 5
10.	Upto lower tropospheric levels	3-7	Southwest Uttar Pradesh and neighbourhood	East	East Uttar Pradesh and neighbourhood	Became less marked on 8
11.	Do	3	East Vidarbha and adjoining Chhattisgarh	Stationary	*In situ*	Became less marked on 4
12.	Do	4	Southeast Arabian Sea off Kerala-Karnataka coast	Do	Do	Merged with the off shore trough on 5
13.	Between 1.5 and 2.1 kms a.s.l.	5-6	Northeast Chhattisgarh and neighbourhood	Northeast	Jharkhand and neighbourhood	Became less marked on 7
14.	Between 4.5 & 5.8 kms a.s.l.	5	South Bihar and neighbourhood	Stationary	*In situ*	Became less marked on 6
15.	Upto 1.5 kms a.s.l.	6	Punjab and neighbourhood	Do	Do	Became less marked on 7
16.	Do	6-7	South Madhya Maharashtra and adjoining south Konkan	East	Marathwada and neighbourhood	Became less marked on 8
17.	Upto 3.1 kms a.s.l.	7	Northwest Uttar Pradesh and neighbourhood	Stationary	*In situ*	Became less marked on 8
18.	Between 1.5 and 3.1 kms a.s.l.	7	Assam and neighbourhood	Do	Do	Became less marked on 8
19.	At 1.5 kms a.s.l.	8-10	Haryana and neighbourhood	Do	Do	Became less marked on 11
20.	At 3.1 kms a.s.l.	8-10	Jammu & Kashmir and adjoining Himachal Pradesh	South	Himachal Pradesh and neighbourhood	Became less marked on 11
21.	Between 3.1 & 7.6 kms a.s.l.	8	East central Arabian Sea off Karnataka coast	Stationary	*In situ*	Became less marked on 9
22.	Upto 1.5 kms a.s.l.	10-11	Central Uttar Pradesh and neighbourhood	Southeast	Bihar and neighbourhood	Became less marked on 12
23.	Upto 5.8 kms a.s.l.	10	East Madhya Pradesh and neighbourhood	Stationary	*In situ*	Became less marked on 11
24.	Upto lower tropospheric levels	12	North Haryana and neighbourhood	Do	Do	Became less marked on 13
25.	Upto 7.6 kms a.s.l.	12-14	South Assam and neighbourhood	East	Central Assam and neighbourhood	Became less marked on 15

TABLE 3 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
26.	Upto 0.9 kms a.s.l.	13	Sub Himalayan West Bengal and Sikkim	Stationary	*In situ*	Became less marked on 14
27.	Upto 1.5 kms a.s.l.	15-26	Central Pakistan and adjoining Punjab	East	Northeast Uttar Pradesh and neighbourhood	Became less marked on 27
28.	At 0.9 kms a.s.l.	15-16	Northeast Bihar and adjoining Sub Himalayan West Bengal and Sikkim	Stationary	*In situ*	Became less marked on 17
29.	At 7.6 kms a.s.l.	15-16	East central Arabian Sea off Karnataka coast	North	East central Arabian Sea off south Maharashtra-Goa coasts	Became less marked on 17
30.	Upto 0.9 kms a.s.l.	16-18	Northern parts of Haryana and neighbourhood	South	North west Uttar Pradesh and neighbourhood	Became less marked on 19
31.	Between 3.1 and 3.6 kms a.s.l.	16-23	South Gujarat and neighbourhood	Do	South Konkan and neighbourhood	Merged with the east west shear zone on 24
32.	Upto 0.9 kms a.s.l.	17-18	Central Assam and neighbourhood	East	East Assam and neighbourhood	Became less marked on 19
33.	Upto 7.6 kms a.s.l.	16	Lakshadweep Maldives area	Stationary	*In situ*	Became less marked on 17
34.	Upto 7.6 kms a.s.l. tilting southwards with height	17-28	West central Bay of Bengal and adjoining south Odisha and north coastal Andhra Pradesh	North	Chhattisgarh and neighbourhood	Merged with the monsoon trough on 29
35.	Upto 0.9 kms a.s.l.	20	Bihar and adjoining east Uttar Pradesh	Stationary	*In situ*	Became less marked on 21
36.	Do	22-23	Central Assam and neighbourhood	Do	Do	Became less marked on 24
37.	Between 2.1 and 3.6 kms a.s.l.	23-30	North Konkan and adjoining south Gujarat	North	Northwest Rajasthan and neighbourhood	Became less marked on 1 July
38.	Between 3.1 and 4.5 kms a.s.l.	25-26	Bihar and adjoining Sub-Himalayan West Bengal	Stationary	*In situ*	Merged with the east west trough from Punjab to east Assam on 27
39.	At 1.5 kms a.s.l.	24-25	West Assam and adjoining Sub Himalayan West Bengal	East	West Assam and neighbourhood	Merged with the monsoon trough on 26
40.	Do	26-28	South Pakistan and adjoining areas of Kutch and west Rajasthan	South	South Rajasthan and adjoining Gujarat Region	Became less marked on 29
41.	At 5.8 kms a.s.l.	27 Jun-1 Jul	South Gujarat and neighbourhood	West	Over North and adjoining central Arabian Sea	Became unimportant on 2 July
42.	At 7.6 kms a.s.l.	28-30	Southeast Arabian Sea off north Kerala Karnataka coast	North	East central Arabian Sea off south Maharashtra coast	Became less marked on 1 July
43.	Between 3.1 and 3.6 kms a.s.l.	30 Jun-8 Jul	Saurashtra and neighbourhood	Do	South Pakistan and neighbourhood	Became less marked on 9

TABLE 3 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**D**)	*East-West trough*					
1.	Upto 1.5 kms a.s.l.	4-10	From Punjab to Gangetic West Bengal	Southeast	Punjab to center of well-marked low pressure area over northeast Bay of Bengal and adjoining Bangladesh coast across Haryana, Uttar Pradesh, Jharkhand and Gangetic West Bengal	Became less marked on 11
2.	At 7.6 kms a.s.l.	17	Telangana to southeast Asia across south interior Karnataka and north Kerala	Stationary	*In situ*	Became less marked on 18
3.	At mid and upper tropospheric levels	18-19	Along Long. 90° E to the north of Lat. 24° N	East	Long. 93° E to north of Lat. 25° N	Became less marked on 20
4.	Upto 0.9 kms a.s.l.	20-22	From cyclonic circulation over Bihar to east Bangladesh	Northeast	From cyclonic circulation over southwest Uttar Pradesh and neighbourhood to Sub Himalayan West Bengal	Became less marked on 23
5.	Do	26-28	Punjab to east Assam across northern parts of Uttar Pradesh, Bihar and Sub Himalayan West Bengal	Do	Southwest Rajasthan to east central Bay of Bengal across Madhya Pradesh, Chhattisgarh and Odisha	It lay as a monsoon trough from 29
(**E**)	*Other troughs/wind discontinuity*					
1.	At lower tropospheric levels	31 May-1 Jun	From central parts of Madhya Pradesh and neighbourhood to Telangana across east Vidarbha	South	From Telangana to Coastal Andhra Pradesh	It became less marked on 2
2.	Upto 0.9 kms a.s.l.	31 May	From circulation over northwest Rajasthan to Bihar across south Uttar Pradesh	Stationary	*In situ*	It merged with the trough that extended from the circulation over north west Rajasthan to Bihar on 1 June
3.	Upto 0.9 kms a.s.l.	1-2	Northwest Rajasthan to northeast Jharkhand across northeast Rajasthan, north Madhya Pradesh south Uttar Pradesh	Southeast	Punjab to Bangladesh	Became less marked on 3
4.	At 1.5 kms a.s.l.	2	Punjab to Northeast Rajasthan	Stationary	*In situ*	Became less marked on 3
5.	At 3.1 kms a.s.l.	2	From the cyclonic circulation over Sub-Himalayan West Bengal and adjoining Bihar to north Bay of Bengal across Bangla Desh	Do	Do	Became less marked on 3

TABLE 3 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
6.	Upto lower tropospheric levels	4	From the cyclonic circulation over southwest Uttar Pradesh to west central Bay of Bengal off south Andhra Pradesh across east Madhya Pradesh, east Vidarbha and Telangana	Stationary	*In situ*	Became less marked on 5
7.	Upto 3.1 and 5.8 kms a.s.l.	6	Along Long. 77° E to the north of Lat. 30° N	Do	Do	Became less marked on 7
8.	At lower levels	13-14	Sub Himalayan West Bengal and Sikkim to Nagaland across Assam and Meghalaya	South	North interior Odisha to west central Bay of Bengal off Andhra Pradesh coast	Became less marked on 15
9.	At 0.9 kms a.s.l.	14	From east Madhya Pradesh to Telangana across east Vidarbha	Stationary	*In situ*	Became less marked on 15
10.	Do	14	South interior Karnataka to Comorin area across interior Tamil Nadu	Do	Do	Became less marked on 15
11.	At 7.6 kms a.s.l.	15-17	From Northeast Bihar to the east central Arabian Sea off Karnataka coast cyclonic circulation	East	Northeast Bihar to the cyclonic circulation over west central bay of Bengal and adjoining south Odisha and north coastal Andhra Pradesh	Became less marked on 18
12.	Upto 0.9 kms a.s.l.	18	From the cyclonic circulation over north Punjab and neighbourhood to northwest Madhya Pradesh across south Haryana and northeast Rajasthan	Stationary	*In situ*	Became less marked on 19
13.	Do	19	From east Bihar to north Bay of Bengal across West Bengal	Do	Do	Became less marked on 20
14.	Upto 1.5 kms a.s.l.	20	From Bihar to cyclonic circulation over south Konkan	Do	Do	Became less marked on 21. The cyclonic circulations over Bihar and adjoining east Uttar Pradesh and over south Konkan and neighbourhood were embedded in the trough
15.	Do	22-23	From Bihar to north west Bay of Bengal across Jharkhand	Do	Do	Became less marked on 24
(**F**)	*East-west shear zone*					
1.	At 3.1 kms a.s.l.	31 May	Along Lat. 9° N	Stationary	Along Lat. 9° N	Became less marked on 1
2.	At 7.6 kms a.s.l.	2-8	Along Lat. 11° N	North	Along Lat. 15° N	Became less marked on 9
3.	Between 3.1 and 7.6 kms a.s.l.	21-24	Along Lat. 18° N	Do	Along Lat. 20° N	Became less marked on 25

The first system in July formed as a low pressure area over northwest Bay of Bengal & neighbourhood on 7th. The second system of July had been a well-marked low pressure area, during 13-19 July. Under the influence of a cyclonic circulation, a low pressure area formed over northwest Bay of Bengal and neighbourhood on 13th. It became a well-marked low pressure area over the same region on 14th night. It gradually moved westwards up to central parts of north Madhya Pradesh and neighbourhood as a low pressure area and became less marked on 19th July. This system revived the active monsoon conditions over major parts of the country and gave heavy to very heavy rainfall at isolated places over northwest, central parts and Peninsula India. The third system of July formed as a low pressure area over northwest Bay of Bengal and adjoining Gangetic West Bengal and Odisha on 19th July which concentrated into a Depression on 21st July morning and intensified into a Deep Depression in the afternoon of 21st July. It crossed north Odisha-West Bengal coasts in the evening of 21st July close to the south of Digha and moved west northwest-wards across the central parts of the country. Under the influence of the system, widespread and intense rainfall activity occurred over Odisha, Gangetic West Bengal, Chhattisgarh, Jharkhand and Madhya Pradesh. Exceptionally heavy rainfall was recorded over Burla ARG 62 cms, Sambalpur 57 cms and Birmaharajpur ARG 43 cms in Odisha. While moving west northwest-wards it weakened and its remnant lay over northwest Uttar Pradesh and neighbourhood as a low pressure area on 28th July. Its persistence over West Uttar Pradesh and neighbourhood for nearly three days caused fairly widespread to widespread rainfall activity with heavy to very heavy and extremely heavy falls over Western Himalayan Region and adjoining plains of northwest India during 26th to 28th July. The fourth and last system of July formed under the influence of a cyclonic circulation over western parts of Bihar and neighbourhood, the low pressure area formed over northeast Uttar Pradesh and neighbourhood on 30th July and became less marked on 3rd and associated cyclonic circulation merged with the monsoon trough on 4th.

In addition, the presence of a nearly stationary cyclonic circulation over South Gujarat and neighbourhood from 9th to 20th July led to increase in rainfall activity over the region and neighbourhood. On 16th it lay over south Gujarat and neighbourhood and extended between 3.1 and 7.6 kms a.s.l. tilting southwestwards with height causing exceptionally heavy falls over Gir Gadhada 50 cms, Una 45 cms and Kodinar 33 cms, all from Saurashtra & Kutch.

The first system of August formed as a Low pressure area over Northwest Bay of Bengal and neighbourhood on 6th August. It subsequently concentrated into a Depression and crossed north Odisha, West Bengal coasts and moved west northwest-wards and weakened into Well Marked Low Pressure Area over Chhattisgarh and neighbourhood and finally lay as a low pressure area over north Madhya Pradesh and neighbourhood on 9th August. It caused fairly widespread to widespread rainfall activity with heavy to very heavy and extremely heavy falls over eastern parts of Central India. Moreover, genesis of this Depression resulted in the strengthening of low level westerlies causing widespread rainfall activity along the west coast. During its westward movement, convergence of easterlies along the foot hills of Himalayas caused fairly widespread to widespread rainfall with isolated heavy to very heavy falls over Western Himalayan Region and adjoining plains of Northwest India. The second system in August formed as a low pressure area over Northwest Bay of Bengal and adjoining Coastal areas of West Bengal and Odisha on 13th August. It subsequently concentrated into a Depression and lay over Coastal Odisha and neighborhood on 15th August, moving west-northwestwards, it weakened gradually and lay as a low pressure area over southwest Madhya Pradesh and neighborhood on 17th August. Under its influence, fairly widespread to widespread rainfall activity with heavy to very heavy falls had been reported from parts of east and adjoining central India. Strengthening of the monsoon flow due to the formation of the low pressure system had caused widespread intense rainfall activity over south peninsular India. During the above mentioned active phase, vigorous monsoon conditions occurred on 5-6 days over Kerala and southern parts of Karnataka. There had been a few instances of extremely heavy rainfall events over these regions as well as over the Ghat sections of Tamil Nadu.

The convective phase of Madden Julian Oscillation (MJO) remained nearly stationary over the tropical Pacific Ocean with moderate to high amplitude during the second week of August. The third system in August was a Low Pressure area which formed over northwest Bay of Bengal and neighbourhood on 19th August. It subsequently moved west northwestwards before it became less marked over northwest Madhya Pradesh and neighbourhood on 22nd August. Under its influence, widespread very intense rainfall activity had been reported from parts of central India and adjoining peninsular India. The remnants of the above system also caused fairly widespread to widespread rainfall activity over parts of northwest India also. August witnessed the development of a fourth system, which formed as a Low pressure area over coastal areas of West Bengal, north Odisha and adjoining North West Bay of Bengal on 25th which further developed into a well-marked Low Pressure Area within subsequent 48 hours and lay over Northwest Bay of Bengal and adjoining West Bengal and Odisha coast. Under its influence, Odisha experienced widespread intense rainfall activity

TABLE 4

Details of the weather systems during July 2018

S. No.	System	Duration	Place of initial location	Direction of movement	Place of Final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**)	*Deep Depression/Depression*					
1.	Deep Depression	21 (0300 UTC)-23	Northwest & Bay of Bengal near Lat. 21.0° N/ Long. 88.0° E	Northwest	Northwest Uttar Pradesh and neighbourhood	Details are given in the article on Storms & Depressions over the north Indian Ocean - 2018
(**B**)	*Well marked low/low pressure area*					
1.	Low Pressure area	7-8	Northwest Bay of Bengal and neighbourhood	East	Northwest parts of Uttar Pradesh and adjoining Bihar	It formed under the influence of a cyclonic circulation extending upto 7.6 kms a.s.l. over southeast Bangladesh and neighbourhood. It became less marked on 8. Associated cyclonic circulation extending upto mid tropospheric levels
2.	Well marked low Pressure area	14-17	Do	Southwest	Northeast Madhya Pradesh & adjoining southeast Uttar Pradesh and north Chhattisgarh	Under the influence of cyclonic circulation over North Coastal Odisha and neighbourhood a low pressure area formed on 13. It lay as a well marked low pressure area over the same region on 14. On 18 it weakened into low pressure area over east Madhya Pradesh & adjoining southeast Uttar Pradesh and Chattisgarh. It became less marked on 20
3.	Low Pressure area	30 Jul-2 Aug	Northeast Uttar Pradesh and neighbourhood	West	East Uttar Pradesh and adjoining Bihar	It formed under the influence of cyclonic circulation over Western parts of Bihar and neighbourhood. Associated cyclonic circulation extended upto 5.8 kms a.s.l. It became less marked on 3. However, associated cyclonic circulation merged with the monsoon trough on 4
(**C**)	*Western Disturbances /Eastward moving Systems*					
(*i*)	*Upper air cyclonic circulation*					
1.	Between 3.1 and 4.5 kms a.s.l.	5-8	North Pakistan and neighbourhood	East	North Pakistan and adjoining Jammu & Kashmir	A trough lay aloft with its axis at 5.8 kms a.s.l. along Long. 72° E and to the north of Lat. 32° N. Cyclonic circulation became less marked on 6. However trough persisted on 6-7. It again emerged as a cyclonic circulation over north Pakistan and adjoining Jammu & Kashmir extending between 4.5 & 5.8 kms a.s.l. on 8, became less marked on 9
2.	At 5.8 kms a.s.l.	19-21	Northeast Afghanistan and adjoining north Pakistan	Do	North Pakistan and neighbourhood	Moved away northeastwards
3.	Do	23-26	North Pakistan and neighbourhood	Do	Northern parts of Jammu & Kashmir and neighbourhood	Moved away northeastwards
(*ii*)	*Trough in Westerlies*					
1.	Mid & upper tropospheric	26 Jul-3 Aug	Along Long. 65° E to the north of Lat. 32° N (axis at 7.6 kms a.s.l.)	East	Along Long. 77° E to the north of Lat. 30° N	It moved away northeastwards

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**D**) *Other upper air cyclonic circulations*						
1.	Between 1.5 and 2.1 kms a.s.l.	1	Himachal Pradesh and adjoining Uttarakhand	Stationary	*In situ*	Became less marked on 2
2.	Mid and upper tropospheric levels	3-6	North coastal Andhra Pradesh and neighbourhood	Northwest	North Chhattisgarh and neighbourhood	Became less marked on 7
3.	Upto 0.9 kms a.s.l.	2-4	West Uttar Pradesh and adjoining Uttarakhand and Haryana	Stationary	*In situ*	Became less marked on 5
4.	Between 4.5 and 5.8 kms a.s.l.	2	East central Arabian Sea off Karnataka coast	Do	Do	Became less marked on 3
5.	Between 1.5 and 2.1 kms a.s.l.	3-4	Central Pakistan and adjoining Punjab	Do	Do	Became less marked on 5
6.	At 5.8 kms a.s.l.	4	South Gujarat region and neighbourhood	Do	Do	Became less marked on 5
7.	Between 4.5 and 5.8 kms a.s.l.	8	North Pakistan and Jammu and Kashmir	Do	Do	It lay as a trough aloft over a cyclonic circulation over north Pakistan and neighbourhood. It became less marked on 9
8.	Upto mid and upper tropospheric levels	8-14	North Odisha and neighbourhood	Northwest	Central parts if south Uttar Pradesh and neighbourhood	It lay as an associated cyclonic circulation with the low pressure over northwest Bay of Bengal. It embedded in the monsoon trough on 11. Merged with the monsoon trough on 15
9.	Upto 7.6 kms a.s.l.	5-6	North interior Karnataka and neighbourhood	North	Marathwada and neighbourhood	Merged with the east west shear zone on 7
10.	Upto 2.1 kms a.s.l	6-9	Eastern parts of Bihar and neighbourhood	West	South Uttar Pradesh and neighbourhood	Merged with the monsoon trough on 10
11.	Upto 0.9 kms a.s.l.	6	East Assam and neighbourhood	Stationary	*In situ*	Became less marked on 7
12.	Upto 1.5 and 2.1 kms a.s.l.	8	Arunachal Pradesh and neighbourhood	Do	Do	Became less marked on 9
13.	Upto 1.5 kms a.s.l.	9-10	North Haryana and neighbourhood	Do	Do	Merged with the monsoon trough
14.	Between 2.1 and 7.6 kms a.s.l.	9-20	South Gujarat and neighbourhood	Northeast	Southeast Rajasthan and Gujarat Region	Became less marked on 21
15.	Between 3.1 and 7.6 kms a.s.l.	10-12	South Odisha and neighbourhood	Do	North Coastal Odisha and neighbourhood	Under its influence, a low pressure area formed over Northwest Bay of Bengal on 13
16.	At 7.6 kms a.s.l.	10-11	North Kerala and neighbourhood	North	South Coastal and adjoining Interior Karnataka	Became less marked on 12
17.	Between 1.5 & 2.1 kms a.s.l.	11	South Pakistan and Adjoining West Rajasthan	Stationary	*In situ*	Became less marked on 12
18.	At 3.1 kms a.s.l.	13-14	North Chattisgarh and neighbourhood	Do	Do	Merged with the monsoon trough
19.	Do	14	West Uttar Pradesh and adjoining Haryana	Do	Do	Became less marked on 15

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
20.	Upto 1.5 kms a.s.l.	14-15	East Assam and neighbourhood	East	Arunachal Pradesh & neighbourhood	Became less marked on 16
21.	At 7.6 kms a.s.l.	18	North Interior Tamilnadu and neighbourhood	Stationary	*In situ*	Became less marked on 19
22.	Upto 1.5 kms a.s.l.	19	Central parts of Pakistan and adjoining Punjab	Do	Do	Became less marked on 20
23.	Do	21-23	North Madhya Pradesh and neighbourhood	Southwest	Northeast Rajasthan and adjoining Haryana	It merged with Cyclonic circulation associated with low pressure area on 24
24.	Between 3.1 & 5.8 kms a.s.l.	21	South Gujarat and neighbourhood	Stationary	*In situ*	Became less marked on 22
25.	Between 4.5 & 5.8 kms a.s.l.	21	East Uttar Pradesh	Do	Do	Became less marked on 22
26.	At 5.8 kms a.s.l.	22-23	North Rajasthan and neighbourhood	West	Central parts of Rajasthan and neighbourhood	It merged with Cyclonic circulation associated with low pressure area on 24
27.	At 3.1 kms a.s.l.	22	Northwest Uttar Pradesh	Stationary	*In situ*	Became less marked on 23
28.	At 7.6 kms a.s.l.	24	South Konkan and neighbourhood	Do	Do	Merged with east-west shear zone on 25
29.	At 5.8 kms a.s.l.	24	Southwest Bay of Bengal & adjoining Sri-Lanka off South Tamilnadu coast	Do	Do	Became less marked on 25
30.	Between 1.5 & 5.8 kms a.s.l.	25-29	Northern parts of Bangladesh & adjoining Sub-Himalayan West Bengal	Northwest	Eastern parts of Bihar and neighbourhood	Under its influence, a low pressure area formed over Northeast Uttar Pradesh on 30
31.	At 7.6 kms a.s.l.	26	Interior Odisha and neighbourhood	Stationary	*In situ*	Merged with the cyclonic circulation over Northern parts of west Bengal & neighbourhood on 27
32.	At 0.9 kms a.s.l.	27-28	Central parts of Assam & neighbourhood	Do	Do	Became less marked on 29
33.	At 7.6 kms a.s.l.	27-28	South Konkan and neighbourhood	North	South Gujarat region and neighbourhood	Became less marked on 29
34.	At 7.6 kms a.s.l.	27	Southwest Bay of Bengal off North Tamilnadu-South Andhra Pradesh coasts	Stationary	*In situ*	Became less marked on 28
35.	Between 5.8 & 7.6 kms a.s.l.	29	North Coastal Odisha & neighbourhood	North	Northwest Bay of Bengal off Odisha-West Bengal coast	Merged with cyclonic circulation over south Bangladesh & adjoining Gangetic West Bengal on 1 August
36.	At 7.6 kms a.s.l.	30	Southeast Bay of Bengal & adjoining Andaman Sea	Stationary	*In situ*	Became less marked on 31
37.	At 0.9 kms a.s.l.	31	Haryana and neighbourhood	Do	Do	Merged with Monsoon trough on 1 August

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**E**)	*Other trough*					
1.	Upto 2.1 kms a.s.l.	30-31	From cyclonic circulation associated with low pressure system over west Uttar Pradesh & neighborhood to Assam	Stationary	*In situ*	Became less marked on 1 August
(**E**)	*East-West Shear Zone*					
1.	Between 3.1 & 7.6 kms a.s.l.	7-11	Roughly along Lat. 19° N	Quasi-Stationary	*In situ*	It extended between 4.5 & 7.6 kms a.s.l. across the Chattisgarh and adjoining Odisha cyclonic circulation on 9, roughly along Lat. 20° N between 3.1 & 4.5 kms a.s.l. on 10, roughly along Lat. 18° N at 5.8 kms a.s.l. on 11
2.	At 7.6 kms a.s.l.	25	Along Lat. 20° N across Peninsular India	Stationary	Do	Became less marked on 26

during 25-27 August. Remnants of this system also caused widespread intense rainfall activity over Chhattisgarh and East Madhya Pradesh during 27-29 August. The eastern part of the monsoon trough passed through northeast India on 23rd August and caused fairly widespread to widespread intense rainfall activity over northeastern states for a couple of days. Apart from the above systems, an east-west shear zone in the mid-tropospheric levels across central India and an active monsoon trough with cyclonic circulations in the lower tropospheric levels embedded in that also caused fairly widespread to widespread rainfall activity with isolated heavy falls over parts of central and northwest India during 23-29 August.

In the last few days of August and initial days of September, the monsoon trough remained slightly north of its normal position but remained active with two to three cyclonic circulations in the lower tropospheric levels embedded in it. This situation caused fairly widespread to widespread rainfall with isolated intense rainfall activity over parts of northwest India (including Western Himalayan Region), east and northeast India and adjoining central India during 30th August to 5th September. However, during this period, monsoon activity remained subdued over south peninsular India, over Maharashtra and Gujarat states.

The first system during September formed as a Low pressure area over northwest Bay of Bengal & neighbourhood in the morning of 5th September and became a Well Marked Low Pressure area by the evening of the same day. It concentrated into a Depression and further intensified into a Deep Depression on 6th September. It crossed West Bengal coast and moved north-westwards and weakened gradually. Under the influence of the system, widespread and very intense rainfall activity occurred over Odisha. The system also caused widespread and intense rainfall activity over Chhattisgarh, Madhya Pradesh and East Rajasthan. During 6-12 September, the monsoon trough lay to the north of its normal position and its eastern end extended across northeastern states on 10th and 11th. Also a north-south trough in the lower tropospheric levels lay extending from eastern parts of Bihar to West Central Bay of Bengal, causing moisture incursion into northeast and adjoining east India. Widespread intense rainfall activity occurred over northeastern states and Sub-Himalayan West Bengal & Sikkim during this period.

The monsoon trough ran close to the foot hills of the Himalayas during 12-14 September. The western part of it continued to run close to the foot hills, whereas its eastern part shifted southwards and extended to Northeast Bay of Bengal on 15th and 16th September. It got filled up and thus became less marked from 17th September. Northeastern states and Sub-Himalayan West Bengal had experienced fairly widespread to widespread and intense rainfall activity during 12-14 September due to the downstream convergence of westerly winds and presence of the trough across the region. Under the influence of a western disturbance, Western Himalayan Region experienced scattered to fairly widespread rainfall with isolated intense activity during 13-15 September. Subdued rainfall activity prevailed over parts of central, northwest and peninsular India during 13-19 September. The last system formed as a low pressure area over East Central

TABLE 5

Details of the weather systems during August 2018

S. No.	System	Duration	Place of initial location	Direction of movement	Place of Final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**)	*Deep Depression/Depression*					
1.	Depression	7 (1430 hrs IST) -8	Over northwest bay of Bengal near Lat. 21.5° N/87.5° E	Westnorth west	North Chhattisgarh and neighbourhood	Details are given in the article on Storms & Depressions over the north Indian Ocean - 2018
2.	Do	15(1730 hrs IST)-17 (0530 hrs IST)	Coastal Odisha and neighbourhood centered near Lat. 20° N and Long. 86° E	Do	Southwest Madhya Pradesh and adjoining Gujarat & north Madhya Maharashtra	Details are given in the article on Storms & Depressions over the north Indian Ocean - 2018
(**B**)	*Well marked low/Low pressure area*					
1.	Low pressure area	19-22	Northwest Bay of Bengal & neighbourhood	West	Northwest Madhya Pradesh & neighbourhood	It formed under the influence of the cyclonic circulation over Northwest Bay of Bengal off West Bengal-Odisha Coast. Associated cyclonic circulation extended up to 7.6 kms a.s.l. It became less marked on 22 August. However, associated cyclonic circulation over Northern parts of central Madhya Pradesh & neighbourhood persisted on 22-23 & became less marked on 24
2.	Well Marked Low pressure area	25-28	Northwest Bay of Bengal and north coastal Odisha	Stationary	*In situ*	A Low formed over coastal areas of west Bengal and north Odisha under the influence of the cyclonic circulation over Northern parts of Gangetic West Bengal & neighbourhood. Associated cyclonic circulation extended up to 5.8 kms a.s.l.
(**C**)	*Western Disturbances /Eastward moving systems*					
(*i*)	*Upper air cyclonic circulation*					
1.	Between 3.1 & 5.8 kms a.s.l.	6	Eastern parts of Jammu & Kashmir and neighbourhood	Stationary	Eastern parts of Jammu & Kashmir and neighbourhood	Moved away east-northeastwards on 7
2.	Between 4.5 & 7.6 kms a.s.l.	7-11	North Pakistan & adjoining Jammu & Kashmir	East	Northern parts of Jammu & Kashmir and neighbourhood	It lay as a trough at 5.8 kms a.s.l. running roughly along Long. 77° E/ Lat. 30° N on 11 & Moved away northeastwards on 12
3.	Between 3.1 & 5.8 kms a.s.l.	16-19	Northeast Afghanistan and neighbourhood	Northeast	Jammu & Kashmir and neighbourhood	It lay at 5.8 kms a.s.l. with trough aloft running roughly along Long. 68° E/ Lat. 28° N. Moved away northeastwards on 19 & cyclonic circulation became less marked on 20
4.	At 3.1 kms a.s.l.	21-23	Jammu & Kashmir	East	Eastern parts of Jammu & Kashmir and neighbourhood	It moved away east northeastwards
(*ii*)	*As A Trough*					
1.	Mid tropospheric westerlies with its axis at 5.8 kms a.s.l.	26-29	Along Long. 70° E/ Lat. 30° N	East	Along Long. 78° E	It moved away east northeastwards

TABLE 5 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.	At 3.1 kms a.s.l.	31	Along Long. 80° E/ north of Lat. 25° N	Stationary	*In situ*	Became less marked on 1 September
(**D**)	*Other upper air cyclonic circulations*					
1.	At 5.8 kms a.s.l.	1-2	Jammu & Kashmir and adjoining Himachal Pradesh	Stationary	*In situ*	Became less marked on 3
2.	Upto 0.9 kms a.s.l.	2-3	Northwest Uttar Pradesh & neighbourhood	Do	Do	Merged with Monsoon trough on 4
3.	Between 3.1 & 5.8 kms a.s.l.	2-5	South Rajasthan & adjoining Gujarat	Do	Do	Became less marked on 6
4.	At 7.6 kms a.s.l.	3	South Konkan & neighbourhood	Do	Do	Merged with shear zone on 4
5.	Between 1.5 & 3.1 kms a.s.l.	4-5	Northern parts of East Uttar Pradesh & neighbourhood	East	Seen as a trough along Long. 80° E/ Lat. 26° N between 3.5 & 4.5 kms a.s.l.	Became less marked on 6
6.	At 5.8 kms a.s.l.	4	Punjab and neighbourhood	Stationary	*In situ*	Became less marked on 5
7.	Upto 0.9 kms a.s.l.	6	Eastern parts of Bihar and neighbourhood	Do	Do	Became less marked on 7
8.	Do	6	Northwest Uttar Pradesh and neighbourhood	Do	Do	Became less marked on 7
9.	Upto 2.1 kms a.s.l.	7-9	Northwest Madhya Pradesh & neighbourhood	West	Southeast Rajasthan and neighbourhood	Became less marked on 10
10.	At 7.6 kms a.s.l.	8-9	Southeast Arabian Sea & adjoining Lakshadweep area	Stationary	*In situ*	Became less marked on 10
11.	Do	9-12	West central Bay of Bengal & adjoining South coastal Andhra Pradesh	West	North coastal Odisha & neighbourhood	Under its influence, a low pressure area formed over northwest Bay of Bengal off West Bengal coast on 13
12.	Between 3.1 & 5.8 kms a.s.l.	10	South Gujarat & neighbourhood	Stationary	*In situ*	Became less marked on 11
13.	Between 3.1 & 3.6 kms a.s.l.	10	North Odisha and neighbourhood	Do	Do	Merged with cyclonic circulation over south Odisha-north Andhra Pradesh on 11
14.	At 0.9 kms a.s.l.	11-12	Northern parts of Haryana and neighbourhood	West	Punjab and adjoining Haryana & Himachal Pradesh	Became less marked on 13
15.	Between 0.9 & 1.5 kms a.s.l.	11-13	West Assam & adjoining Sub-Himalayan West Bengal	East	Assam & neighbourhood	Became less marked on 14
16.	At 7.6 kms a.s.l.	13	East central Arabian Sea off Karnataka coast	Stationary	*In situ*	Became less marked on 14
17.	At 0.9 kms a.s.l.	13-15	East Uttar Pradesh & adjoining Bihar	West	East Uttar Pradesh	Became less marked on 16
18.	At 3.1 kms a.s.l.	13-14	Central parts of Rajasthan and neighbourhood	East	East Rajasthan and neighbourhood	Merged with the trough of cyclonic circulation associated with depression to Southeast Rajasthan on 15

TABLE 5 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
19.	Between 3.1 & 4.5 kms a.s.l.	13	Jammu & Kashmir and adjoining Pakistan	East	Jammu & Kashmir and neighbourhood	Became less marked on 15
20.	Between 3.1 & 5.8 kms a.s.l.	15	Northern parts of Punjab & neighbourhood	Stationary	*In situ*	Became less marked on 16
21.	At 0.9 kms a.s.l.	19	South Haryana and neighbourhood	Do	Do	Became less marked on 20
22.	At 7.6 kms a.s.l.	19	North Interior Karnataka and neighbourhood	Do	Do	Became less marked on 20
23.	Do	19-21	Southeast Arabian Sea off Kerala coast	Do	Do	Became less marked on 22
24.	At 1.5 kms a.s.l.	20	North Haryana and neighbourhood	West	-	Became less marked on 21
25.	At 3.1 kms a.s.l.	20	South Gujarat and neighbourhood	Stationary	*In situ*	Became less marked on 21
26.	Between 5.8 & 7.6 kms a.s.l.	22	Saurashtra & neighbourhood	Do	Do	Became less marked on 23
27.	Upto 3.1 kms a.s.l.	22-25	East Bihar & neighbourhood	South	Northern parts of Gangetic West Bengal & neighbourhood	Under its influence, a low pressure area formed on over coastal areas of West Bengal & North Odisha and adjoining Northwest Bay of Bengal on 26
28.	At 7.6 kms a.s.l.	22-23	Northwest Bay of Bengal and neighbourhood	North	North Bay of Bengal and adjoining Bangladesh	Became less marked on 24
29.	Upto 0.9 kms a.s.l.	23-26	Assam and neighbourhood	East	East Assam & neighbourhood	Became less marked on 27
30.	Between 3.1 & 3.6 kms a.s.l.	23-29	Southwest Rajasthan & neighbourhood	South	South Gujarat and neighbourhood	It merged with the shear zone along Lat. 22° N on 30
31.	At 4.5 kms a.s.l.	23	Lakshadweep area and neighbourhood	Stationary	*In situ*	Became less marked on 24
32.	At 7.6 kms a.s.l.	23-25	Southeast Tamilnadu and neighbourhood	West	Rayalaseema & adjoining Coastal Andhra Pradesh	It merged with the shear zone along Lat. 15° N on 26
33.	At 1.5 kms a.s.l.	24	Northern Parts of Haryana and neighbourhood	Stationary	*In situ*	Became less marked on 24
34.	Upto 3.1 kms a.s.l.	24-26	Northeast Uttar Pradesh and neighbourhood	West	Northern Parts of East Uttar Pradesh and neighbourhood	Became less marked on 27
35.	Between 2.1 & 3.6 kms a.s.l.	25	Central Parts of Uttar Pradesh	Stationary	*In situ*	Became less marked on 26
36.	At 5.8 kms a.s.l.	25	Southeast Arabian Sea & adjoining Lakshadweep area	Do	Do	Became less marked on 26
37.	Upto 3.1 kms a.s.l.	27-30	Southwest Uttar Pradesh & neighbourhood	West	Northern parts of Haryana and neighbourhood	Became less marked on 31
38.	At 7.6 kms a.s.l.	27	North Tamil Nadu and neighbourhood	Do	North Interior Tamil Nadu and neighbourhood	Became less marked on 29

TABLE 5 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
39.	Between 5.8 & 7.6 kms a.s.l.	29	Central Parts of Konkan & adjoining Madhya Maharashtra	North	North Konkan and adjoining south Gujarat Region	Became less marked on 31
(**E**)	*North-South trough/other trough*					
1.	Upto 3.1 kms a.s.l.	4-5	Southwest Bangladesh & neighbourhood to western parts of Bihar	Eastward	Bihar to Nagaland	Became less marked on 6
2.	At 1.5 kms a.s.l.	11-12	Jharkhand to West central Bay of Bengal off Andhra Pradesh coast	Do	Bihar to Western parts of Gangetic west Bengal	Became less marked on 13
3.	Between 3.1 & 5.8 kms a.s.l.	15	Cyclonic circulation associated with depression over Coastal Odisha & neighbourhood to southeast Rajasthan	Westward	Cyclonic circulation associated with depression over south Chattisgarh & adjoining Vidarbha to South Gujarat	Became less marked on 16
4.	Between 5.8 & 7.6 kms a.s.l.	22	Saurashtra & neighbourhood to North Chhattisgarh	Stationary	*In situ*	Became less marked on 23
(**E**)	*East-West shear zone*					
1.	At 7.6 kms a.s.l.	1-2	Along Lat.18° N	North	Along Lat. 19° N	Became less marked on 3
2.	Do	4	Along Lat.16° N	Stationary	*In situ*	Became less marked on 5
3.	Do	11	Along Lat.10° N	Do	Do	Became less marked on 12
4.	Between 3.1 & 7.6 kms a.s.l.	17	Along Lat.20° N	Do	Do	Became less marked on 22
5.	At 7.6 kms a.s.l.	26	Along Lat.15° N	Do	Do	Became less marked on 27
6.	Between 3.6 & 5.8 kms a.s.l.	28	Along Lat. 20° N	Do	Do	Became less marked on 28

Bay of Bengal and adjoining Myanmar coast on 18th September, evening. It concentrated into a Depression over east central Bay of Bengal and neighbourhood during the night of 19th. It then intensified further into Cyclonic Storm 'DAYE' over northwest Bay of Bengal on 20th September and crossed south Odisha and adjoining north Andhra Pradesh coasts close to Gopalpur during mid-night of 21st September, gradually weakened into a Depression and moved across central India upto western parts of Madhya Pradesh on 21st and 22nd September. During the traverse, it started interacting with a Western Disturbance and thus the system, after weakening into a well-marked low pressure area, started re-curving northwards. This constructive interaction between the monsoon low pressure system and the Western Disturbance caused a revival of the active to vigorous monsoon conditions over central and northwest India during 21-25 September. Subsequent to the dissipation of the remnant low pressure area over Haryana and neighborhood on 25th September, a drastic reduction in rainfall activity occurred over northwest and adjoining central India. Cyclonic Storms affecting the Indian coast during September is not very common. Past such occurrence was in 2005, when Cyclonic Storm 'PYARR' crossed Andhra Pradesh coast on 21st September. Cyclonic vorticity advection from the remnants of Typhoon 'Manghkut' and Tropical Cyclone 'Barijat' formed over west Pacific had contributed to the formation of Cyclonic Storm 'DAYE.

4. Extra Indian features

4.1. *Cross Equatorial Flow*

4.1.1. *Over the Arabian Sea*

The Cross Equatorial Flow (CEF) along the equatorial belt (equator to 5° N/5° S) over Arabian Sea was stronger than normal during June 2018 and in 2nd

TABLE 6

Details of the weather systems during September 2018

S. No.	System	Duration	Place of initial location	Direction of movement	Place of Final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**)	*Depression/Deep depression*					
1.	Cyclonic Storm DAYE	19-22 (1200 UTC)	East Central Bay of Bengal	Northwest	West Madhya Pradesh & neighbourhood	Details are given in the article on Storms & Depressions over the north Indian Ocean - 2018
2.	Deep Depression	6(0000 UTC)-7	Northwest Bay of Bengal and adjoining West Bengal & north coastal Odisha	Do	North Chhattisgarh & neighbourhood	Details are given in the article on Storms & Depressions over the north Indian Ocean - 2018.
(**B**)	*Western Disturbances /Eastward moving systems*					
(*i*)	*As an upper air cyclonic circulation*					
1.	At 3.1 kms a.s.l.	12-14	Northeast Afghanistan and adjoining Pakistan	Northeast	Jammu & Kashmir and neighbourhood with a trough aloft along Long. 77° E to the north of Lat. 32° N	Moved away east-northeastwards
2.	Upto 5.8 kms a.s.l.	15-16	North Pakistan and neighbourhood	Stationary	*In situ*	It lay as a trough in mid tropospheric westerlies with its axis at 5.8 kms a.s.l. roughly along Long. 75° E to the north of Lat. 32° N on 16 and it has moved away northeastwards
(*ii*)	*As a trough*					
1.	Upto Mid tropospheric levels	13	Along Long. 76° E to the north of Lat. 32° N (axis at 5.8 kms a.s.l.)	Stationary	*In situ*	It merged with W. D. over Jammu & Kashmir and neighbourhood with a trough aloft along Long. 77° E to the north of Lat. 32° N on 14
2.	Upto mid and upper troposphere	21-24	Along Long. 62° E to the north of Lat. 30° N	East	Along Long. 70° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	Moved away northeastwards
3.	Do	25 Sep-1 Oct	Along Long. 55° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	East northeastwards	Along Long. 68° E to the north of Lat. 25° N (axis at 5.8 kms a.s.l.)	It was seen as a cyclonic circulation over central parts of Pakistan & neighbourhood on 29. Moved away on 2 October
(**C**)	*Other upper air cyclonic circulations*					
1.	Upto mid and lower tropospheric levels	31 Aug-2 Sep	East Assam & neighbourhood	Stationary	*In situ*	Became less marked on 3
2.	Upto lower tropospheric levels	31 Aug-4 Sep	Southeast Pakistan and neighbourhood	East	South Rajasthan and adjoining Gujarat region	Became less marked on 5
3.	Upto Mid & upper tropospheric levels	31 Aug-3 Sep	Gangetic West Bengal and neighbourhood	West	Northeast Jharkhand & neighbourhood	Became less marked on 4
4.	Between 5.8 & 7.6 kms a.s.l.	1-3	South Konkan & neighbourhood	Stationary	*In situ*	Became less marked on 4

TABLE 6 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
5.	Between 1.5 & 2.1 kms a.s.l.	2-11	Haryana and adjoining northwest Uttar Pradesh	Quasi-stationary	Northern parts of Haryana & adjoining northwest Uttar Pradesh	Became less marked on 6
6.	Upto 2.1 kms a.s.l.	4-7	East Uttar Pradesh & adjoining Bihar	Stationary	Central parts of south Uttar Pradesh and adjoining north Madhya Pradesh	Merged with monsoon trough on 7 evening
7.	At 7.6 kms a.s.l.	4-5	West Central Bay of Bengal off south Odisha North Andhra Pradesh coasts	Do	Northwest Bay of Bengal and neighbourhood	Merged with the cyclonic circulation associated with the low pressure area over North West Bay of Bengal & neighbourhood 5
8.	At 3.1 kms a.s.l.	4-6	South Interior Karnataka & neighbourhood	West	Coastal Karnataka & neighbourhood	Became less marked on 6
9.	Between 3.1 & 4.5 kms a.s.l.	5-6	Southwest Rajasthan & neighbourhood	Stationary	*In situ*	Became less marked on 7
10.	Between 3.1 kms & 5.8 kms	6	Over Arakan coast & neighbourhood	Do	Do	Became less marked on 7
11.	Between 3.1 and 4.5 kms a.s.l.	7-8	South Gujarat Region and adjoining north Konkan	Do	Do	Became less marked on 9
12.	Between 1.5 kms & 4.5 kms	9	Gangetic West Bengal & neighbourhood	Do	Do	Became less marked on 10
13.	At 5.8 kms a.s.l.	9	North Gujarat & neighbourhood	Do	Do	Became less marked on 10
14.	Between 5.8 & 7.6 kms a.s.l.	9-11	East Central Arabian Sea off Maharashtra coast	Qausi-Stationary	Southeast and adjoining east central Arabian Sea off Karnataka coast	Became less marked on 12
15.	At 5.8 kms a.s.l.	9	South Interior Karnataka & neighbourhood	Stationary	*In situ*	Became less marked on 10
16.	Do	11- 13	North Tamil Nadu and neighbourhood	East	Southwest Bay of Bengal off Tamil Nadu coast	Became less marked on14
17.	Between 1.5 kms & 3.1 kms	12-15	Interior Karnataka & adjoining Rayalaseema & Telangana	Qusi-Stationary	Rayalaseema & neighbourhood	Became less marked on 16
18.	At 5.8 kms a.s.l.	12	South Interior Karnataka and Neighbourhood	Stationary	*In situ*	Became less marked on 13
19.	Between 3.1 and 5.8 kms a.s.l.	13-18	Southwest Madhya Pradesh and neighbourhood	West	East Central and adjoining North East Arabian Sea and adjoining areas of Konkan & Goa and south Gujarat	Became less marked on 19
20.	Upto 0.9 kms a.s.l.	14	Sub Himalayan West Bengal and adjoining Bihar	Stationary	*In situ*	A trough ran from cyclonic circulation to Manipur across Assam & Meghalaya Both the systems became less marked on 15
21.	Between 1.5 & 2.1 kms a.s.l.	14	Lakshadweep area and adjoining South East Arabian Sea off north Kerala coast	Do	Do	Became less marked on 15

TABLE 6 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
22.	Upto 1.5 kms a.s.l.	15	Meghalaya and adjoining Mizoram and Tripura	Stationary	*In situ*	Became less marked on 16
23.	At 1.5 kms a.s.l.	16	North Coastal Andhra Pradesh and neighbourhood	Do	Do	A trough ran from this cyclonic circulation to north Tamil Nadu at the same level. Both became less marked on 17
24.	At 5.8 kms a.s.l.	17	Interior Maharashtra and neighbourhood	Do	Do	A trough from this cyclonic circulation ran to Lakshadweep across Coastal Karnataka at same level. Both became less marked on 18
25.	Upto 1.5 kms a.s.l.	19	Meghalaya and neighbourhood	Do	Do	Became less marked on 20
26.	At 7.6 kms a.s.l.	21	Lakshadweep area and adjoining south Kerala coast	Do	Do	Became less marked on 22
27.	Upto lower and mid tropospheric levels	22-26	Gulf of Siam & neighbourhood	West	Southwest Bay of Bengal off Tamil Nadu coast	Became less marked on 27
28.	Between 2.1 & 7.6 kms a.s.l.	23-25	North Coastal Karnataka & neighbourhood	North	East central Arabian Sea off south Maharashtra-Goa coasts	Became less marked on 26
29.	Upto 0.9 kms a.s.l.	23	Central Assam & neighbourhood	Stationary	*In situ*	A trough aloft runs roughly along Long. 93° E to the north of Lat. 25° N. Cyclonic circulation became less marked on 24. However, the trough remain stationary and was seen between 0.9 kms & 2.1 kms a.s.l. on 24 and between 0.9 kms & 3.1 kms a.s.l. on 25 and became less marked on 26
30.	Upto 1.5 kms a.s.l.	24	South Interior Karnataka	Do	Do	A trough ran from the cyclonic circulation to north Coastal Andhra Pradesh across Rayalaseema at 1.5 kms a.s.l. on 27. It became less marked on 28. Cyclonic circulation Became less marked on 25
31.	At 0.9 kms a.s.l.	24	South Odisha and neighbourhood	Do	Do	Became less marked on 25
32.	Upto 3.1 kms a.s.l.	27	Northern parts of East Uttar Pradesh & neighbourhood	Do	Do	Become less marked on 28
33.	At 3.1 kms a.s.l.	27	North Gujarat & adjoining southwest Rajasthan	Do	Do	Become less marked on 28
34.	At 0.9 kms	27	Central parts of Assam & neighbourhood	Do	Do	A trough lay aloft between 1.5 and 3.1 kms a.s.l. roughly along Long. 93° E to the north of Lat. 22° N on 28. Became less marked on 29 September. Cyclonic circulation became less marked on 4 October
(**D**)	*Other troughs/Wind discontinuity*					
1.	At 7.6 kms a.s.l.	1	North interior Tamilnadu to north Odisha across Rayalaseema & Coastal Andhra Pradesh	Stationary	*In situ*	Became less marked on 2

TABLE 6 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.	Between 3.1 & 5.8 kms	5-8	Northwest bay of Bengal & neighbourhood to southeast Haryana across Gangetic West Bengal, Jharkhand and south Uttar Pradesh	West	Southwest Rajasthan to west central Bay of Bengal off north Andhra Pradesh coast	It ran from the cyclonic circulation associated with the Deep Depression over North West Bay of Bengal and adjoining West Bengal & north coastal Odisha. It was seen as an East-West trough between 1.5 & 2.1 kms on 8 and became less marked on 9
3.	At 1.5 kms a.s.l.	8	Northwest Madhya Pradesh to Punjab across Haryana	Oscillatory	Along Lat. 16° N	Became less marked on 9
4.	At 7.6 kms a.s.l.	18-20	Along Lat. 15° N across the cyclonic circulation over eastcentral Bay of Bengal	Do	Do	Became less marked on 21
5.	At 5.8 kms. a.s.l.	19	Uttarakhand to north Madhya Maharashtra across west Uttar Pradesh, east Rajasthan and west Madhya Pradesh	Stationary	*In situ*	Became less marked on 20
6.	Between 1.5 kms & 3.1 kms a.s.l.	21	Cyclonic circulation associated with the Deep Depression over Interior Odisha and & neighbourhood to south Konkan across Telangana and north Interior Karnataka	Do	Do	Became less marked on 22
7.	At 1.5 kms a.s.l.	28	North Bihar to Jharkhand	Do	Do	Became less marked on 29
8.	At 0.9 kms a.s.l.	29 Sep-1 Oct	Sri Lanka to North Interior Karnataka	Oscillatory	South West Bay of Bengal to south Madhya Maharashtra across Tamilnadu & interior Karnataka	An embedded cyclonic circulation lay over Sri Lanka & neighbourhood extending upto 0.9 kms on 29. Cyclonic circulation became less marked on 2 October
(**E**)	*Trough in westerlies*					
1.	At 7.6 kms a.s.l.	1-11	Along Long. 63° E/ north of Lat. 30° N	West	Jammu & Kashmir and neighbourhood	Moved away northeastwards
2.	Between 0.9 kms & 2.1 kms a.s.l.	10-13	East Bihar to Westcentral Bay of Bengal across Jharkhand and Gangetic West Bengal	Do	Sub Himalayan West Bengal to North East Bay of Bengal across Bangladesh	Became less marked on 14
(**F**)	*Trough in easterlies*					
1.	Between 5.8 & 7.6 kms a.s.l.	27	Maldives area to South Interior Karnataka	Stationary	*In situ*	Moved away westwards
(**G**)	*North south Trough*					
1.	Upto 1.5 kms a.s.l.	4-5	South Interior Karnataka to Comorin area across interior Tamil Nadu	Stationary	*In situ*	Became less marked on 6
2.	At 1.5 kms a.s.l.	9-13	South Interior Karnataka to south Tamilnadu and extends	Quasi-Stationary	South Interior Karnataka and Interior Tamilnadu	Became less marked on 14

TABLE 6 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
3.	Upto 1.5 kms a.s.l.	24-28	North Interior Karnataka to Gulf of Mannar across South Interior Karnataka	Oscillatory	East Central Arabian Sea off south Maharashtra coast to Southwest Bay of Bengal off Sri Lanka coast across north Kerala and Tamilnadu	Cyclonic circulation over South Interior Karnataka and neighbourhood extending up to 1.5 kms embedded in the trough and became less marked on 28. Trough became less marked on 29
4.	Do	26	East Bihar to north west Bay of Bengal across Jharkhand and Gangetic Bay of Bengal	Stationary	*In situ*	Became less marked on 27
(**H**)	*East west trough*					
1.	At 1.5 kms a.s.l.	26	Along Lat. 11° N across south peninsular India	Stationary	*In situ*	Became less marked on 27

and 3rd week of July but in 1st & 4th week of July it was close to normal and stronger than normal in August, 2018 and September, 2018.

The surface winds over Arabian Sea to the north of 5° N were stronger than normal in 2nd, 3rd and 4th week while it was normal in 1st week during June 2018, close to normal in 1st, 3rd and 4th week but stronger than normal in 2nd week of July 2018, near normal in 1st, 2nd and 4th week but weaker than normal in 3rd week of August, 2018 and stronger than normal during September, 2018.

4.1.2. *Over the Bay of Bengal*

The CEF along the equatorial belt (equator to 5° N/ 5° S) over Bay of Bengal was stronger than normal during June, stronger than normal in 2nd & 3rd week but in 1st & 4th week it was close to normal in July and stronger than normal in August and September.

The surface winds over the Bay of Bengal to the north of 5° N were stronger than normal during June and in the 1st, 2nd & 3rd week of July and was normal in the 4th week of July and stronger than normal during August and September.

4.2. *Systems in West Pacific Ocean/South China Sea*

There were in all 25 low pressure systems (reaching the intensity of Tropical depression and above) in the northwest Pacific Ocean/South China Sea during June to September 2018.

4.3. *Troughs in mid & upper westerlies affecting the Indian region to the south of 30° N*

The number of troughs in westerlies which moved across Indian region from west to east penetrated to the south of 30° N were 4 in June, 2 in July, 3 in August and 2 in September at 500 hPa and 2 each in June and August and 3 each in July and September at 300 hPa.

4.4. *Troughs in westerlies over South Indian Ocean, which penetrated to the north of latitude 30° S*

The troughs in upper air westerlies which moved across the South Indian Ocean from west to east penetrated to the north of Lat. 30° S, in the Southern Hemisphere, during June-September, 2018 are 6 in June, 3 in July, 7 in August and 6 in September at 500 hPa and 7 in June, 6 in July, 5 each in August and September at 300 hPa.

4.5. *Systems in southern hemisphere*

4.5.1. *Tropical storms/depressions: South Indian Ocean*

One Tropical Depression was reported in southwest of Diego Garcia from 13-17 September, 2018.

4.5.2. *Mascarene High*

The Mascarene HIGH with its mean position at 34.2° S/ 70.3° E was strengthened by 3.2 hPa during the monsoon

period June-September, 2018. It was above normal by 2.9, 5.5 and 4.1 hpa during the months of June, July and September, 2018 respectively and was near normal in the month of August, 2018.

5. Semi-permanent systems

5.1. *Heat low*

This year, the Heat Low gradually strengthened and got established in its near normal position in the first week of June. It was mostly seen in its near normal position all through the season with varying intensity. It started gradually filling up from first week of September and became less marked in the second week part of October.

The lowest and the second lowest values of the Heat Low were:

June: 990 hPa (on 13) and 992 hPa (on 12)

July: 992 hPa (on 3, 15, 16, 18, 22 & 23) and 994 hPa (on 5, 11-14, 17, 19, 20 and 24)

August: 994 hPa (on 2, 6-8, & 12-13) and 996 hPa (on 4, 14, 16, 18-19 and 21)

September: 998 hPa (on 2), 1000 hPa (on 1, 3, 13 and 22)

5.2. *Monsoon trough*

This year, shallow Heat trough was seen over the Indo-Gangetic plains in first week of June. This remained as a shallow heat trough all through the month of June. With the southwest monsoon covering the entire country, it got established as the monsoon trough south of its normal position on 29th June. The trough remained to the normal position for most of the days till mid-August. Then either its eastern or western end remained north of normal position till 17th September.

The monsoon trough got disorganized and disappeared from the pressure & wind field from 17th September.

5.3. *Tibetan anticyclone/high*

This year, the Tibetan anticyclone was seen to southeast of its normal position upto mid-June. Then it was seen to the east/south east of normal and got established in its near normal position on 21st June. Almost all through the months of July it remained either to the north, east or west of normal position and in August it remained to the north or shifted to northwest indicating

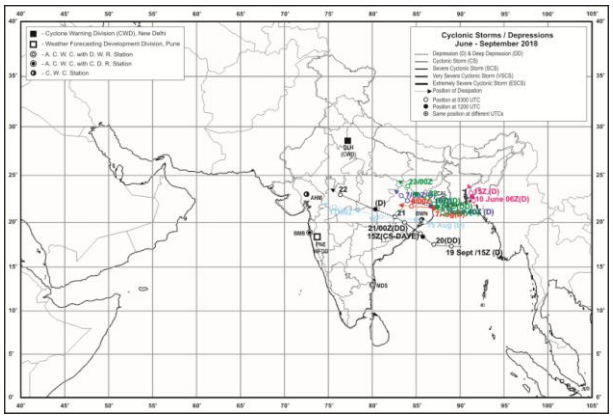

Fig. 8. Tracks of the intense low pressure systems during SW Monsoon 2018

weak monsoon circulation. In September, it oscillated between east and west position of normal on most of the days of first half of the month and in second half it occupied a position to the southeast of normal. It then shifted south-eastwards thus becoming un-important in the third week of October.

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

The STWJ started shifting northwards from the second week of May. Srinagar reported 78 knots wind (at 150 hPa) at 0000 UTC of 28th June. Subsequently, the core of STWJ shifted to the north of the Himalayas. However, it made occasional re-appearances along the latitude of Srinagar on 4th July with 63 kts at 300 hPa (0000 UTC) and observed at 200 hPa on 5-6 July with winds at 69 Kts and reappeared on 13th September with 75 kts at 200 hPa (0000 UTC). In the third week of September, it once again shifted southwards as evident by the 86 kts westerly wind reported over Srinagar at 192 hPa on 22nd September (0000 UTC).

5.5. *Tropical Easterly Jet (TEJ)*

The TEJ got established over the southern tip of Peninsular India by 31st May with Thiruvananthapuram reporting easterlies of 66 kts at 111 hPa level. A wide latitudinal spread of the easterly jet speed winds was observed during August and September while during June and July; the stations over the Peninsular India only reported jet speed winds. The highest wind speed of 122 kts at 142 hPa was reported at Chennai on 3rd July.

Apart from Thiruvananthapuram, Chennai, Amini divi, Minicoy, Karaikal, Mangaluru and Port Blair, Jet speed winds were reported over, Bhubaneswar, Hyderabad, Jagdalpur, Jharsuguda, Kolkata, Hyderabad, Machilipatnam, Karaikal and Visakhapatnam on a few days during the season.

6. Other features

6.1. *Monthly wind anomalies during Southwest Monsoon 2018*

The monthly circulation anomaly features at lower, middle and upper tropospheric levels, 850, 700, 500 and 200 hPa during the Southwest Monsoon Season are discussed below:

6.1.1. *June wind anomaly features*

In the monthly wind pattern, an anomalous cyclonic circulation was seen at 850 hPa over Southeast (SE) Arabian Sea off Karnataka coast extending upto 700 hPa. An anomalous anticyclonic circulation was seen at 850 hPa over Gangetic West Bengal (GWB) and neighbourhood extending upto 700 hPa.

In the week ending 6th June, two anomalous cyclonic circulations were seen at 850 hPa one over Lakshadweep area & neighbourhood extending upto 300 hPa & second over Southeast (SE) Bay of Bengal & neighbourhood extending upto 700 hPa. Two anomalous anticyclonic circulations were seen at 700 hPa, one over Rajasthan & neighbourhood and second over Arunachal Pradesh and neighbourhood.

In the week ending 13th June, two anomalous cyclonic circulations were seen at 850 hPa, one over West Madhya Pradesh & adjoining East Rajasthan extending upto 700 hPa & second over NMMT & neighbourhood extending upto 300 hPa.

In the week ending 20th June, two anomalous anticyclonic circulations were seen at 850 hPa, one over Kerala coast and neighbourhood and second over Coastal Andhra Pradesh. A ridge at 200 hPa extended along 27° N.

In the week ending 27th June, three anomalous cyclonic circulations were seen at 850 hPa, one over Telangana & neighbourhood extending upto 700 hPa, second over west Madhya Pradesh and neighbourhood and third over NMMT & neighbourhood.

6.1.2. *July wind anomaly features*

In the monthly wind pattern, two anomalous cyclonic circulations were seen at 850 hPa, one over Northwest Bay of Bengal & neighbourhood extending upto 300 hPa and second over East Rajasthan & neighbourhood extending upto 500 hPa. A ridge at 200 hPa extended along 27° N.

In the week ending 4th July, an anomalous cyclonic circulation was seen at 850 hPa over west Rajasthan & neighbourhood extending upto 500 hPa. An anomalous anticyclone was seen over NE Bay of Bengal and neighbourhood from 85 hPa to 500 hPa. A ridge at 200 hPa extended along 31° N.

In the week ending 11th July, an anomalous anticyclonic circulation was seen at 850 hPa over Southwest (SW) Bay of Bengal off Coastal Andhra Pradesh extending upto 300 hPa. A ridge at 200 hPa extended along 31° N.

In the week ending 18th July, two anomalous cyclonic circulations were seen at 850 hPa, one over West Central (WC) Bay of Bengal off Odisha coast extending upto 300 hPa and second over N. Maharashtra coast extending upto 500 hPa. A ridge at 200 hPa extended along 28° N.

In the week ending 25th July, an anomalous cyclonic circulation was seen at 850 hPa over Northwest (NW) Bay of Bengal off Odisha coast extending upto 300 hPa. A ridge at 200 hPa extended along 28° N.

In the week ending 1st August, an anomalous cyclonic circulation was seen at 850 hPa over NNMT & neighbourhood extending upto 500 hPa.

6.1.3. *August wind anomaly features*

In the monthly wind pattern, four anomalous cyclonic circulations were seen at 850 hPa, one over West Central (WC) Bay of Bengal off Odisha coast extending upto 500 hPa, second over Chhattisgarh and neighbourhood upto 700 hPa, third over West Rajasthan & neighbourhood extending upto 700 hPa and fourth over Himachal Pradesh & neighbourhood extending upto 700 hPa. A ridge at 200 hPa extended along 31° N.

In the week ending 8th August, an anomalous anticyclonic circulation was seen at 850 hPa over Maharashtra coast. An anomalous cyclonic circulation was seen at 700 hPa over Assam & Meghalaya and neighbourhood. A ridge at 200 hPa extended along 31° N.

In the week ending 15th August, two anomalous cyclonic circulations were seen at 850 hPa, one over West Central (WC) Bay of Bengal off coastal Andhra Pradesh extending upto 500 hPa and second over west Rajasthan & neighbourhood. A ridge at 200 hPa extended along 28° N.

In the week ending 22nd August, two anomalous cyclonic circulations were seen at 850 hPa, one over West Central (WC) Bay of Bengal off Odisha coast extending upto 500 hPa and second over Vidarbha & neighbourhood.

In the week ending 29th August, two anomalous cyclonic circulations were seen at 850 hPa, one over West Central (WC) Bay of Bengal off Odisha coast extending upto 500 hPa and second over West Uttar Pradesh & neighbourhood extending upto 700 hPa.

6.1.4. *September wind anomaly features*

In the monthly wind pattern, three anomalous cyclonic circulations were seen at 850 hPa, one over Haryana & neighbourhood, second over Arunachal Pradesh & neighbourhood and third over Andaman Sea & neighbourhood. Two anomalous anticyclonic circulations were seen at 850 hPa, one over Andhra Pradesh & neighbourhood extending upto 500 hPa and second over Gangetic West Bengal & neighbourhood extending upto 700 hPa. An anomalous cyclonic circulation was seen at 700 hPa over West Madhya Pradesh & neighbourhood extending upto 500 hPa. A ridge at 200 hPa extended along 30° N.

In the week ending 5th September, three anomalous cyclonic circulations were seen at 850 hPa, one over West Central Bay of Bengal off Coastal Andhra Pradesh, second over East Uttar Pradesh & neighbourhood extending upto 700 hPa and third over west Rajasthan and neighbourhood extending upto 500 hPa. A ridge at 200 hPa extended along 31° N.

In the week ending 12th September, two anomalous cyclonic circulations were seen at 850 hPa, one over Jharkhand & neighbourhood and second over west Madhya Pradesh & neighbourhood extending upto 700 hPa. An anomalous anticyclonic circulation was seen at 850 hPa over Telangana & neighbourhood. A ridge at 200 hPa extended along 30° N.

In the week ending 19th September, two anomalous cyclonic circulations were seen at 850 hPa, one over west Central Bay of Bengal off Coastal Andhra Pradesh extending upto 300 hPa and second over North Madhya Maharashtra & neighbourhood extending upto 500 hPa. A ridge at 200 hPa extended along 13° N.

In the week ending 26th September, an anomalous cyclonic circulation was seen at 850 hPa over west Madhya Pradesh & neighbourhood extending upto 700 hPa. A cyclonic circulation was seen at 700 hPa over South East Arabian sea off Karnataka coast extending upto 500 hPa. A ridge at 200 hPa extended along 32° N.

In the week ending 3rd October, an anomalous cyclonic circulation was seen at 850 hPa over Arunachal Pradesh & neighbourhood. An anomalous anticyclonic circulation was seen at 850 hPa over Chhattisgarh & neighbourhood extending upto 500 hPa.

7. Disastrous weather events and damage during Monsoon months

7.1. *June*

Convective activity in Uttar Pradesh and related incidents played havoc in the state. Dust storms in Uttar Pradesh claimed 92 lives and left several injured in this month. Due to thunderstorm and lightning, 16 people were killed in Uttar Pradesh, 4 dead and 2 injured in Andhra Pradesh. 2 people lost their lives in rain related incidents in Maharashtra and 9 in Kerala. Incessant rains claimed 6 lives in a massive landslip that buried five houses at Kattippara in Kozhikode district. In another incident rains claimed 2 lives while 16 houses were fully damaged and 217 partially, in Kochi, Kerala. 5 people died in Assam in rain related incidents. Three women died in a landslide triggered by heavy rains in Jammu and Kashmir.

7.2. *July*

According to media reports maximum number of casualties in rain related incidents was reported from Uttar Pradesh with 68 died, 60 injured and 225 houses damaged in July. Incessant rains claimed 3 lives in Jammu and 2 Amarnath pilgrims in Kashmir's Sonmarg area, 7 in Manipur. 2 people dead and around 250 people shifted to safer places in most parts of the Saurashtra region of Gujarat. 2 women died and 9 sustained injuries in Bhubaneswar, Odisha. Heavy rain claimed 14 lives in Kerala.

7.3. *August*

Kerala state witnessed unprecedented floods in this month, torrential showers forced authorities to open dam gates and sent rivers surging, taking the death toll to 341. Dams and rivers overflowed parts of highways collapsed and homes swept away in severe flooding. About one lakh buildings, including homes, were damaged, over 10,000 km of highways and roads and hundreds of bridges washed away and crop in millions of hectares lost.

22 people died in rain related incidents in Uttar Pradesh and around 2 crore people affected in the state faced the wrath of floods in different districts. In Nagaland at least 12 people dead and 4000 families evacuated to safer places following torrential rains and flashflood. Incessant rains have caused floods and landslides in several parts of the state affecting many and the damage is pegged at around 800 crore rupees. 3 persons drowned in Andhra Pradesh's coastal districts of

Krishna, west Godavari and east Godavari as heavy rains, overflowing rivers and streams disrupted normal life. 20 dead in rain related incidents in Uttarakhand.

7.4. *September*

According to media reports and other disaster reports, 12 people died and 14 injured in rain-related incidents, including lightning strike, as many as 226 houses/huts were damaged and three herds of cattle dead in Uttar Pradesh.

Due to flash flood, 10 people died in Arunachal Pradesh. Heavy rains, claimed lives of 69 sheep and 3 goats in Tamil Nadu. Due to flash flood, 4 people died in Arunachal Pradesh.

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Appendix

Definitions of the terms given in *'Italics'*

Rainfall

Very light	-	0.1 to 2.4 mm
Light	-	2.5 to 15.5 mm
Moderate	-	15.6 to 64.4 mm
Heavy	-	64.5 to 115.5 mm
Very heavy	-	115.6 to 204.4 mm
Extremely Heavy	-	≥204.5 mm

Monthly/Seasonal Rainfall Distribution on Regional scale

Large Excess	-	Percentage departure from normal rainfall is + 60% or more
Excess	-	Percentage departure from normal rainfall is + 20% to +59%
Normal	-	Percentage departure from normal rainfall is from + 19 % to – 19 %
Deficient	-	percentage departure from normal rainfall is from – 20 % to – 59 %
Large Deficient	-	Percentage departure from normal rainfall is from – 60 % to –99%
No rain	-	-100%

Rainfall distribution on All India scale

Below Normal	-	percentage departure from normal rainfall is from < 10 %
Normal	-	percentage departure from normal rainfall is from + 10 % to – 10 %.
Above Normal	-	percentage departure from normal rainfall is from > 10 %

Monsoon activity

Active	-	Average rainfall of a sub-division is more than 1½ to 4 times the normal with minimum 5 cms along the west coast and 3 cms elsewhere in at least two stations in the sub-division
Vigorous	-	Average rainfall of a sub-division is more than 4 times or more than the normal with minimum 7 cm along the west coast and 5 cm elsewhere in at least two stations in the sub-division