

Weather in India

MONSOON SEASON (June to September 2020)†

1. Introduction

The rainfall over the country as a whole during the monsoon season (June-September) was 109% of its long period average (LPA) thus categorized as *normal* monsoon rainfall.

Seasonal rainfall over the homogenous regions of, south Peninsula, central India and northeast India were above normal at 129%, 115% and 107% of their respective LPA while Northwest India was below normal at 86% of LPA.

The rainfall over India for August 2020 (127% of LPA) was second highest, for the period 1901-2020, previously it was in August 1926 that 33% above normal rainfall was recorded. Monthly rainfall over the homogeneous region of central India (161% of LPA) and south Peninsula (162% of LPA) were highest in the month of August and September respectively since 1901.

A total number of 13 low pressure systems formed, the first low pressure system formed over Arabian sea on 31 May and intensified into severe cyclonic storm, “NISARGA” on 2 June. Of the other low pressure systems that formed during the monsoon season, none intensified into depression / deep depression as against the normal frequency of 4-6 monsoon depressions per season.

Southwest monsoon reached over the parts of Andaman sea on 15 May (normal date 22 May), however, it set in over Kerala on 1 June, its normal date and covered the entire country on 26 June, 12 days earlier than normal (normal date 8 July). Typically, the monsoon current begins to withdraw around 17 September, with the retreat completed by 15 October. This year, the withdrawal began on 28 September and was complete by 28 October and the commencement of the Northeast monsoon rains occurred simultaneously. Past dates of withdrawal of southwest monsoon from entire India since 1975 shows that withdrawal from the country was most delayed during 2010 (29 October) followed by 2016 and 2020 (28 October).

A coherent Madden Julian Oscillation (MJO) signal was not evident during June and on most days of July.

**Definitions of terms in italics other than sub-titles are given in Appendix*

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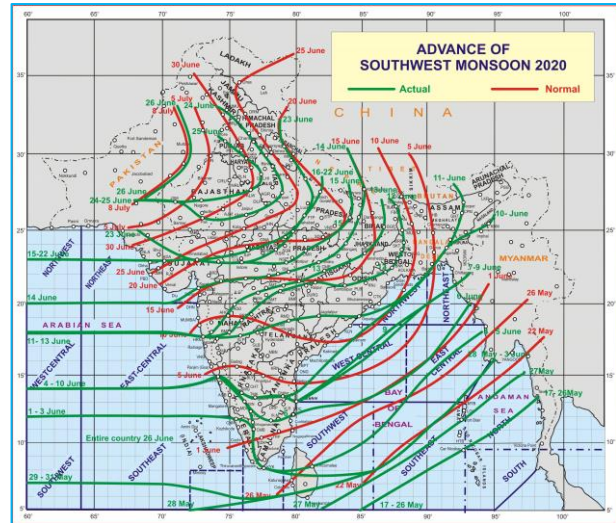


Fig. 1. Isochrones of advance of SW monsoon 2020

Only towards the end of July upto mid of August, the signal became active and slight eastward propagation from Indian Ocean to the maritime continent was seen. As the MJO moved eastwards over the Indian seas, the Arabian Sea and Bay of Bengal became convectively active in August. A weak MJO re-entered eastern Indian Ocean in late August and propagated eastwards into maritime continent with weak amplitude by the end of monsoon season.

2. Various aspects of southwest Monsoon-2020

2.1. Onset and advance

Fig. 1 shows the isochrones of advance of monsoon over the country. In association with persistent cloudiness from 15th May onwards over south Andaman sea, adjoining south Bay of Bengal and Nicobar Islands, strengthening of southwesterly winds in the lower levels and deepening (up to 6 km) over the southern latitudes and Outgoing Long wave Radiation (OLR) derived by the Satellite (INSAT-3D) over the region being less than 200 W/m² in the box confined to Lat. 5-10°N and Long. 70-75°E, the southwest monsoon advanced into south Andaman sea on 17 May ahead of its normal date, i.e., 20 May. The further advance was delayed due to the formation and movement of super cyclonic storm, “AMPHAN” over the Bay of Bengal during the period 16 -21 May. It was only on 27 May that the monsoon

TABLE 1
Advance of southwest monsoon 2020

S. No.	Date	Southwest monsoon advanced over	Northern limit of monsoon passed through
1.	17 May	The Southwest Monsoon advanced into some parts of south Bay of Bengal, Nicobar Islands & Andaman Sea	Lat. 5°N/Long. 85°E, Lat. 8°N/Long. 80°E, Car Nicobar, Lat. 11°N/Long. 95°E
2.	27 May	Some more parts of south Bay of Bengal, most parts of Andaman Sea and Andaman & Nicobar Islands	Lat. 5°N/Long. 82°E, Lat. 7°N/Long. 86°E, Lat. 10°N/Long. 90°E, Port Blair, Lat. 15°N/Long. 97°E
3.	28 May	Some parts of Maldives-Comorin area, some more parts of south Bay of Bengal, remaining parts of Andaman Sea and Andaman & Nicobar Islands	Lat. 5°N/Long. 72°E, Lat. 6°N/Long. 79°E, Lat. 6°N/Long. 79°E, Lat. 8°N/Long. 86°E, Lat. 11°N/Long. 90°E, Lat. 14°N/Long. 93°E and Lat. 16°N/Long. 95°E
4.	29 May	Some parts of southwest and southeast Arabian Sea and some more parts of Maldives-Comorin area	Lat. 7°N/Long. 50°E, Lat. 7°N/Long. 60°E, Lat. 7°N/Long. 70°E, Lat. 6°N/Long. 75°E, Lat. 6°N/Long. 79°E, Lat. 8°N/Long. 86°E, Lat. 11°N/Long. 90°E, Lat. 14°N/Long. 93°E and Lat. 16°N/Long. 95°E
5.	1 June	Entire south Arabian Sea and Lakshadweep area, remaining parts of Maldives area, most parts of Kerala & Mahe. Some parts of Tamil Nadu, Puducherry & Karaikal, some more parts of Comorin area and southwest Bay of Bengal. Thus, Southwest Monsoon has set in over Kerala the 1 st June, 2020, coinciding with its normal date of onset over Kerala	Lat. 12°N/Long. 60°E, Lat. 12°N/Long. 70°E, Cannur, Coimbatore, Kanyakumari, Lat. 8°N/Long. 86°E, Lat. 11°N/Long. 90°E, Lat. 14°N/Long. 93°E and Lat. 16°N/Long. 95°E
6.	4 June	Some parts of central Arabian Sea, entire Kerala & Mahe, some parts of Karnataka, some more parts of Comorin Area and southwest Bay of Bengal, most parts of southeast Bay of Bengal and some parts of eastcentral Bay of Bengal	Lat. 14°N/Long. 60°E, Lat. 14°N/Long. 70°E, Karwar, Hassan, Coimbatore, Kanyakumari, Lat. 10°N/Long. 85°E, Lat. 15°N/Long. 90°E and Lat. 18°N/Long. 94°E
7.	6 June	Some more parts of south interior Karnataka and Tamil Nadu, Puducherry & Karaikal; most parts of southwest Bay of Bengal, entire southeast Bay of Bengal; some more parts of eastcentral Bay of Bengal and some parts of westcentral & northeast Bay of Bengal	Lat. 14°N/Long. 60°E, Lat. 14°N/Long. 70°E, Karwar, Hassan, Salem, Puducherry, Lat. 13°N/Long. 85°E, Lat. 16°N/Long. 90°E and Lat. 20°N/Long. 93°E
8.	7 June	Some more parts of south interior Karnataka, some parts of Rayalaseema, most parts of Tamil Nadu, entire southwest Bay of Bengal, some more parts of westcentral Bay of Bengal, entire eastcentral Bay of Bengal and some parts of northwest and some more parts of northeast Bay of Bengal	Lat. 14°N/Long. 60°E, Lat. 14°N/Long. 70°E, Karwar, Shimoga, Tumkur, Chittoor, Chennai, Lat. 16°N/Long. 85°E, Lat. 20°N/Long. 90°E and Lat. 22°N/Long. 93°E
9.	9 June	Some more parts of west Central & north Bay of Bengal	Lat. 14°N/Long. 60°E, Lat. 14°N/Long. 70°E, Karwar, Shimoga, Tumukuru, Chittoor, Chennai, Lat. 18°N/Long. 87°E and Lat. 22°N/Long. 93°E
10.	10 June	Remaining parts of Tamil Nadu, some more parts of westcentral & north Bay of Bengal and some parts of Tripura & Mizoram	Lat. 14°N/Long. 60°E, Lat. 14°N/Long. 70°E, Karwar, Shimoga, Tumukuru, Chittoor, Ponneri, Lat. 18°N/Long. 85°E, Lat. 22°N/Long. 90°E, Agartala, Silchar, Kohima and Lat. 26°N/Long. 95°E
11.	11 June	Some more parts of central Arabian Sea, entire Goa, some parts of Konkan, Madhya Maharashtra & Marathwada, remaining parts of Karnataka, entire Rayalaseema & coastal Andhra Pradesh, most parts of Telangana, some parts of south Odisha, some more parts of westcentral & north Bay of Bengal, remaining parts of Nagaland, Manipur, Mizoram & Tripura, most parts of Arunachal Pradesh and some more parts of Assam & Meghalaya	Lat. 18°N/Long. 60°E, Lat. 18°N/Long. 70°E, Harnai, Solapur, Ramagundam, Jagdalpur, Gopalpur, Lat. 21°N/Long. 89°E, Agartala, Chaparmukh, Tezpur and Lat. 28°N/Long. 92°E
12.	12 June	Some more parts Madhya Maharashtra & Marathwada, remaining parts of Telangana, some parts of Vidarbha, some more parts of Chhattisgarh, remaining parts of Bay of Bengal, Arunachal Pradesh and Assam & Meghalaya, most parts of Odisha, West Bengal and entire Sikkim	Lat. 18°N/Long. 60°E, Lat. 18°N/Long. 70°E, Harnai, Baramati, Beed, Wardha, Raipur, Sambalpur, Baripada, Bardhaman, Siliguri, Lat. 27°N/Long. 87.5°E

TABLE 1 (Contd.)

S. No.	Date	Southwest monsoon advanced into	Northern limit of monsoon passed through
13.	13 June	Some more parts of Madhya Maharashtra, most parts of Marathwada & Vidarbha, some more parts of Chhattisgarh, remaining parts of Odisha & West Bengal, most parts of Jharkhand and some parts of Bihar	Lat. 18°N/Long. 60°E, Lat. 18°N/Long. 70°E, Harnai, Ahmednagar, Aurangabad, Gondia, Champa, Ranchi, Bhagalpur, Lat. 27°N/Long. 86.5°E
14.	14 June	Remaining parts of Central Arabian Sea, some parts of Gujarat state, remaining parts of Maharashtra (including Mumbai), some parts of Madhya Pradesh and most parts of Chhattisgarh, Jharkhand and Bihar	Lat. 20°N/Long. 60°E, Lat. 20°N/Long. 70°E, Surat, Nandurbar, Betul, Seoni, Pendra Road, Ambikapur, Gaya, Patna and Lat. 27°N/Long. 85°E
15.	15 June	Some more parts of north Arabian Sea, Gujarat State, entire Diu, some more parts of Madhya Pradesh, remaining parts of Chhattisgarh, Jharkhand, Bihar and some parts of east Uttar Pradesh	Lat. 23°N/Long. 60°E, Kandla, Ahmedabad, Indore, Narsinghpur, Umariya, Balia and Lat. 28°N/Long. 84°E
16.	16 June	Some more parts of west Madhya Pradesh, most parts of east Madhya Pradesh, and some more parts of east Uttar Pradesh	Lat. 23°N/Long. 60°E, Kandla, Ahmedabad, Indore, Raisen, Khajuraho, Fatehpur, Bahraich and Lat. 28°N/Long. 81.5°E
17.	23 June	Remaining parts of north Arabian Sea and Kutch, some more parts of Gujarat Region, Madhya Pradesh and Uttar Pradesh and some parts of Uttarakhand	Lat. 25°N/Long. 68°E, Ahmedabad, Shajapur, Fatehpur, Lat. 29°N/Long. 80°E, Rudraprayag and Lat. 32°N/Long. 79°E
18.	24 June	Remaining parts of Kutch, Gujarat Region, Madhya Pradesh, some parts of Rajasthan, Chandigarh and north Punjab, most parts of Uttar Pradesh & Himachal Pradesh and entire Uttarakhand and Jammu-Kashmir & Ladakh, Gilgit-Baltistan, Muzaffarabad	Lat. 27°N/Long. 68°E, Jaisalmer, Pali, Sawai Madhopur, Mainpuri, Bijnor, Pathankot and Lat. 32°N/Long. 73°E
19.	25 June	Some more parts of Rajasthan, remaining parts of Uttar Pradesh and Himachal Pradesh, entire Delhi, some parts of Haryana and most parts of Punjab	Lat. 27°N/Long. 68°E, Nagaur, Alwar, Delhi, Karnal and Firozpur
20.	26 June	South-West Monsoon has further advanced into remaining parts of Rajasthan, Haryana and Punjab and thus it has covered the entire country, the 26 th June 2020	

TABLE 2

Withdrawal of Southwest Monsoon 2020

S. No.	Date	Southwest monsoon advanced into	Northern limit of monsoon passed through
1.	28 Sep	Some parts of west Rajasthan and Punjab	Amritsar, Bhatinda, Hanumangarh, Bikaner, Jaisalmer and Lat. 26°N/Long. 70°E
2.	30 Sep	Some more parts of Rajasthan, remaining parts of Punjab, entire Western Himalayan region and Haryana, Chandigarh & Delhi and some parts of Uttar Pradesh	Lat. 29°N/Long. 81°E, Lakhimpur Kheri, Shahjahanpur, Alwar, Nagaur and Lat. 26°N/Long. 70°E
3.	3 Oct	Most parts of Rajasthan, some more parts of Uttar Pradesh and some parts of northwest Madhya Pradesh	Lat. 28°N/Long. 82°E, Bahraich, Gwalior, Sawai Madhopur, Jawai dam and Lat. 25°N/Long. 70°E
4.	6 Oct	Some more parts of Uttar Pradesh and Madhya Pradesh; most parts of Gujarat State and some parts of north Arabian Sea	Lat. 28°N/Long. 83°E, Faizabad, Fatehpur, Nowgong, Rajgarh, Ratlam, Vallabh Vidyanagar, Porbandar, Lat. 21°N/Long. 65°E and Lat. 21°N/Long. 60°E
5.	21 Oct	Remaining parts of Uttar Pradesh, entire Bihar, northern parts of West Bengal & Sikkim, northern parts of Jharkhand, north Chhattisgarh, some parts of east Madhya Pradesh and more parts of west Madhya Pradesh	Lat. 27°N/Long. 90°E, Cooch Bihar, Sriniketan, Ranchi, Pendra Road, Mandla, Narsinghpur, Indore, Vallabh Vidyanagar, Porbandar, Lat. 21°N/Long. 65°E and Lat. 21°N/Long. 60°E
6.	26 Oct	Some more parts of Gangetic West Bengal; most parts of Jharkhand; some parts of Odisha; remaining parts of Chhattisgarh; some parts of coastal Andhra Pradesh, Telangana; entire Vidarbha; remaining parts of Madhya Pradesh; some parts of Marathwada, Madhya Maharashtra, Konkan; remaining parts of Gujarat and north Arabian Sea today	Through Lat. 27°N/Long. 90°E, Cooch Behar, Sriniketan, Ghatshila, Keonjhar, Nowrangpur, Elluru, Nalgonda, Nanded, Nasik, Dahau, Lat. 20°N/Long. 65°E and Lat. 20°N/Long. 60°E
7.	27 Oct	Remaining parts of Chhattisgarh, some parts of coastal Andhra Pradesh, most parts of Telangana, entire Maharashtra, most parts of north interior Karnataka and north Arabian Sea	Through Lat. 27°N/Long. 90°E, Cooch Behar, Sriniketan, Ghatshila, Keonjhar, Nowrangpur, Elluru, Mehbubnagar, Raichur, Belgavi, Panjim Lat. 15°N/Long. 70°E and Lat. 15°N/Long. 60°E
8.	28 Oct	Withdrawn from the entire country simultaneously with the setting in of north easterly winds in the lower tropospheric levels, the northeast monsoon rains commenced over extreme south peninsular India, on 28 October 2020	

TABLE 3
Rainfall figures (mm) for each month and season as a whole (June-September 2020)

S. No.	Meteorological Sub-divisions	June			July			August			September			Monsoon Season		
		Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)
1.	Andaman & Nicobar Islands	498.3	413.7	20%	362.8	402.0	-10%	370.0	409.0	-10%	481.3	429.1	12%	1712.4	1653.8	4%
2.	Arunachal Pradesh	522.7	490.7	7%	625.1	523.8	19%	318.1	360.6	-12%	506.1	351.5	44%	1972.0	1726.6	14%
3.	Assam & Meghalaya	637.2	496.9	28%	687.7	557.7	23%	286.9	404.3	-29%	541.2	314.8	72%	2152.9	1773.7	21%
4.	Naga., Mani., Mizo. and Tri.	259.3	398.0	-35%	295.6	389.5	-24%	229.1	355.4	-36%	191.7	283.8	-32%	975.6	1426.7	-32%
5.	Sub-Himalayan West Bengal & Sikkim	680.2	483.3	41%	870.7	625.9	39%	414.5	480.7	-14%	725.7	380.9	91%	2691.1	1970.8	37%
6.	Gangetic West Bengal	279.0	256.2	9%	277.2	334.7	-17%	341.3	314.1	9%	167.0	276.5	-40%	1064.6	1181.5	-10%
7.	Orissa	251.1	217.7	15%	224.8	344.6	-35%	511.2	366.4	40%	153.8	226.6	-32%	1140.9	1155.3	-1%
8.	Jharkhand	205.7	199.9	3%	244.4	322.3	-24%	301.8	297.8	1%	146.4	234.7	-38%	898.3	1054.7	-15%
9.	Bihar	305.8	167.7	82%	443.5	349.0	27%	202.6	285.2	-29%	320.5	215.3	49%	1272.4	1017.2	25%
10.	East Uttar Pradesh	201.2	108.2	86%	262.8	281.2	-7%	189.9	263.8	-28%	128.4	186.2	-31%	782.4	839.4	-7%
11.	West Uttar Pradesh	51.3	76.0	-33%	182.5	243.9	-25%	200.2	256.7	-22%	19.3	144.7	-87%	453.3	721.3	-37%
12.	Uttaranchal	145.5	177.8	-18%	367.3	407.7	-10%	370.1	397.7	-7%	60.2	193.7	-69%	943.1	1176.9	-20%
13.	Haryana, Chandigarh & Delhi	47.4	48.1	-1%	166.3	156.8	6%	140.9	159.2	-11%	25.2	79.9	-68%	379.8	444.0	-14%
14.	Punjab	46.1	50.4	-9%	185.2	176.2	5%	134.1	160.0	-16%	22.1	80.7	-73%	387.5	467.3	-17%
15.	Himachal Pradesh	68.1	100.5	-32%	203.5	273.0	-25%	265.4	262.3	1%	29.9	127.7	-77%	567.0	763.5	-26%
16.	Jammu & Kashmir	48.3	74.0	-35%	96.0	203.7	-53%	204.3	185.4	10%	30.8	102.9	-70%	422.4	566.0	-25%
17.	West Rajasthan	36.4	36.9	-1%	85.4	101.7	-16%	147.0	88.0	67%	67.4	38.7	74%	336.2	265.3	27%
18.	East Rajasthan	73.9	66.8	11%	118.0	218.9	-46%	320.4	222.2	44%	81.3	95.0	-14%	593.7	602.9	-2%
19.	West Madhya Pradesh	192.2	105.9	81%	167.5	287.2	-42%	475.2	303.8	56%	131.2	160.8	-18%	966.0	857.7	13%
20.	East Madhya Pradesh	212.5	140.4	51%	200.0	342.4	-42%	484.3	366.2	32%	128.3	199.4	-36%	1025.1	1048.4	-2%
21.	Gujarat region	104.9	138.6	-24%	170.8	340.1	-50%	635.7	295.3	115%	123.7	148.9	-17%	1035.0	922.9	12%
22.	Saurashtra & Kutch	123.3	94.0	31%	303.9	195.6	55%	621.5	141.0	341%	97.5	76.6	27%	1146.2	507.2	126%
23.	Konkan & Goa	699.9	689.7	1%	1086.6	1068.1	2%	1410.3	759.0	86%	461.4	358.5	29%	3658.1	2875.3	27%
24.	Madhya Maharashtra	238.3	157.0	52%	211.2	240.8	-12%	329.6	197.1	67%	190.2	156.3	22%	969.3	751.2	29%
25.	Marathwada	217.3	138.0	57%	233.2	179.1	30%	167.3	186.5	-10%	249.4	165.2	51%	867.2	668.8	30%
26.	Vidarbha	168.2	170.6	-1%	254.4	307.1	-17%	308.2	306.6	1%	121.3	158.8	-24%	852.1	943.1	-10%
27.	Chattisgarh	277.9	193.5	44%	269.7	375.5	-28%	519.2	364.2	43%	167.4	208.9	-20%	1234.3	1142.1	8%
28.	Coastal Andhra Pradesh & Yanam	120.0	105.2	14%	220.6	157.9	40%	167.6	162.1	3%	217.2	161.7	34%	725.3	586.9	24%
29.	Telangana	169.9	130.4	30%	272.6	232.7	17%	403.0	225.5	79%	250.2	163.3	53%	1095.8	751.9	46%
30.	Rayalaseema	120.2	70.9	69%	238.5	92.6	158%	122.6	108.5	13%	274.8	139.6	97%	756.1	411.6	84%
31.	Tamil Nadu, Puducherry and Karaikal	59.6	51.7	15%	130.2	73.3	78%	94.9	92.8	2%	140.8	118.3	19%	425.6	336.1	27%
32.	Coastal Karnataka	788.3	866.7	-9%	973.3	1116.3	-13%	1147.4	806.3	42%	772.9	305.8	153%	3681.9	3095.1	19%
33.	North interior Karnataka	138.5	107.1	29%	203.2	123.5	65%	170.7	122.0	40%	227.3	144.5	57%	739.6	497.1	49%
34.	South interior Karnataka	145.6	144.1	1%	207.0	213.3	-3%	235.5	178.0	32%	228.0	146.4	56%	816.2	681.8	20%
35.	Kerala and Mahe	535.6	643.0	-17%	514.9	720.1	-28%	575.3	426.7	35%	601.9	259.5	132%	2227.8	2049.3	9%
36.	Lakshadweep	265.4	330.3	-20%	476.2	294.0	62%	269.6	223.2	21%	334.3	165.6	102%	1345.4	1013.1	33%

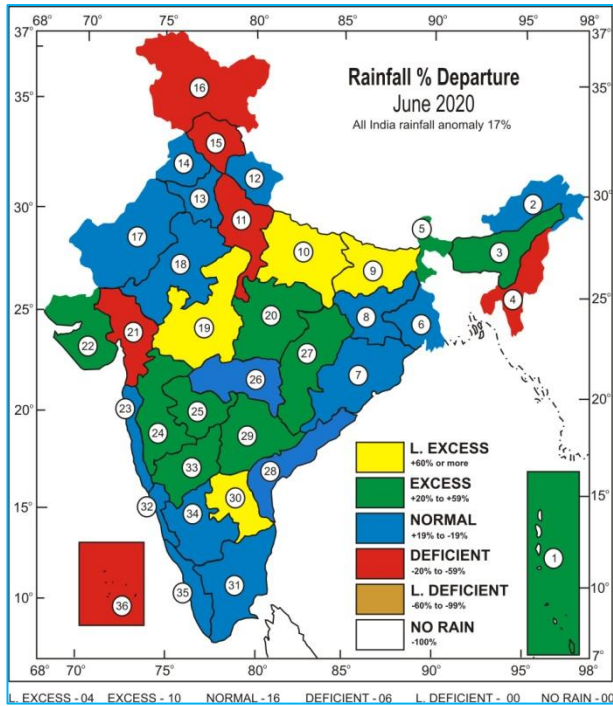


Fig. 2. Rainfall for the month of June 2020 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1 20	7 15	13 -1	19 81	25 57	31 15
2 7	8 3	14 -9	20 51	26 -1	32 -9
3 28	9 82	15 -32	21 -24	27 44	33 29
4 -35	10 86	16 -35	22 31	28 14	34 1
5 41	11 -33	17 -1	23 1	29 30	35 -17
6 9	12 -18	18 11	24 52	30 -69	36 -20

current further advanced and covered some more parts of south Bay of Bengal, most parts of Andaman Sea and Andaman and Nicobar islands, with the formation of a low-pressure area under the influence of cyclonic circulation over westcentral and adjoining southwest Arabian sea. The further advance was swift and it reached Kerala on 1st June, coinciding with its normal date of onset. It covered peninsular India by 12th, east and northeast India by 15th June (its near normal date). There was a hiatus from 17th June to 22nd June when the Northern Limit of Monsoon (NLM) passed through Lat. 23°N / Long. 60°E, Kandla, Ahmedabad, Indore, Raisen, Khajuraho, Fatehpur, Bahraich and Lat. 28°N/ Long. 81.5°E. The conditions became favourable and the monsoon advanced into remaining parts of north Arabian Sea, most parts of Kutch, some more parts of Gujarat Region, Madhya Pradesh, Uttar Pradesh and some parts of Uttarakhand on 23rd. The further advance of the monsoon current was fast and it advanced into the northwest States of Rajasthan, Uttar Pradesh, Himachal Pradesh, entire

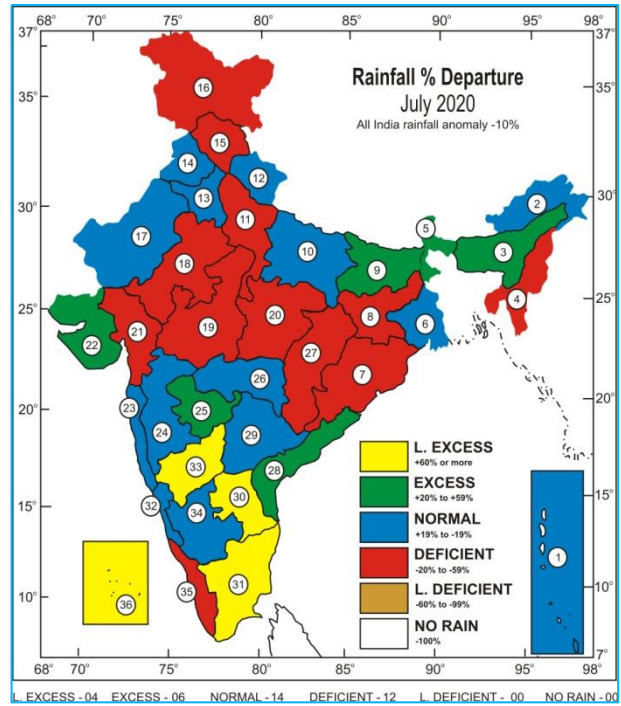


Fig. 3. Rainfall for the month of July 2020 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1 -10	7 -35	13 6	19 -42	25 30	31 78
2 19	8 -24	14 5	20 -42	26 -17	32 -13
3 23	9 27	15 -25	21 -50	27 -28	33 65
4 -24	10 -7	16 -53	22 55	28 40	34 -3
5 39	11 -25	17 -16	23 2	29 17	35 -28
6 -17	12 -10	18 -46	24 -12	30 158	36 62

Delhi, Haryana and Punjab and thus covered the entire country on 26th June 2020; which was 12 days prior to its normal date of 8th July for entire country coverage.

2.2. Monthly rainfall distribution

Figs. 2-5 show the monthly spatial distribution of rainfall. Table 3 gives the monthly and seasonal sub-divisional rainfall and percent departures.

The all India monthly rainfall was above normal in June (117% of LPA), August (127% of LPA), September (105% of LPA) and below normal in July (90% of LPA). It was a record rainfall in August 2020, when all India rainfall was 127% of LPA.

In June the precipitation over the country was above normal at 117% of LPA and all the homogenous regions received above normal rainfall with central India receiving excess rainfall at 130% of LPA.

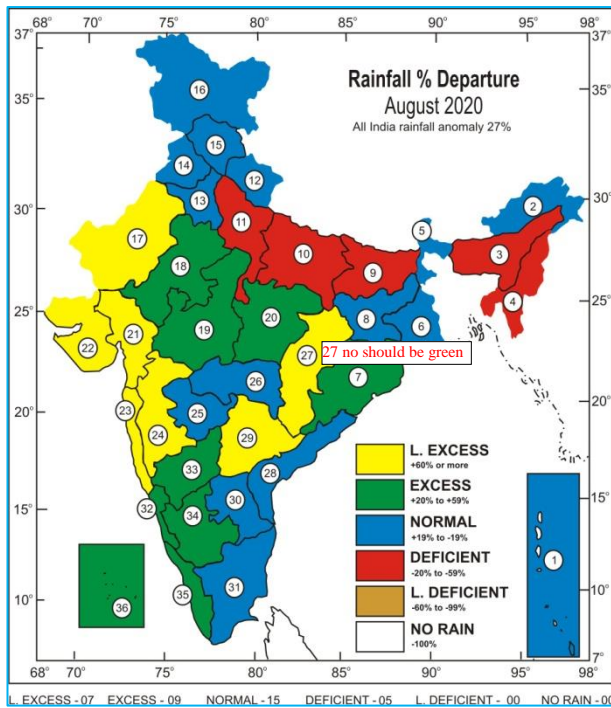


Fig. 4. Rainfall for the month of August 2020 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1 -10	7 40	13 -11	19 56	25 -10	31 2
2 -12	8 1	14 -16	20 32	26 1	32 42
3 -29	9 -29	15 1	21 115	27 -43	33 40
4 -36	10 -28	16 10	22 341	28 3	34 32
5 -14	11 -22	17 67	23 86	29 79	35 35
6 9	12 -7	18 44	24 67	30 13	36 21

In July, the rainfall over the country was *deficient* in 12 sub-divisions covering 42% of the country, mostly from northwest and central India. The homogenous regions of northwest India and central India recorded *deficient* rainfall at 74% and 78% of LPA respectively, while east & northeast India and south peninsula regions were *normal* at 109% and 116% of LPA. The below normal monsoon in July was mainly due to absence of any major monsoon disturbance over Bay of Bengal, the prevalence of a weak cross equatorial flow in general, the monsoon trough being weak and its location to the north of the normal or close to the foothills of the Himalayas on many days decreasing drastically rains over the country while increasing the rainfall along the foothills in the east and northeast region during the month resulting in frequent and prolonged floods over northeastern India, Bihar and adjoining areas of East Uttar Pradesh.

In August rainfall activity over the country as a whole was *above normal* at 127% of LPA, breaking the

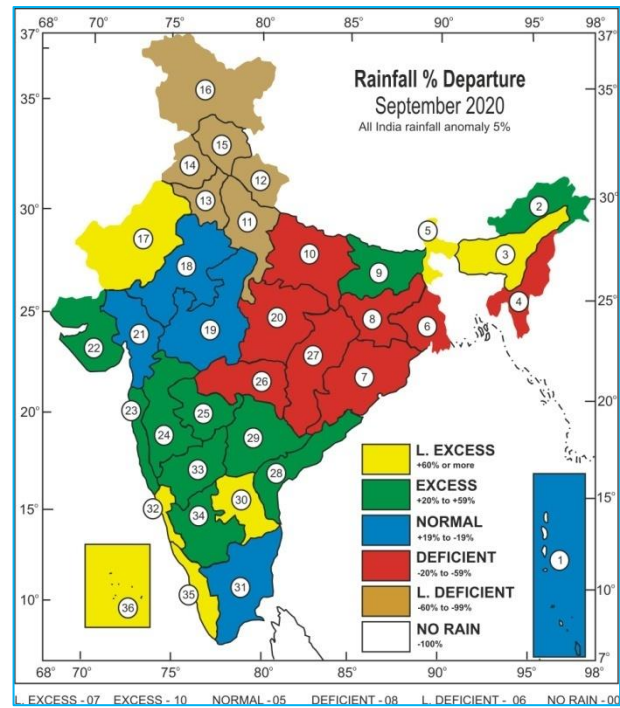


Fig. 5. Rainfall for the month of September 2020 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1 12	7 -32	13 -68	19 -18	25 51	31 19
2 44	8 -38	14 -73	20 -36	26 -24	32 153
3 72	9 49	15 -77	21 -17	27 -20	33 57
4 -32	10 -31	16 -70	22 27	28 34	34 56
5 91	11 -87	17 74	23 29	29 53	35 132
6 -40	12 -69	18 -14	24 22	30 97	36 102

previous record of August 1983, when it was 24% above normal of LPA. So far during the period 1901-2020, highest August rainfall occurred in 1926 which was 33% above normal.

Monthly rainfall over the homogeneous region of central India in the month of August too was highest in the last 120 years with 161% of LPA. There was back to back formation of five low pressure systems in the north Bay of Bengal during this month, all these systems moved in a west north-westward direction across central India, reaching Madhya Pradesh and even Rajasthan. Arabian sea was very active with stronger winds reaching up to 50-60 kmph in lower levels, monsoon trough was mostly south of its normal position and remained active, during a few days in the month.

All the homogenous regions except east, northeast India received above normal rainfall with central India recording *large excess* rainfall at 161% of LPA and south

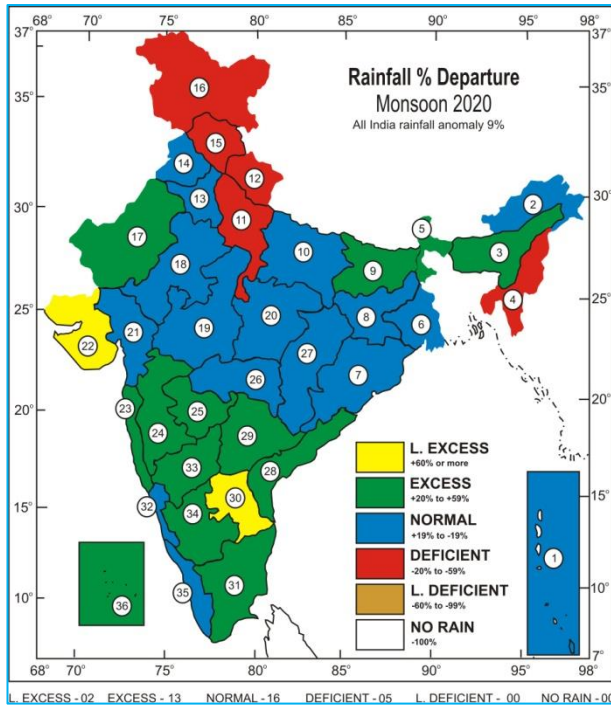


Fig. 6. Rainfall for the month of monsoon 2020 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	4	7	-1	13	-14	19	13	25	30	31	27
2	14	8	-15	14	-17	20	-2	26	-10	32	19
3	21	9	25	15	-26	21	12	27	8	33	49
4	-32	10	-7	16	-25	22	126	28	24	34	20
5	37	11	-37	17	27	23	27	29	46	35	9
6	-10	12	-20	18	-2	24	29	30	84	36	33

peninsula *excess* at 135% of LPA rainfall in August. Sixteen sub-divisions covering 50% of the country, mostly from central India and south peninsula region received *excess* or *large excess* rainfall in this month.

Some of the stations received record 24-hour rainfall. A list of stations is given below with their previous record and date.

Station name	Previous record (mm)	Date of record	Year of record	New record (mm)	Date August 2020
Indore	212.6	10	1981	263.4	22
Mumbai (Colaba)	287	3	1881	331.8	6
Dahanu	353.3	14	1945	383.1	5
Hanamkonda	190.5	26	1924	212.2	15
Pamban	73.9	31	1937	121.8	9

Source : IMD Climate Diagnostics Bulletin of India August 2020

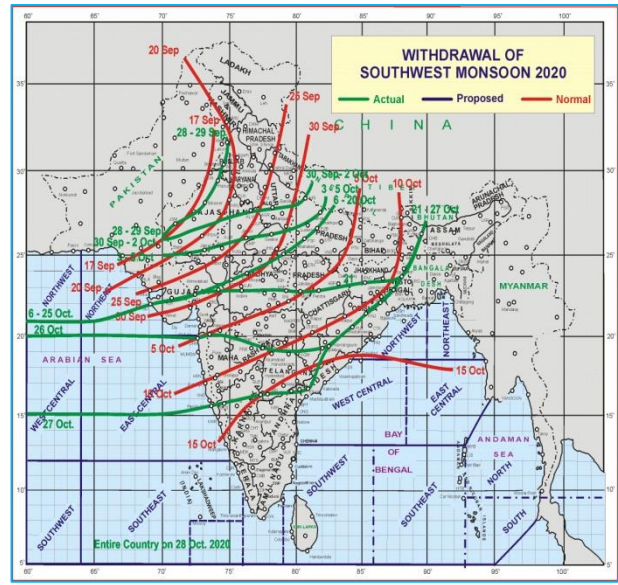


Fig. 7. Isochrones of withdrawal of SW monsoon 2020

In September, rainfall activity over the homogenous region of south peninsula was *large excess* at 162% of LPA, *excess* over east and northeast sub-division (123% of LPA), *normal* over central India (89% of LPA) and *deficient* over northwest India at 54% of LPA. In September, strong cross equatorial flow in the lower levels, stronger than normal tropical easterly jet at 200 hPa level, east-west shear zone which lay extended across south peninsula in the lower levels, off-shore trough at mean sea level along the west coast of peninsular India, upper air cyclonic circulations low pressure areas that formed over the Bay of Bengal coast with their associated upper air cyclonic circulation extending upto mid tropospheric levels tilting southwestwards with height resulting in large excess rainfall over south peninsula.

2.3. Seasonal rainfall distribution

Meteorological sub-divisionwise seasonal rainfall distribution in terms of percentage departures from normal is given in Fig. 6. Out of the total 36 meteorological sub-divisions, 2 sub-divisions, Rayalaseema and Saurashtra & Kutch received large excess rainfall, 13 sub-divisions excess, 16 normal and 5 deficient rainfall. Sub-divisions in central India and south peninsula received normal to large excess rainfall and no sub-division recorded deficient rainfall in both the homogenous regions. South peninsula region recorded above normal rainfall in all the months with August and September rainfall being exceptionally high at 135% and 162% of LPA respectively.

TABLE 4
Details of the weather systems during June 2020

S. No.	System	Duration	Place of initial location	Direction of movement	Place of final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A) Cyclonic storm						
1.	Severe cyclonic storm 'NISARGA'	1-4	East-central and adjoining southeast Arabian Sea	North-northeast	Over western parts of Vidarbha	Details are given in the article on Storms & Depressions over the north Indian Ocean-2020
(B) Low pressure area						
1.	Low pressure area	9-12	East-central Bay of Bengal and neighbourhood	North west	North coastal Andhra Pradesh-Yanam and adjoining coastal Odisha and neighbourhood	It formed under the influence of the cyclonic circulation over same region. Associated cyclonic circulation extends upto mid tropospheric level and became less marked on 13. However, the associated cyclonic circulation extended up to same level lay over north interior Odisha and neighbourhood. It became less marked on 18
(C) Western disturbances / Eastward moving systems						
(i) Upper air cyclonic circulation						
1.	Between 5.8 & 7.6 kms a.s.l.	2-5	North Pakistan and adjoining Jammu & Kashmir	East	Punjab and neighbourhood	A trough aloft ran with its axis at 7.6 km a.s.l. roughly along Long. 73°E to the north of Lat. 26°N on 5. It then lay as a trough between 5.8 & 7.6 kms a.s.l. ran roughly along Long. 78°E to the north of Lat. 28°N on 6. It moved away east-northeastwards on 8
2.	Upto 3.1 kms a.s.l.	9-10	North Pakistan & neighbourhood	Do	Central Pakistan and neighbourhood	It then lay as a cyclonic circulation over north Rajasthan & neighbourhood between 0.9 km & 2.1 kms a.s.l. on 11 & became less marked on 13
(ii) As a trough						
1.	Upto Mid tropospheric levels	12-16	Along Long. 65° E to the north of Lat. 27° N (axis at 5.8 kms a.s.l.)	Northeast	Along Long. 79°E to the north of Lat. 30°N	It moved away northeastwards on 17
2.	Upto mid tropospheric levels	18-22 (Mrg)	Along Long. 65° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	Do	Along Long. 82° E to the north of Lat. 32° N (axis at 5.8 kms a.s.l.)	Moved away eastwards on 22 subsequently
(D) Other upper air cyclonic circulations						
1.	Upto 1.5 kms a.s.l.	1-8	West Rajasthan and neighbourhood	Oscillatory	North Haryana and neighbourhood	Became less marked on 9
2.	Upto 0.9 kms a.s.l.	6	East Vidarbha & neighbourhood	Stationary	<i>In situ</i>	Became less marked on 7
3.	Between 3.1 & 5.8 kms a.s.l.	6-8	East-central Bay of Bengal and adjoining north Andaman sea	West	East-central Bay of Bengal	Under its influence, a low pressure area formed over East-central Bay of Bengal on 9
4.	At 5.8 kms a.s.l.	7-8	Southeast Arabian Sea off Kerala coast	Stationary	<i>In situ</i>	Became less marked on 9
5.	Between 2.1 & 3.1 kms a.s.l.	7-13	Central Gujarat	South	North Madhya Maharashtra and neighbourhood	Became less marked on 14
6.	Upto 1.5 kms a.s.l.	9	East Uttar Pradesh & neighbourhood	Stationary	<i>In situ</i>	Merged with the cyclonic circulation over north Odisha & neighbourhood on 10
7.	At 1.5 km above m.s.l.	11-12	South Chhattisgarh & neighbourhood	Northwest	South-east Madhya Pradesh and neighbourhood	Merged with the trough over north-west Rajasthan to north interior Odisha on 13

TABLE 4 (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
8.	At 1.5 km above m.s.l.	14	Northeast Rajasthan & neighbourhood	Stationary	<i>In situ</i>	Became less marked on 15
9.	Between 5.8 and 7.6 km above m.s.l.	15	North Andaman Sea and neighbourhood and extended	Do	<i>In situ</i>	Became less marked on 16
10.	Between 5.8 and 7.6 km above m.s.l.	16-17	East Vidarbha & neighbourhood	Do	<i>In situ</i>	Became less marked on 18
11.	Between 3.1 and 3.6 km above m.s.l.	16-18	North Konkan & neighbourhood	Do	Do	Became less marked on 19
12.	Between 3.1 and 5.8 km above m.s.l.	17-21	Jharkhand and neighbourhood	Northwest	Southeast Uttar pradesh and nbd	Became less marked on 22
13.	At 1.5 km above m.s.l.	17	Central Assam and neighbourhood	Stationary	<i>In situ</i>	Merged with the trough from central Pakistan to Manipur on 18
14.	Between 1.5 and 7.6 km above m.s.l.	18 Jun - 4 Jul	Central Arabian sea and neighbourhood	West	Westcentral and adjoining northwest Arabian sea	Became less marked on 5 July
15.	Between 3.6 and 5.8 km above m.s.l.	19-25	South Gujarat region and neighbourhood	South	Eastcentral Arabian sea off north Maharashtra coast	Became less marked on 26
16.	Upto 1.5 km	19-20	Central Pakistan and neighbourhood	Stationary	<i>In situ</i>	Became less marked on 21
17.	Upto 1.5 km	19	South Assam and neighbourhood	Do	Do	Became less marked on 20
18.	Between 2.1 and 5.8 kms a.s.l	20-24	North Odisha and neighbourhood	East	Northeast Madhya Pradesh and neighbourhood	Became less marked on 25
19.	Upto 1.5 km	23-29	Central Pakistan and neighbourhood	Stationary	<i>In situ</i>	Merged with the heat low on 30
20.	Between 3.1 and 5.8 kms above m.s.l.	23-25	Southeast Bay of Bengal	West	Southwest and adjoining southeast Bay of Bengal	Merged with the shear zone on 26
21.	At 1.5 km a.s.l.	24-26	Northeast Rajasthan and neighbourhood	East	West Uttar Pradesh and neighbourhood	Became less marked on 27
22.	At 4.5 km a.s.l.	24	Coastal Karnataka and neighbourhood	Stationary	<i>In situ</i>	Became less marked on 25
23.	At 7.6 km a.s.l.	23	Southeast Arabian sea off Kerala coast	Do	Do	It became less marked on 24
24.	Between 1.5 and 4.5 kms a.s.l.	30 Jun - 4 Jul	South Gujarat and neighbourhood	Do	Do	Under its influence, a low pressure area formed over coastal Saurashtra & nbd on 5 morning
25.	Between 4.5 and 5.8 kms a.s.l	30 Jun	North Interior Karnataka and neighbourhood	Do	Do	It became less marked on 1 July
26.	Between 3.1 & 4.5 kms above m.s.l.	30 Jun	North Chhattisgarh and neighbourhood	Do	Do	Merged with the trough ran from cyclonic circulation over east Uttar Pradesh to Vidarbha on 1 July
27.	At 7.6 kms a.s.l.	27-29	Southeast Arabian sea off Kerala coast	Do	Do	It became less marked on 30
28.	Upto 0.9 km a.s.l.	27	North interior Karnataka and neighbourhood	Do	Do	It became less marked on 28

TABLE 4 (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
29.	Between 1.5 & 3.6 kms a.s.l.	29	South coastal Andhra Pradesh & neighbourhood	Stationary	<i>In situ</i>	It became less marked on 30
30.	At 0.9 kms a.s.l.	29	East Uttar Pradesh and neighbourhood	Do	Do	Merged with the Monsoon trough on 30
31.	At 3.1 kms a.s.l.	29	Marathwada & neighbourhood	Do	Do	Became less marked on 30
(E) Other troughs/wind discontinuity						
1.	At 0.9 kms a.s.l.	1	Northwest Uttar Pradesh to interior Odisha across east Madhya Pradesh and Chhattisgarh	Stationary	<i>In situ</i>	Became less marked on 2
2.	Upto 1.5 kms a.s.l.	2-3	Bihar to Chhattisgarh	Oscillatory	North Bihar to Jharkhand	Became less marked on 4
3.	Upto 1.5 kms a.s.l.	8	North Bangladesh to interior Odisha across Gangetic west Bengal and Jharkhand	Stationary	<i>In situ</i>	Became less marked on 9
4.	At 0.9 kms a.s.l.	10-12	From north Pakistan to the cycir associated with Low Pressure Area over EC & adjoining WC BOB across north Rajasthan, north Madhya Pradesh, Chhattisgarh & Odisha	Oscillatory	From the cyclonic circulation over south Haryana to the cyclonic circulation associated with the low pressure area across north Madhya Pradesh, Chhattisgarh	Merged with the trough over northwest Rajasthan to north interior Odisha on 13
5.	At m.s.l. & upto 1.5 km a.s.l.	13-26	From northwest Rajasthan to north interior Odisha across north Madhya Pradesh, north Chhattisgarh	Do	From Punjab to east Bihar across Haryana and Uttar Pradesh	Merged with the Monsoon trough on 27
6.	Between 1.5 and 3.1 km above m.s.l.	17	From east Uttar Pradesh to Bangladesh across Jharkhand and Gangetic West Bengal	Stationary	<i>In situ</i>	Became less marked on 18
7.	At 3.1 km above m.s.l.	26	From Bihar to east Vidarbha across north Chhattisgarh	-	From Northeast Madhya Pradesh to north Madhya Maharashtra	Became less marked on 29
8.	At m.s.l.	27-28	From Karnataka coast to Kerala coast	-	From Karnataka coast to Lakshadweep-Maldives area	Became less marked on 29
9.	At m.s.l.	29 Jun - 19 Jul	From Karnataka coast to Kerala coast	-	South Maharashtra coast to Kerala coast	Became less marked on 20
(F) East-West shear zone						
1.	At 3.1 kms a.s.l.	12-15	Along Lat. 17°N	Oscillatory	Sub Himalayan West Bengal to north Konkan across the cyclonic circulation over southeast Uttar Pradesh, south Madhya Pradesh and north Madhya Maharashtra	become less marked on 16
2.	At 3.1 km a.s.l.	17-	Jharkhand to the cyclonic circulation over Konkan across Chhattisgarh, Telangana and north interior Karnataka	Stationary	<i>In situ</i>	It became less marked on 18
3.	Between 2.1 and 5.8 kms a.s.l.	26-28	Along Lat. 10°N	North	Along 15°N	It became less marked on 29

TABLE 5
Details of the weather systems during July 2020

S. No.	System	Duration	Place of initial location	Direction of movement	Place of final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A) Well marked low/low pressure area						
1.	Well marked Low Pressure area	6-8	Kutch and neighbourhood	North west	Gulf of Kutch and neighbourhood	Under the influence of a cyclonic circulation over south Gujarat & neighbourhood, a low pressure area formed over coastal Saurashtra and neighbourhood with associated cyclonic circulation extended upto 5.8 kms a.s.l. on 5 morning. It intensified subsequently. It then weakened into Low over Northeast Arabian sea & adjoining South Pakistan on 9 and became less marked on 12 morning. However, associated cyclonic circulation became less marked on 15
2.	Low Pressure area	5-7	Northwest Bay of Bengal off Odisha-GWB coast	Stationary	Western parts of Jharkhand and neighbourhood	Associated cyclonic circulation extended upto 7.6 kms above m.s.l. It became less marked on 7 evening, however, associated cyclonic circulation merged with the Monsoon trough subsequently
(B) Western disturbances / eastward moving systems						
<i>(i) Upper air cyclonic circulation</i>						
1.	At 3.1 kms a.s.l.	24-27	Western parts of Afghanistan & neighbourhood	East	North Pakistan and neighbourhood	Became less marked on 28
<i>(ii) Trough in westerlies</i>						
1.	Mid tropospheric level	5-7	Along Long. 63°E to the north of Lat. 30°N	East	Along Long. 72°E to the north of Lat. 30°N	It moved away east-northeastwards on 8
2.	Mid tropospheric level	8-15	Along Long. 60°E to the north of Lat. 23°N	Do	Along Long. 75°E to the north of Lat. 34°N	It moved away northeastwards on 15 subsequently
3.	Mid tropospheric level	18-23	Along Long. 64°E to the north of Lat. 30°N	Do	Along Long. 80°E to the north of Lat. 30°N	It moved away northeastwards on 24
4.	At 1.5 km a.s.l.	28	Jammu division to northeast Arabian sea off Pakistan coast	Stationary	<i>In situ</i>	Became less marked on 29
(C) Other upper air cyclonic circulations						
1.	At 0.9 km a.s.l.	1	West Rajasthan and neighbourhood	Stationary	<i>In situ</i>	Became less marked on 2
2.	At 0.9 km a.s.l.	1	Interior Odisha and neighbourhood	Stationary	Do	Became less marked on 2
3.	Between 1.5 and 4.5kms a.s.l.	1-4	East Uttar Pradesh and neighbourhood	Stationary	Do	Became less marked on 5
4.	At 3.1 kms a.s.l.	3-4	Westcentral Bay of Bengal off Andhra Pradesh coast	Stationary	Westcentral and adjoining northwest Bay of Bengal off north coastal Andhra Pradesh & south Odisha coast	Under its influence, a low pressure area formed northwest Bay of Bengal off Odisha-GWB coast on 5

TABLE 5 (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
5.	Between 3.6 and 5.8 kms a.s.l.	2	South coastal Odisha neighbourhood	Stationary	<i>In situ</i>	Became less marked on 3
6.	At 0.9 kms a.s.l.	3-5	Northeast Rajasthan & neighbourhood	East	Northwest Madhya Pradesh	Became less marked on 6
7.	At 5.8 kms a.s.l.	7	North coastal Andhra Pradesh and neighbourhood	Stationary	<i>In situ</i>	Became less marked on 8
8.	Between 2.1 and 3.6 kms a.s.l.	8	Southeast Bihar and neighbourhood	Do	Do	Became less marked on 9
9.	At 1.5 kms a.s.l.	9	Haryana and neighborhood	Do	Do	Became less marked on 10
10.	At 3.1 kms a.s.l.	9	South Odisha and neighborhood	Do	Do	Became less marked on 10
11.	At 5.8 kms a.s.l.	10	Eastcentral Arabian sea off Maharashtra coast	Do	Do	Became less marked on 11
12.	At 5.8 kms a.s.l.	11	Southeast Arabian Sea off Kerala coast	Do	Do	Became less marked on 12
13.	At 5.8 kms a.s.l.	11-12	Malacca strait and neighbourhood	Do	Do	Became less marked on 13
14.	Between 3.1 & 7.6 km a.s.l.	12-14	East Bihar and neighbourhood	Do	Do	With a trough aloft with its axis at 7.6 kms a.s.l. ran roughly along Long. 86°E to the north of Lat. 22° Non 13 and became less marked on 14. However cyclonic circulation also became less marked on 15
15.	At 2.1 km a.s.l.	13	Southwest Rajasthan and neighborhood	Do	Do	Became less marked on 14
16.	Between 2.1 & 5.8 km a.s.l.	14-15	Northwest Bay of Bengal and adjoining Gangetic West Bengal	West	Jharkhand & neighbourhood	Became less marked on 16
17.	Upto 1.5 kms a.s.l	14-16	Southeast Uttar Pradesh & neighbourhood	Do	Central parts of north Madhya Pradesh and neighbourhood	Became less marked on 17
18.	Between 3.6 & 4.5 km a.s.l.	14	North interior Karnataka & neighbourhood	Stationary	<i>In situ</i>	Merged with the shear zone along 18°N on 15
19.	At 1.5 kms a.s.l.	15-20	North Konkan and neighbourhood	North	Southwest Rajasthan and neighbourhood	Became less marked on 21
20.	Upto 0.9 kms a.s.l.	17	South Rajasthan & neighbourhood	Stationary	<i>In situ</i>	Became less marked on 18
21.	Upto 1.5 kms a.s.l.	18-20	Southwest Bay of Bengal off Sri Lanka coast	West	Comorin area and neighbourhood	Became less marked on 21
22.	Upto 1.5 kms a.s.l.	19	Central Pakistan & neighbourhood	Stationary	<i>In situ</i>	Merged with the heat low on 20
23.	At 5.8 kms a.s.l.	20-26	Southeast Arabian sea off Lakshadweep & Kerala coast	North	Eastcentral Arabian sea off Konkan coast	Became less marked on 27
24.	At 0.9 kms a.s.l.	21	Southwest Uttar Pradesh and neighbourhood	Stationary	<i>In situ</i>	Became less marked on 22
25.	At 1.5 kms a.s.l.	21	North interior Karnataka & neighbourhood	Do	Do	Became less marked on 22

TABLE 5 (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
26.	Upto 1.5 kms a.s.l.	22-25	South Assam & neighborhood	West	Chhattisgarh and adjoining interior Odisha	With a trough aloft between 3.1 & 7.6 kms a.s.l. roughly along Long. 89°E to the north of Lat. 20°N and became less marked on 23. However, cyclonic circulation became less marked on 26
27.	Between 3.6 & 5.8 kms a.s.l.	24-25	Southwest Uttar Pradesh & neighbourhood	Do	Northeast Rajasthan	Became less marked on 26
28.	Between 0.9 & 1.5 kms a.s.l.	25	Central parts of Rajasthan	Stationary	<i>In situ</i>	Became less marked on 26
29.	At 1.5 kms a.s.l.	25	South Gujarat region and neighbourhood	Do	Do	Became less marked on 26
30.	Between 2.1 & 3.6 kms a.s.l.	26-30	Southeast Bay of Bengal and adjoining central Andaman sea	West	South coastal Andhra Pradesh and adjoining north Tamil Nadu	Merged with the shear zone along Lat. 13°N on 31
31.	Between 4.5 & 5.8 kms a.s.l.	27-28	South Assam and neighbourhood	Do	Sub-Himalayan West Bengal, Sikkim and adjoining Bangladesh	Became less marked on 29
32.	Between 2.1 & 3.1 kms a.s.l.	28-29	Southwest Rajasthan	South	Southwest Rajasthan and adjoining north Gujarat	Became less marked on 30
33.	Upto 1.5 kms a.s.l.	29	Northeast Madhya Pradesh and neighbourhood	Stationary	<i>In situ</i>	Became less marked on 30
34.	At 1.5 kms a.s.l.	29	Central Pakistan and neighbourhood	Do	Do	Merged with the heat low on 30
35.	Upto 0.9 kms a.s.l.	29	Punjab and neighbourhood	Do	Do	Became less marked on 30
36.	At 0.9 kms a.s.l.	31	Meghalaya and neighbourhood	Do	Do	Became less marked on 1 August
37.	Upto 0.9 kms a.s.l.	31	Punjab and neighbourhood	Do	Do	Became less marked on 1 August
(D) Other troughs						
1.	At 0.9 kms a.s.l.	1	West Rajasthan to interior Odisha across Madhya Pradesh and Chhattisgarh	Stationary	<i>In situ</i>	Became less marked on 2
2.	Between 1.5 & 3.1 km a.s.l.	1-3	From Cyclonic circulation over east Uttar Pradesh to Vidarbha across east Madhya Pradesh	Oscillatory	East Uttar Pradesh to east Vidarbha across east Madhya Pradesh	Became less marked on 4
3.	At 0.9 kms a.s.l.	8	From cyclonic circulation associated with the WML over Gulf of Kutch & neighbourhood to north Rajasthan	Stationary	<i>In situ</i>	Became less marked on 9
4.	At 4.5 kms a.s.l.	10-11	East Uttar Pradesh to south Odisha across Chhattisgarh	South	Southeast Uttar Pradesh to south Chhattisgarh	Became less marked on 12
5.	Between 1.5 & 2.1 km a.s.l.	17-18	From cyclonic circulation over south Gujarat and neighbourhood to south Madhya Pradesh across north Maharashtra	Oscillatory	From cyclonic circulation over coastal areas of Saurashtra, Kutch and neighbourhood to north Rajasthan	Became less marked on 19

TABLE 5 (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
6.	At 0.9 kms a.s.l.	19-21	North interior Karnataka to south Tamil Nadu	Oscillatory	North interior Karnataka to interior Tamil Nadu across south interior Karnataka	Became less marked on 22
7.	Between 4.5 & 7.6 km a.s.l.	25	Saurashtra & Kutch to Punjab	Stationary	<i>In situ</i>	Became less marked on 26
8.	At m.s.l.	25	From Karnataka coast to north Kerala coast	Do	Do	Became less marked on 26
9.	Between 0.9 & 2.1 km a.s.l.	26	From western disturbance over north Pakistan & neighbourhood to eastcentral Arabian sea off Konkan coast across west Rajasthan and Saurashtra & Kutch	Do	Do	Became less marked on 27
10.	At 4.5 kms a.s.l.	26	From cyclonic circulation over eastcentral Arabian sea off Konkan coast to southeast Uttar Pradesh	Do	Do	Became less marked on 27
11.	At 1.5 kms a.s.l.	27-28	Bihar to north coastal Odisha	Do	Do	Became less marked on 29
12.	At 1.5 kms a.s.l.	29	From cyclonic circulation over southwest and adjoining westcentral Bay of Bengal off south Andhra Pradesh-north Tamil Nadu coast to west Vidarbha across south coastal Andhra Pradesh & Telangana	Do	Do	Became less marked on 30
13.	Upto 0.9 kms a.s.l.	30	From northeast Uttar Pradesh to southeast Madhya Pradesh	Do	Do	Became less marked on 31
14.	At 3.1 kms a.s.l.	30	South Maharashtra coast to southwest Madhya Pradesh across north Madhya Maharashtra	Do	Do	Became less marked on 31
15.	At 1.5 kms a.s.l.	31 Jul	Marathwada to north Tamil Nadu across interior Karnataka	Do	Do	Became less marked on 1 August
(E) East-west shear zone						
1.	Between 4.5 & 5.8 kms a.s.l.	1	Along Lat. 15°N	Stationary	<i>In situ</i>	Became less marked on 2
2.	Between 3.6 & 5.8 kms a.s.l.	3	Along Lat. 16°N	Do	Do	Became disorganized on 4
3.	between 3.1 & 5.8 km a.s.l.	15-17	Along Lat. 18°N	North	Along Lat. 20°N	Became less marked on 18
4.	between 3.1 & 5.8 km a.s.l.	31 Jul - 3 Aug	Along Lat. 13°N	Do	Along Lat. 16°N	Became less marked on 4 August

TABLE 6
Details of the weather systems during August 2020

S. No.	System	Duration	Place of initial location	Direction of movement	Place of final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A) Well marked low/low pressure area						
1.	Well marked low pressure area	4 (eve) - 5	Northwest Bay of Bengal off north Odisha-West Bengal coast	West	Northwest Bay of Bengal & adjoining north Odisha-West Bengal coast	It formed under the influence of the cyclonic circulation over northeast Bay of Bengal and neighbourhood between 3.1 & 4.5 km above mean sea level. It intensified as a Low over North Bay of Bengal and neighbourhood on 4 morning. Associated cyclonic circulation extending upto 7.6 km above mean sea level tilting southwestward with height. It weakened as low on 5(evening) and became less marked on 7
2.	Well marked low pressure area	8	Central parts of north Arabian sea & adjoining south Pakistan	Northwest	Northeast Madhya Pradesh and adjoining south Uttar Pradesh	Under the influence of cyclonic circulation over Northeast Arabian sea, a low pressure area formed over northeast Arabian sea & adjoining coastal areas of Kutch & south Pakistan with associated cyclonic circulation extending upto 5.8 km above mean sea level on 7 (evening). It intensified subsequently. It then weaken into low over northwest Arabian sea off Oman coast on 9 morning & became less marked on 10
3.	Low pressure area	9 (0000 UTC) - 11(0000 UTC)	Northwest & adjoining westcentral Bay of Bengal off Odisha-North Andhra Pradesh coast	West	Northwest Madhya Pradesh and neighbourhood	It formed under the influence of the cyclonic circulation over northwest Bay of Bengal & neighbourhood. The associated cyclonic circulation extending upto 5.8 km above mean sea level tilting southwestwards with height. It became less marked Subsequently. However, associated cyclonic circulation over northeast Rajasthan & neighbourhood also less marked on 12
4.	Well marked low pressure area	14 (1200 UTC) - 15	North coastal Odishaand adjoining areas of northwest Bay of Bengal-Gangetic West Bengal	Stationary	<i>In situ</i>	under the influence of the cyclonic circulation over northwest & adjoining westcentral Bay of Bengal off Odisha -north Andhra Pradesh coast, a low pressure area formed over northwest Bay of Bengal off north Odisha & west Bengal coast with associated cyclonic circulation extended upto 7.6 km above mean sea level tilting southwestwards with height on 13. It intensified subsequently. It then weaken into Low pressure area over Jharkhand & adjoining Gangetic west Bengal on 16 and became less marked on 18. However, associated cyclonic circulation also became less marked on 19
5.	Well marked low pressure area	19-22	Northwest Bay of Bengal and neighbourhood	West	Northwest Madhya pradesh and neighbourhood	Under the influence of the cyclonic circulation over northeast Bay of Bengal & neighbourhood a low pressure area formed over north Bay of Bengal & neighbourhood with associated cyclonic circulation extended upto 7.6 km above mean sea level tilting southwestwards with height on 19 mornings. It intensified subsequently. It then weaken into Low pressure area over central parts of east Rajasthan & neighbourhood on 23 and became less marked on 26. However, Associated cyclonic circulation over south Pakistan and neighbourhood became less marked on 29
6.	Well Marked low pressure area	25-30 (0000 UTC)	Northwest Bay of Bengal and adjoining coastal areas of Gangetic west Bengal & north Odisha		West Madhya Pradesh and adjoining east Rajasthan	Under the influence of cyclonic circulation over Bangladesh & neighbourhood, a low pressure area formed over north Bay of Bengal & neighbourhood with associated cyclonic circulation extended upto 7.6 kms a.s.l. on 24 mornings. It intensified subsequently. It then weaken into low pressure area over West Madhya Pradesh and adjoining east Rajasthan on 30 (0300 UTC) and merged with the heat low on 2 Sep (0000 UTC) and remnant cyclonic circulation over Pakistan and adjoining Punjab became les marked on 6 September

TABLE 6 (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(B) Western disturbances/eastward moving systems						
<i>(i) Upper air cyclonic circulation</i>						
<i>(ii) As A trough</i>						
1.	Mid & Upper tropospheric westerlies with its axis at 5.8 kms a.s.l.	31 Aug - 4 Sep	Long. 60°E to the north of Lat. 28°N	East	Long. 64°E to the north of Lat. 32°N	It moved away northeastwards on 5
(C) Other upper air cyclonic circulations						
1.	Between 1.5 & 2.1 kms a.s.l.	1-4	South Rajasthan and adjoining north Gujarat	West	South Pakistan and neighbourhood	Became less marked on 5
2.	Between 2.1 & 3.1 kms a.s.l.	3	Gangetic west Bengal & adjoining Bangladesh	Stationary	<i>In situ</i>	Merged with the low pressure area over north Bay of Bengal off west Bengal-Bangladesh coast on 4
3.	Between 3.6 & 4.5 kms a.s.l.	3-7	Eastcentral Arabian sea off north Maharashtra coast	Oscillatory	Eastcentral Arabian sea off Maharashtra coast	Became less marked on 8
4.	At 1.5 kms a.s.l.	5	North Pakistan and neighbourhood	Stationary	<i>In situ</i>	Became less marked on 6
5.	At 7.6 kms a.s.l.	9-10	Interior Tamil Nadu & neighbourhood	East	Southwest Bay of Bengal off Tamil Nadu coast	Merged with the shear zone along Lat. 18° N on 11
6.	At 1.5 km a.s.l.	9	Southeast Uttar Pradesh & neighbourhood	Stationary	<i>In situ</i>	Merged with the associated cyclonic circulation of low pressure area over northeast Madhya Pradesh & neighbourhood on 10
7.	Between 1.5 & 2.1 km a.s.l.	10	Southeast Pakistan & adjoining Kutch	Oscillatory	South Pakistan & adjoining west Rajasthan	Became less marked on 14
8.	At 0.9 kms a.s.l.	11	East Assam and neighbourhood	Stationary	<i>In situ</i>	Became less marked on 12
9.	At 5.8 km a.s.l.	13	South Gujarat & neighbourhood	Stationary	Do	Became less marked on 14
10.	Upto 1.5 km a.s.l.	14-20	South Haryana & neighbourhood	West	Southwest Rajasthan & neighbourhood	Became less marked on 21
11.	Between 1.5 & 3.6 kms a.s.l.	14-18	Kutch and adjoining south Pakistan	East	South Gujarat region and neighbourhood	Became less marked on 19
12.	Upto 1.5 km a.s.l.	16-17	Meghalaya & neighbourhood	West	Central parts of Assam & neighbourhood	Became less marked on 18
13.	Upto 1.5 kms a.s.l.	22-23	South Assam & neighbourhood	Stationary	<i>In situ</i>	Became less marked on 24
14.	Between 3.1 & 5.8 km a.s.l.	22-25	Northeast Arabian sea & neighbourhood	West	Northwest Arabian sea & neighbourhood	Merged with the cyclonic circulation over south Pakistan & neighbourhood on 26
15.	Between 1.5 & 2.1 kms a.s.l.	26	Northwest Rajasthan and adjoining areas of Haryana & Punjab	Stationary	<i>In situ</i>	Became less marked on 27

TABLE 6 (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(D) North-south trough/other trough						
1.	Between 5.8 & 7.6 kms a.s.l	5	South Gujarat & neighbourhood to the cyclonic circulation of well-marked low pressure area over northwest Bay of Bengal & adjoining north Odisha-west Bengal coast across south Chhattisgarh, Vidarbha & north Madhya Maharashtra	Stationary	<i>In situ</i>	Became less marked on 6
2.	Between 2.1 & 4.5 kms a.s.l	7-9 (Mrg)	From Cyclonic circulation over Kutch & neighbourhood to Gangetic west Bengal across Madhya Pradesh, north Chhattisgarh & Jharkhand		Northwest Arabian sea off Oman coast to southeast Uttar Pradesh across south Rajasthan & north Madhya Pradesh	Became less marked subsequently
3.	At 3.1 kms a.s.l.	8	Along Long. 90°E to the north of Lat. 20°N	Do	<i>In situ</i>	Became less marked on 9
4.	At 3.1 km above m.s.l.	9	Southeast Rajasthan to the cyclonic circulation associated with low pressure area over northwest Bay of Bengal off north Odisha-Gangetic west Bengal coast	Do	Do	Became less marked on 10
5.	At m.s.l.	9-10	North Karnataka coast to south Kerala coast	Oscillatory	Karnataka coast to Lakshadweep area	Became less marked on 11
6.	Between 1.5 & 2.1 km a.s.l.	11	Southwest Uttar pradesh to south Chhattisgarh across east Madhya pradesh	Stationary	<i>In situ</i>	Became less marked on 12
7.	Upto 3.1 kms a.s.l.	12	North Bihar to westcentral Bay of Bengal across Jharkhand, Gangetic west Bengal & northwest Bay of Bengal	Do	Do	It merged with the low pressure area over northwest Bay of Bengal off north Odisha & west Bengal coast on 13
8.	Upto 1.5 kms a.s.l.	24-31	Rayalaseema to south coastal Tamil Nadu across interior Tamil Nadu		Along Tamil Nadu coast	Became less marked on 1 September
(E) East-west shear zone						
1.	Between 3.1 & 5.8 km a.s.l.	10-11	Along Lat. 21°N across central India	South	Along Lat. 18°N	Became disorganized on 12
2.	Between 5.8 & 7.6 km a.s.l.	14-21	Along Lat. 18°N	Oscillatory	Along Lat. 22°N	Became less marked on 22

TABLE 7

Details of the weather systems during September 2020

S. No.	System	Duration	Place of initial location	Direction of movement	Place of final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A) Well marked low/low pressure area						
1.	Low pressure area	6 (0000 UTC) - 7	Southeast & adjoining eastcentral Arabian sea	North west	Eastcentral Arabian sea off Karnataka coast	It formed under the influence of cyclonic circulation over eastcentral Arabian sea & adjoining southeast Arabian sea off Karnataka & north Kerala coast on 3. Associated cyclonic circulation extended upto 4.5 km a.s.l. It merged with the off shore trough from north Maharashtra coast to Lakshadweep area on 8. However, associated cyclonic circulation became less marked on 16
2.	Well marked low pressure area	15-16	Westcentral Bay of Bengal & adjoining north Andhra Pradesh coast		Telangana & adjoining south Chhattisgarh	It formed under the influence of cyclonic circulation over Westcentral Bay of Bengal off Andhra Pradesh coast on 12. It intensified as a low pressure area on 13 with the associated cyclonic circulation extended upto mid tropospheric levels and again intensified subsequently. It then less marked on 16. However, associated cyclonic circulation over Telangana and neighbourhood became less marked on 19
3.	Low pressure area	20 (0000 UTC) - 26	Northeast Bay of Bengal		East Bihar and neighbourhood	Associated cyclonic circulation extended upto 7.6 kms a.s.l. tilting southwestwards with height. It became less marked on 27 morning. However, associated cyclonic circulation became less marked on 1 October
(B) Western disturbances/eastward moving systems						
(i) Upper air cyclonic circulation						
1.	Between 5.8 & 7.6 kms a.s.l.	25-26	Central Pakistan and neighbourhood	Northeast	North Pakistan & adjoining Jammu - Kashmir and Ladakh	Initially, WD as a cyclonic circulation over Western parts of Afghanistan & neighbourhood with a trough aloft in mid & upper tropospheric westerlies with its axis at 5.8 kms a.s.l. roughly along Long. 62°E to the north of Lat. 30°N on 23 and then it lay as a trough on 24. It moved away northeastwards on 27
2.	Between 3.1 & 3.6 kms a.s.l	28-29	NorthPakistan & neighbourhood	Stationary	<i>In situ</i>	Moved away northeastwards on 30
3.	Between 3.1 & 3.6 kms a.s.l	30	Northwest Afghanistan and neighbourhood	Do	Do	Initially, it lay as a trough in mid & upper tropospheric westerlies ran with its axis at 5.8 km a.s.l. roughly along Long. 60°E to the north of 28°N on 29. Again, it lay as a trough at 5.8 kms a.s.l. roughly along Long. 65°E to the north of 32°N on 1 October and moved away northeastwards on 3 October
(ii) As a trough						
1.	Mid & upper troposphere	5-8	Along Long. 54°E to the north of 30°N	East	Along Long. 69°E to the north of 30°N	It moved away east-northeastwards on 9

TABLE 7 (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.	At 5.8 km a.s.l.	9-11	Along Long. 60°E to the north of 30°N	East	Along Long. 64°E to the north of 28°N	It then lay as a cyclonic circulation over south Afghanistan & neighbourhood between 3.1 & 5.8 km a.s.l. on 12 & became less marked on 15
3.	At 5.8 km a.s.l.	14-15	Along Long. 60°E to the north of 28°N	East	Along Long. 63°E to the north of 32°N	It moved away northeastwards on 16
4.	Between 3.1 & 5.8 km a.s.l.	16-17	Along Long. 87°E to the north of 25°N	Stationary	<i>In situ</i>	It became Less marked on 18
5.	At 5.8 km a.s.l.	16-20	Along Long. 55°E to the north of 32°N	East	Along Long. 75°E to the north of 32°N	It moved away northeastwards on 21
(C) Other upper air cyclonic circulations						
1.	Upto 0.9 km a.s.l.	1-3	Gangetic west Bengal and neighbourhood	West	North Chhattisgarh and neighbourhood	It became Less marked on 4
2.	Between 1.5 & 3.6 kms a.s.l.	1-2	South Assam & neighbourhood	East	East Assam and neighbourhood	It became Less marked on 3
3.	Upto 2.1 kms a.s.l	2	Westcentral Bay of Bengal off coastal Andhra Pradesh & north Tamil Nadu coasts	Stationary	<i>In situ</i>	It became Less marked on 3
4.	Upto 2.1 kms a.s.l	3-7	Northwest Madhya Pradesh & neighbourhood	West	Northeast Rajasthan and neighbourhood	It merged with the trough ran from northwest Uttar Pradesh to central parts of east Rajasthan on 8
5.	Between 3.1 & 4.5 kms a.s.l.	3	South Chhattisgarh and neighbourhood	Stationary	<i>In situ</i>	It became Less marked on 4
6.	Between 1.5 & 3.1 kms a.s.l.	4	Bihar and adjoining east Uttar Pradesh	Do	Do	It became Less marked on 5
7.	At 3.1 kms a.s.l.	4	South Rajasthan and adjoining Gujarat	Do	Do	It became Less marked on 5
8.	Upto 0.9 kms a.s.l	6-7	East Assam & neighbourhood	Do	Do	It became Less marked on 8
9.	At 1.5 kms a.s.l.	7	Northwest Uttar Pradesh & neighbourhood	Do	Do	It merged with the trough ran from northwest Uttar Pradesh to central parts of east Rajasthan on 8
10.	At 0.9 kms a.s.l.	8	West Assam and adjoining Sub-Himalayan west Bengal & Sikkim	Do	Do	It became Less marked on 9
11.	At 1.5 kms a.s.l.	8	Westcentral Bay of Bengal off Andhra Pradesh coast	Do	Do	It became less marked on 9
12.	Between 1.5 & 3.6 kms a.s.l.	9	Jammu region & neighbourhood	Do	Do	It became less marked on 10
13.	Upto 2.1 km a.s.l.	9-10	Gangetic west Bengal & neighbourhood	Do	Do	It became less marked on 11
14.	Between 3.1 km & 3.6 km a.s.l.	12	Jammu-Kashmir and Ladakh & neighbourhood	Do	Do	It moved away northeastwards on 13
15.	Upto 0.9 km a.s.l.	14	East Vidarbha & adjoining south Chhattisgarh	Do	Do	Became less marked on 15
16.	Upto 0.9 km a.s.l.	14-16	Southwest Uttar Pradesh and neighbourhood	West	Central parts of Rajasthan and neighbourhood	It became less marked on 17

TABLE 7 (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
17.	At 1.5 km a.s.l.	15	South Gujarat region and neighbourhood	Stationary	<i>In situ</i>	It became less marked on 16
18.	At 7.6 km a.s.l.	17-18	Southwest Bay of Bengal off north Tamil Nadu coast	Do	Do	It merged with the shear zone which ran roughly along Lat. 16°N on 19
19.	Between 5.8 & 7.6 km a.s.l.	17-18	Sub Himalayan west Bengal & neighbourhood	Do	Do	It became less marked on 19
20.	Between 3.1 & 3.6 km a.s.l.	17	North coastal Andhra Pradesh & neighbourhood	Do	Do	It merged with the shear zone which ran roughly along Lat. 16°N on 18
21.	At 1.5 km a.s.l.	18-19	Westcentral Bay of Bengal off north Andhra Pradesh-south Odisha coast	West	North coastal Andhra Pradesh and neighbourhood	Became less marked on 20
22.	Upto 0.9 km a.s.l.	21-23	North Maharashtra coast and neighbourhood	West	North Konkan and neighbourhood	Became less marked on 22
23.	At 1.5 km a.s.l.	22-24	Northwest Rajasthan and adjoining Punjab	East	Northeast Rajasthan	Became less marked on 25
24.	At 3.1 km a.s.l.	25-28	Southwest Rajasthan & neighbourhood	Do	South Rajasthan and neighbourhood	Became less marked on 29
25.	At 5.8 km a.s.l.	27-28	South Andhra Pradesh & neighbourhood	Stationary	<i>In situ</i>	Merged with the cyclonic circulation over westcentral Bay of Bengal off Andhra Pradesh coast on 29
26.	At 3.1 kms a.s.l.	28	Northwest Uttar Pradesh and neighbourhood	Do	Do	Became less marked on 29
27.	Upto 5.8 km a.s.l.	28-29	Gulf of Thailand and neighbourhood	West	Arakan coast and neighbourhood	Became less marked on 30
28.	Upto 1.5 km a.s.l.	29	East Assam & neighbourhood	Stationary	<i>In situ</i>	Became less marked on 30
29.	Upto 1.5 km a.s.l.	29	North interior Odisha & neighbourhood	Do	Do	Became less marked on 30
30.	Between 2.1 & 5.8 km a.s.l.	29 Sep-04 Oct	South Gujarat & neighbourhood		Eastcentral Arabian sea & adjoining south Maharashtra coast	Became less marked on 5 October
31.	Between 1.5 & 7.6 km a.s.l.	29-30	Westcentral Bay of Bengal off Andhra Pradesh coast		Westcentral & Adjoining Northwest Bay off Bengal off North Andhra Pradesh-south Odisha coast	Under its influence, a low pressure area formed over same region on 1 October
32.	At 3.1 km a.s.l.	5-12	Along Lat. 10°N across the cyclonic circulation over southeast & adjoining eastcentral Arabian sea	North	Along Lat. 15°N across Peninsular India	Became less marked on 13
33.	between 3.1 & 5.8 km a.s.l.	15-21	Along Lat. 15°N	Do	Along Lat. 17°N	It became less marked on 22
(D) North-south trough/other trough						
1.	At 3.1 km a.s.l.	4	North Odisha to the cyclonic circulation over Bihar & adjoining east Uttar Pradesh	Stationary	<i>In situ</i>	Became less marked on 5

TABLE 7 (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.	At 3.1 km a.s.l.	5-6	Northwest Uttar Pradesh to Jammu region across north Haryana & southern parts of Himachal Pradesh	Oscillatory	Cyclonic circulation over northeast Rajasthan and neighbourhood to Jammu region across Haryana & Punjab	Became less marked on 7
3.	Upto 3.6 km a.s.l.	8-11	Northwest Uttar Pradesh to central parts of east Rajasthan	Oscillatory	Bihar to south Chhattisgarh across Jharkhand	Became less marked on 12
4.	At m.s.l.	8-14	North Maharashtra coast to Lakshadweep area	Oscillatory	South Gujarat coast to north Karnataka coast	Became less marked on 15
5.	Upto 2.1 km a.s.l.	13	Southwest Uttar Pradesh to the cyclonic circulation over northeast Arabian sea & adjoining south Gujarat coast across east Rajasthan	Stationary	<i>In situ</i>	Became less marked on 14
6.	Between 1.5 & 5.8 km a.s.l.	15	From the low pressure area over westcentral Bay of Bengal & adjoining north Andhra Pradesh coast to the cyclonic circulation over south Gujarat region across Telangana, Marathwada & north Madhya Maharashtra	Stationary	Do	Became less marked on 14
7.	At 0.9 km a.s.l.	16-18	Northeast Uttar Pradesh to southwest Madhya Pradesh	Oscillatory	Bihar to south interior Odisha across Jharkhand	It the lay as a cyclonic circulation over north interior Odisha & neighbourhood on 19 which became less marked on 20
8.	Between 3.1 & 5.8 km a.s.l.	22-28	Sub Himalayan west Bengal with embedded cyclonic circulation associated with low pressure area over north Chhattisgarh & neighbourhood to south Maharashtra	Do	Cyclonic circulation over east Bihar and adjoining sub Himalayan west Bengal & Sikkim to westcentral Bay of Bengal off Andhra Pradesh coast across Gangetic west Bengal & coastal Odisha	Became less marked on 29
9.	At 0.9 km a.s.l.	25	Madhya Maharashtra to Comorin area across interior Karnataka & Kerala	Stationary	<i>In situ</i>	Became less marked on 26
10.	At 3.1 km a.s.l.	26	South Chhattisgarh to south interior Karnataka across Telangana & Rayalaseema	Stationary	Do	Became less marked on 27

2.4. Withdrawal of southwest Monsoon

Fig. 7 shows the isochrones of withdrawal of southwest monsoon.

The formation of two low pressure areas in the month of September led to an active monsoon trough

which delayed the withdrawal of monsoon which commenced on 28th September from some parts of west Rajasthan and Punjab, against its normal date of 17th September with the establishment of an anticyclonic circulation in the lower tropospheric levels over western parts of northwest India and substantial reduction in moisture content and rainfall. A further change in the low

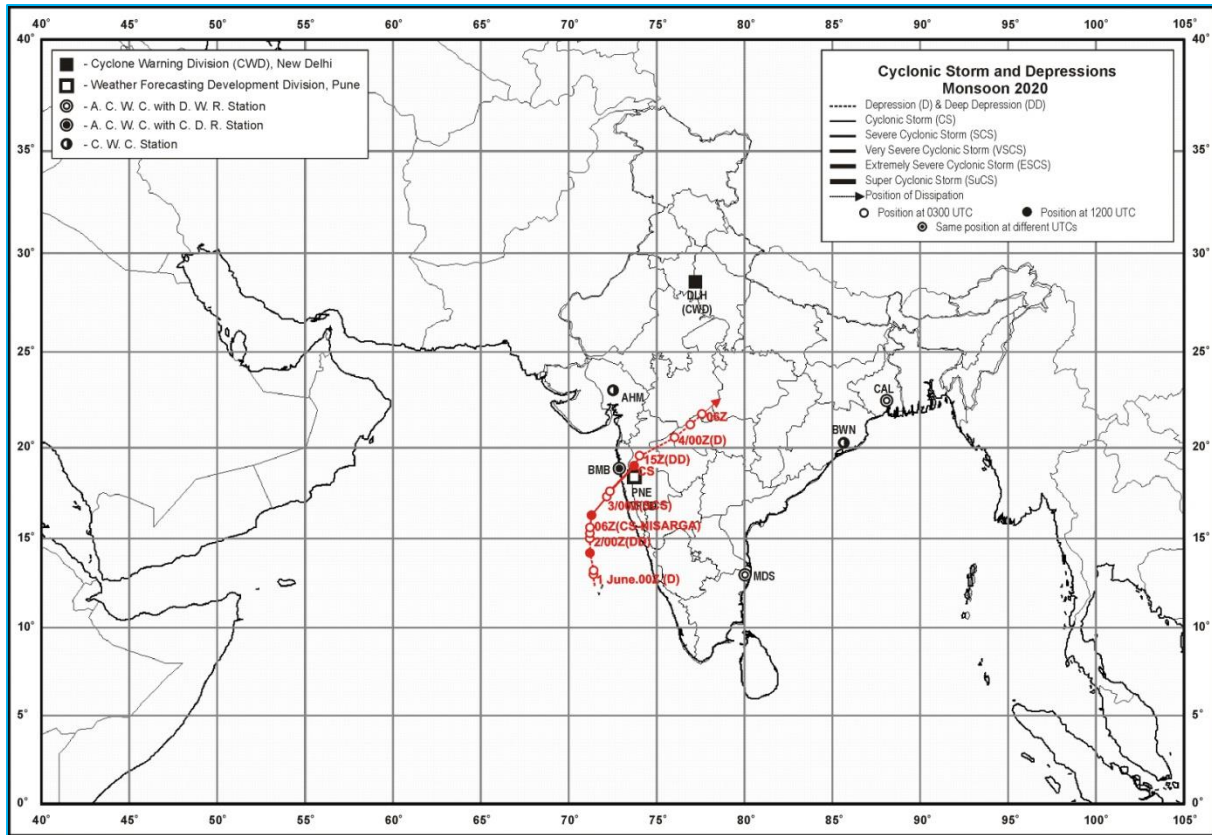


Fig. 8. Tracks of the intense low pressure systems during SW Monsoon 2020

level wind pattern into north westerlies, reduction in moisture content and cessation of rainfall over northwest India, led to the withdrawal of southwest monsoon from some more parts of Rajasthan, remaining parts of Punjab, entire Western Himalayan region, Haryana, Chandigarh, Delhi and some parts of Uttar Pradesh on 30th September. It then withdrew from most parts of Rajasthan, some more parts of Uttar Pradesh and some parts of north west Madhya Pradesh on 3rd October and from remaining parts of Rajasthan, some more parts of Uttar Pradesh and Madhya Pradesh, most parts of Gujarat State and some parts of North Arabian Sea on 6 October. There was a hiatus in further withdrawal of southwest monsoon from 7th to 20th October with the formation and passage of deep depression (11-14 October) through north peninsular India. The remnant of this deep depression emerged into east central Arabian Sea and intensified into depression over Arabian sea (17-19 Oct) and then monsoon withdrew from most parts of central India on 21st October, further withdrawal was delayed by formation of another depression over Bay of Bengal (22-24 Oct). After the passage of this system the southwest monsoon withdrew from some more parts of Gangetic West Bengal, most parts of Jharkhand, some parts of Odisha, most parts of Chhattisgarh, entire Vidarbha, remaining parts of Madhya

Pradesh and Gujarat state, some parts of Marathwada and Madhya Maharashtra on 26th, remaining parts of Chhattisgarh, some parts of coastal Andhra Pradesh, most parts of Telangana, entire Maharashtra, most parts of north interior Karnataka and north Arabian Sea on 27th. Further in view of significant reduction in rainfall activity over most parts of the country, it withdrew from the entire country on 28 October making it the second most delayed withdrawal from the country.

3. Chief synoptic features of southwest Monsoon 2020

The synoptic features which affected the Indian monsoon region during June, July, August and September are given in Tables 4 to 7, respectively.

The first low pressure system of the season 2020; the severe cyclonic storm, "NISARGA" originated from a low pressure area which formed over southeast and adjoining east central Arabian sea and Lakshadweep area in the early morning of 31 May. It concentrated into a depression over east central and adjoining Southeast Arabian Sea in the early morning of 1 June. It intensified further into a deep depression over east central Arabian

Sea in the early morning and into a cyclonic storm, "NISARGA" in the noon of 2 June. It moved northwards till evening of 2 June and gradually recurved northeastwards and intensified into a severe cyclonic storm in the early morning of 3 June. Continuing to move northeastwards, it crossed Maharashtra coast close to south of Alibag as a severe cyclonic storm during the afternoon of 3 June. Continuing to move northeastwards after landfall, it weakened into a cyclonic storm in the evening over north Madhya Maharashtra and into a deep depression in the midnight of 3rd June over the same region. It further weakened into a depression over western parts of Vidarbha and neighbourhood in the early morning and into a wellmarked low pressure over central parts of Madhya Pradesh in the evening of 4 June. It weakened further into a low pressure area over southeast Uttar Pradesh and adjoining Bihar in the afternoon of 5 June. The track of severe cyclonic Storm, "NISARGA" formed during monsoon season is given in Fig. 8. During the month of June, apart from the above system, a low pressure area formed over west central Bay of Bengal (9-12 June) and its associated cyclonic circulation strengthened the monsoon flow. Cyclonic vortices at upper levels off both the coasts, over central and north India, east-west shear zone across peninsular India, an east-west trough at mean sea level extending upto lower tropospheric levels with cyclonic circulations embedded in it were also observed. All these systems caused fairly widespread to widespread rainfall activity over most parts of the country and thus supported the advance of monsoon over the country. Towards the end of the month, the monsoon trough shifted northwards with its eastern part close to the foot hills of Himalayas during 27 June - 2 July.

During the month of July, many unfavorable features of monsoon appeared resulting in deficient rainfall over the country. However, in the first week of July, with the formation of two low pressure areas; one over coastal Saurashtra and neighbourhood (5 -12 July) and the other over northwest Bay of Bengal off Odisha-Gangetic West Bengal coast (5-6 July) and their associated cyclonic circulations tilting southwards with height, monsoon trough was observed in its normal/south of its normal position during 3-8 July. The low-pressure area which formed over coastal Saurashtra and neighbourhood, became well marked on 6 July over Kutch and neighbourhood. In addition to this low pressure area, an offshore trough, a shear zone along 16°N and the monsoon trough to the south of its normal position resulted in widespread rainfall activity over Gujarat State and over coastal and interior parts of Maharashtra and the other low pressure area over Bay of Bengal caused widespread rainfall activity over eastern parts of India. During the subsequent three weeks of July, an off-shore

trough along south Maharashtra and Kerala coasts, cyclonic vortices over north Konkan coast and eastwest shear zone across peninsular India caused widespread / fairly widespread rainfall with heavy to very heavy rainfall activity along the west coast and adjoining interior parts of peninsular India. In the same period, the interactions of the eastern end of monsoon trough (which lay north / close to foot hills of Himalayas) with the cyclonic circulations and convergence of strong southwesterly to southerly winds from Bay of Bengal over east and northeast India triggered monsoon activity over northeast and adjoining east India. The interaction of western end of monsoon trough with the systems in westerlies, circulations in the lower tropospheric levels and moisture incursions from the Arabian Sea caused widespread / fairly widespread rainfall with heavy rainfall over western Himalayan region, plains of northwest India and adjoining central and west India during third and fourth week of the month. Thus, in association with absence of low pressure systems over the Bay of Bengal, shifting of monsoon trough to the foothills on many days and unfavourable conditions, the monsoon rainfall was deficient in July over northwest and central India. At the same time, it caused flood over northeastern states, Bihar and East Uttar Pradesh on a few occasions.

As the MJO moved eastwards over the Indian seas, the Arabian Sea and Bay of Bengal became convectively active in August. The formation of five low pressure systems over the north Bay of Bengal in succession out of which four of them became well marked (4-10, 9-11, 13-18, 19-26 and 24-31 August) and their westnorthwestward movement across central India upto Gujarat and south Rajasthan, active MJO, active monsoon trough mostly south of its normal position and stronger winds reaching up to 50-60 kmph in lower levels over Arabian sea during a few days in the month led to active monsoon conditions over most parts of the country and caused significantly higher than normal rainfall over central and western parts of India during the month of August. During the month, strengthening of the monsoon flow in the Arabian Sea, led to convergence of strong low level westerlies along the west coast. Also, the presence of cyclonic vortices, offshore trough, east-west shear zone over peninsular India caused widespread rainfall / thundershowers along the west coast, over parts of peninsular India, Gujarat State, Konkan, Goa and Madhya Maharashtra. System in westerlies and convergence of moist low level winds from Arabian Sea, cyclonic circulations over northwest India and presence of strong easterlies due to the presence of low pressure systems caused scattered to fairly widespread rainfall / thunderstorms over western Himalayan region and adjoining parts of northwest India during the month. The active monsoon conditions consecutively for 4 weeks led

TABLE 8

Representative amounts of rainfall in cm for June, July, August and September 2020 (21cm and above)

Date	Some representative amounts of rainfall in cm for June, July, August September 2020 (21 cm and above)
6 Jun	Mawsynram 28
6 Jun	Alipurduar Cwc and Alipurduar PTO 24 each
13 Jun	Vaibhavwadi 23, Sawantwadi 21
16 Jun	Mawsynram 25
16 Jun	Falakata 22
17 Jun	Basti Cwc 33
17 Jun	Korba 25
18 Jun	Mawsynram 37, Cherrapunji (Rkm) 27, Cherrapunji 24, Williamnagar 23
22 Jun	Vadakara 25
23 Jun	Bagbahara 21
24 Jun	Mawsynram and Cherrapunji 36 each, Cherrapunji (Rkm) 27
25 Jun	Mawsynram 29, Dholla Bazar 24, Cherrapunji 21
25 Jun	Alipurduar Cwc and Alipurduar PTO 29 each, Cooch Behar 26, Barobhisha 25
26 Jun	Cherrapunji (Rkm) 38, Cherrapunji and Mawsynram 33 each
26 Jun	Sankalan 167
27 Jun	Roing 21
27 Jun	Mawsynram 66, Cherrapunji (Rkm) 55, Cherrapunji 49, Manash Nh Xing 27, Aie Nh Xing 26, Hazuah and Drf 24 each, Kokrajhar 23, Goibargaon, Gossaigaon and Panbari 22 each, Khliehriat 21
27 Jun	Mangan 25, Sankalan 23, Singhik and Alipurduar PTO 21 each
28 Jun	Cherrapunji 57, Cherrapunji (Rkm) 55, Khliehriat 24
28 Jun	Dhengbridge 21
2 Jul	Williamnagar 23
2 Jul	Alipurduar Cwc and Alipurduar PTO 31 each, Amfu Pundibari 25
4 Jul	Mawsynram 43
5 Jul	Mawsynram 55
5 Jul	Kessariah 25
5 Jul	Thane 38 Mandangad 25, Shriwardhan 23, Mhasla, Uran, Panvelagri and Matheran 21 each
6 Jul	Khambhalia 49, Kalyanpur 35, Porbandar AP 29, Okha and Dwarka 28 each, Ranavav 27, Kutiana 21
6 Jul	Belapur (Thane) 21
7 Jul	Elgin Bridge 22
7 Jul	Kalavad 39, Jamnagar IAF 24, Khambhalia and Paddhari 23 each, Lalpur and Rajkot 22 each, Dhrol 21
8 Jul	Okha 48, Khambhalia 30, Kalyanpur 29, Dwarka 22, Bhanvad 21
8 Jul	Castle Rock 28
8 Jul	Agumbe 22
9 Jul	Mawsynram 31, Cherrapunji 23
10 Jul	Passighat 30, Roing 21
10 Jul	Cherrapunji 55, Mawsynram 48, Cherrapunji (Rkm) 44, Khliehriat 22
11 Jul	Cherrapunji (Rkm) 55, Cherrapunji 52, Mawsynram 47, Khliehriat 23
11 Jul	Buxaduar 22

TABLE 8 (Contd.)

Date	Some representative amounts of rainfall in cm for June, July, August and September 2020 (21 cm and above)
12 Jul	Cherrapunji 27, Mawsynram, Khliehriat and Williamnagar 23 each, Cherrapunji (Rkm) 22
12 Jul	Gajoldoba 46, Alipurduar Cwc and Alipurduar PTO 35 each, Baghdogra AP and Neora 24 each, Chepan 23, Barobhisha, Murti and Amfu Pundibari 21 each
13 Jul	Birpur 26
18 Jul	Chepan 23
19 Jul	Mawsynram 39, Cherrapunji (Rkm) 34, Cherrapunji 29, Kokrajhar 26, Aie Nh Xing 23
20 Jul	Cherrapunji (Rkm) 40, Cherrapunji 33, Mawsynram 21
20 Jul	Ramnagar 29, Chanpatia 25, Jhanjharpur and Sursand 22 each, Kamtaul and Sheohar 21 each
21 Jul	Mawsynram 45, Cherrapunji (Rkm) 43, Cherrapunji 39, Khliehriat 27
21 Jul	Alipurduar Cwc and Alipurduar PTO 29 each, Amfu Pundibari 24
22 Jul	Mawsynram 22
22 Jul	Nh31 Bridge 22, Buxaduar 21
25 Jul	Ghumarwin 23
26 Jul	Umerpada 21
28 Jul	Bagrakote 23
29 Jul	Kapkot 31
29 Jul	Baderajpur 23
30 Jul	Beki Mathungari and Mawsynram 21 each
30 Jul	Falakata 22
31 Jul	Beki Mathungari 22
31 Jul	Barobhisha 22
4 Aug	Mumbai (SCZ) 27, Mumbai (Colaba) 25
4 Aug	Hosanagar 21
5 Aug	Jujumura 29, Nimpara 23
5 Aug	Madhbun and Khanvel 39 each, Umergam 36, Vapi 24, Silvassa 23
5 Aug	Palgharagri 46, Talasari 39, Dahanu 38, Mangaon 33, Dodamarg 28, Tala 27, Pernem and Rajapur 25 each, Vaibhavwadi 24, Sangameshwar Devrukh and Bhira 23 each, Vasai and Ratnagiri 22 each, Roha and Poladpur 21 each
5 Aug	Mahabaleshwar* 32, Gaganbawada 31
5 Aug	Kottigehara 31, Medikeri 23, Hosanagar 22, Agumbe 21
6 Aug	Mumbai (Colaba) 33, Uran 32, Roha 30, Bhira 29, Palgharagri 26, Matheran, Shriwardhan and Tala 24 each, Mandangad 23, Mangaon, Pen and Panvelagri 22 each, Murud and Sudhagad Pali 21 each
6 Aug	Radhanagari 23, Gaganbawada 21
6 Aug	G Bazar 33, Naduvattam 23, Devala 22
6 Aug	Bhagamandala 49, Kottigehara 39, Kalasa 27
7 Aug	Devala 36, G Bazar 35, Chinnakalar 31, Valparai Taluk Office 23, Naduvattam 22
7 Aug	Bhagamandala 40, Kottigehara 36, Medikeri and Kammardi 23 each, Murnadu 22, Mudigere 21
7 Aug	Peermade To 26, Munnar KSEB and Idukki 23 each, Mananthavady 21
8 Aug	Devala 34
8 Aug	Agumbe 22, Bhagamandala 21
8 Aug	Vadakara 33
9 Aug	Haldwani 21

TABLE 8 (Contd.)

Date	Some representative amounts of rainfall in cm for June, July, August and September 2020 (21 cm and above)
10 Aug	Gurur 23, Dhamtari 21
12 Aug	Bhalukpong 22
12 Aug	Mawsynram 22
12 Aug	Elgin Bridge 22
13 Aug	Elgin Bridge 23
13 Aug	Ghumarwin 27
13 Aug	Mandvi and Ukai 21 each
14 Aug	Udaipura 22
14 Aug	Anand 32, Umerpada 30, Vallabh Vidyanagar 21
14 Aug	Lakhtar 22
15 Aug	Chandikhola 34, Binjharpur and Jajpur 32 each, Bari 30, Dhamnagar 26, Mahanga 24, Bhuban 23, Akhuapada 21
15 Aug	Jamwaramgarh 25
15 Aug	Nallabelly 27, Shayampet 23, Atmakurwrgl, Hanamkonda and Hasanparthy 21 each
16 Aug	Padampur 24
16 Aug	Sama 27
16 Aug	Mahabaleshwar* 21
16 Aug	Bhopalpatnam 32, Bijapur 23, Bhairamgarh 22
16 Aug	Venkatapuram 23
16 Aug	Castle Rock 24
17 Aug	Mawsynram 21
17 Aug	Mahabaleshwar* 21
17 Aug	Kollur 21
17 Aug	Hosanagar 23
18 Aug	Mandvi 25
18 Aug	Matheran 21
19 Aug	Barhi 22
20 Aug	Salepur and Nischintakoili 30 each, Nawarangpur 24
20 Aug	Bijnor 25
20 Aug	Bhairamgarh 23, Darbha 21
21 Aug	Sakoli 25
22 Aug	Loharia 21
22 Aug	Sehore - AWS 32, Hatpiplaya 27, Indore and Goharganj 26 each, Ichhawar 25, Ashta -Arg and Badnagar 24 each, Khategaon and Badnawar 23 each, Arerahills, Kalapipal, Bhopal and Rehti 21 each
23 Aug	Bhungra 36, Ghatol 30, Pipalkhunt 28, Kesarpura 27, Jagpura 26
23 Aug	Bajna 27, Gulana 26, Moman Badodiya 25, Sarangpur 22
24 Aug	Kadi 33, Umerpada 26, Becharaji 22, Saraswati 21
24 Aug	Jodia 34, Tankara 27, Morbi 25
25 Aug	Abdasa 23, Naliya 22
26 Aug	Marsaghai and Tensa 23 each, Boudhgarh and Baripada 21 each
27 Aug	Telkoi, Laikera and Kirmira 21 each

TABLE 8 (Contd.)

Date	Some representative amounts of rainfall in cm for June, July, August and September 2020 (21 cm and above)
28 Aug	Narsingpur 30
28 Aug	Akaltara 28, Pusaur 27, Pamgarh 26, Sakti 24, Champa 23, Masturi 22, Janjgir and Baloda 21 each
29 Aug	Sohagpur 24, Pachmarhi 23, Timarni 22, Hoshangabad 21
29 Aug	Chauri 41, Parasia 33, Harrai 31, Umreth 30, Mohkheda 29, Amarwara 27, Chindwara 24, Seoni and Sausar 21 each
30 Aug	Alipurduar Cwc and Alipurduar PTO 23 each
30 Aug	Aspur 36
30 Aug	Hoshangabad 34, Budhni 28, Ichhawar and Rehti 27 each, Mahidpur 26, Jawar 23, Barod 22, Nusrulgunj - Arg and Sonkatch 21 each
30 Aug	Abdasa 21
31 Aug	Shergarh 23
31 Aug	Jamjodhpur 24, Khambhalia 21
7 Sep	Kollur 24
8 Sep	Aie Nh Xing 24, Barpeta and Panbari 21 each
9 Sep	Sevoke 21
10 Sep	Devala 21
11 Sep	Mathabhanga 23, Nh31 Bridge 22
11 Sep	Mulki 30, Mangalooru AP 26, Panambur 23
12 Sep	Kollur 22
15 Sep	Alipurduar Cwc and Alipurduar PTO 29 each, Cooch Behar 23
16 Sep	Cherrapunji 25
17 Sep	Mawsynram 42, Cherrapunji (Rkm) 21
18 Sep	Gaunaha 21
18 Sep	Umerpada 27
20 Sep	Brahmavar AWS 39, Karkala 28, Mulki and Udupi 27 each, Mangalooru AP 22
20 Sep	Agumbe 22
20 Sep	Vadakara 21
21 Sep	Kollur 24, Ankola 22, Castle Rock and Manki 21 each
21 Sep	Agumbe 27, Kottigehara 21
22 Sep	Mawsynram 24
22 Sep	Vengurla 26, Malvan 25, Rameshwaragri 24
23 Sep	Kumargram 25
23 Sep	Panvelagri 31, Mumbai (SCZ) 29
24 Sep	Mawsynram 51, Cherrapunji 27, Cherrapunji (Rkm) 25, Khliehriat 24
24 Sep	Forbesganj 23
24 Sep	Azamgarh 30, Bansi Tehsil 26
25 Sep	Mawsynram 45, Cherrapunji and Cherrapunji (Rkm) 42 each, Nongstein 32, Shillong 25, Khliehriat 23, Shillong AWS 21
25 Sep	Hathwa 27, Bhore 24, Tribeni / Balmikinagar 23, Forbesganj 22
25 Sep	Basti Cwc 29, Chanderdeepghat 23
26 Sep	Khliehriat 36, Nongstein and Cherrapunji (Rkm) 24 each, Mawsynram 23
27 Sep	Khliehriat 27, Cherrapunji (Rkm) 23
27 Sep	Amfu Pundibari 26, Mathabhanga 25, Cooch Behar 21

to excess rainfall activity over the country. Fairly widespread to widespread rainfall / thunderstorms over parts of Northeast and adjoining parts of east India with heavy to very heavy rainfall was also observed during the first, second and the last week of August due to the convergence of moist southwesterlies to southerlies from the Bay of Bengal and presence of cyclonic vortices in the lower levels. A weak MJO re-entered eastern Indian Ocean in late August and propagated eastwards into maritime continent with weak amplitude by the end of monsoon season. From the last week of August till the formation of a low pressure area off north Andhra coast on 13 September, either the western or the eastern end of monsoon trough remained north of its normal position or close to foot hills of Himalayas. The low pressure area which formed on 13 September subsequently became well marked low and dissipated over Telangana and adjoining south Chhattisgarh. It triggered monsoon activity over Central and Peninsular India. After the dissipation of the low pressure area on 16, the monsoon trough lay north of its normal position and regained its near-normal position with the formation of another low pressure system on 20 September over Northeast Bay of Bengal and neighbourhood. This low pressure system dissipated over east Bihar and neighbourhood on 26 September. East Uttar Pradesh, Bihar and Sub Himalayan West Bengal experienced widespread rainfall/thunderstorms due to this system. The monsoon trough became disorganized on 28 September. Apart from the above two low pressure systems in the month, another low-pressure system (6-8 September) formed over southeast and adjoining east central Arabian sea and in conjunction with an east-west shear zone over south peninsula caused widespread rainfall activity over south peninsular India, Lakshadweep area and coastal and interior parts of Maharashtra during the first week of the month. Circulation features favoring convergence of strong moist winds from the Bay of Bengal in the lower tropospheric levels and the alignment of monsoon trough over northeast India and adjoining east India continued to trigger the monsoon activity over the region during the month.

4. Extra Indian features

4.1. Cross Equatorial Flow

4.1.1. Over the Arabian Sea

The cross equatorial flow along the equatorial belt (equator to 5 °N / 5 °S) over Arabian Sea was : June 2020, it was above normal in 1st, 2nd and 3rd week, it was normal in 4th week.

July 2020, it was above normal in 4th week and normal in 1st, 2nd and 3rd week.

August 2020, it was above normal in 2nd and 4th week, it was below normal in 3rd week and normal in 1st week.

September 2020, it was above normal in 1st, 2nd, 3rd and 4th week.

The surface winds over Arabian Sea to the north of 5 °N were:

June 2020, it was below normal in 1st and 4th week, it was normal in 2nd and 3rd week.

July 2020, it was below normal in 1st, 2nd, 3rd and 4th week.

August 2020, it was above normal in 4th week, it was below normal in 1st and 3rd week and normal in 2nd week.

September 2020, It was above normal in 1st, 2nd, 3rd, 4th week.

4.1.2. Over the Bay of Bengal

The Cross Equatorial flow along the equatorial belt (equator to 5 °N / 5 °S) over Bay of Bengal was:

June 2020 : it was above normal in 1st, 2nd, 3rd week, it was below normal in 4th week.

July 2020 : it was above normal in 1st, 2nd and 4th week, it was normal in 3rd week.

August 2020 : it was above normal in 1st, 2nd and 4th week, it was normal in 3rd week.

September 2020 : It was above normal in 1st, 2nd, 4th week, it was normal in 3rd week.

The surface winds over the Bay of Bengal to the north of 5 °N were:

June 2020 : it was above normal in 1st, it was normal in 2nd, 3rd, 4th week.

July 2020 : it was above normal in 1st, 4th week, it was normal in 2nd, 3rd week.

August 2020 : it was above normal in 1st, 2nd, 3rd and 4th week.

September 2020 : it was above normal in 1st, 3rd, 4th week, it was normal in 2nd week.

Position of Equatorial Trough was:

Jun 2020 : North of its normal position by 1° - 2° , from 40° E to 67° E and from 70° E to 100° E in the 1st week. South of its normal position by 2° - 3° from 40° E to 75° E and from 85° E to 100° E in 2nd week. South of its normal position by 2° - 5° from 50° E to 70° E and North of its normal position by 1° - 2° from 70° E to 100° E in 3rd week. South of its normal position by 1° - 3° from 40° E to 80° E and from 90° E to 110° E in 4th week.

Jul 2020 : South of its normal position by 1° - 6° , from 20° E to 65° E and from 80° E to 110° E in the first week. South of its normal position by 1° - 3° from 40° E to 110° E and in 2nd week. South of its normal position by 1° - 8° from 40° E to 110° E in 3rd week. South of its normal position by 1° - 10° from 40° E to 110° E in 4th week.

Aug 2020 : South of its normal position by 1° - 7° , from 40° E to 110° E in the 1st week. South of its normal position by 1° - 5° from 40° E to 110° E in the 2nd week. In the third week it was close to the normal position. South of its normal position by 1° - 6° from 40° E to 110° E in 4th week.

Sep 2020 : South of its normal position by 1° - 9° , from 40° E to 110° E in the 1st week. South of its normal position by 1° - 2° from 40° E to 110° E in the 2nd week. South of its normal position by 1° - 7° from 40° E to 110° E in 3rd week and 4th week.

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

There were, in all, 16 low pressure systems (reaching the intensity of Tropical depression and above) in the northwest Pacific Ocean / South China Sea during June - September 2020.

4.3. *Troughs in mid and 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 are 5 in June, 6 in July, 4 in August and 7 in September at 500 hPa and 4 in June and September each, 3 in August and July each, 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 to September 2019 are 6 in June and July each, 7 in August and 5 in September at 500 hPa and 5 in June, 6 in July, 2 in August and 3 in September at 300 hPa.

4.5. *Systems in southern hemisphere*

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

No low pressure system (TD, TS or Typhoon) was reported in Southern Hemisphere during June-September 2020.

4.5.2. *Mascarene High*

The Mascarene High (MH) is a high-pressure area centered at 30° S / 50° E off the coast of Madagascar near the Mascarene Islands in the Southern Indian Ocean (SIO). Short period variation in the intensity of the MH is dominated by the passage of the extra-tropical waves in SIO (Sikka and Gray, 1981). The intensification of Mascarene High strengthens the cross equatorial flow in the form of Low-Level Jet and the corresponding monsoon current over the Arabian Sea. The pressure in the Mascarene High was above normal by an average of about 2.4 hPa during the entire monsoon period. It was above normal by 4.2, 2.2, 0.2 and 3 hPa in the month of June, July, August and September respectively.

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 last week of August and became less marked in the last week of September.

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

Jun : 998 hPa (on 06) and 996 hPa (on 16-20, 28-29)

Jul : 994 hPa (on 5, 11-12, 16, 20-21) and 996 hPa (12-15, 30)

Aug : 992 hPa (on 4-6, 2, 6, 7, 11) and 994 hPa (on 3, 13-17, 19), 1000 hPa (28-31)

Sep : 1000 hPa (11).

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 till 25th June. With the southwest monsoon covering the entire country, it got established as the monsoon trough north of its normal position on 26th June. It oscillated between foothills to south of normal position throughout the month of July. The trough remained to the normal position for most of the days till last week of August and near foothills for many days in the month of September.

The monsoon trough got disorganized and disappeared from the pressure & wind field from 28th September.

5.3. Tibetan Anticyclone/High

This year, the Tibetan anticyclone was seen to either south to east-southeast of its normal position upto mid-June. Then it was seen to the east / east-southeast of normal and got established in its near normal position on 6th July. Almost all through the months of July, it remained either to the north, east or west of normal position and till mid-August, it remained to the normal or to the south of normal position. In September, it remained to east or southeast on most of the days. It then shifted south-eastwards thus becoming un-important in the third week of October.

5.4. Tropical Easterly Jet (TEJ)

The TEJ got established over the southern tip of Peninsular India by 28th May with Minicoy reporting easterlies of 64 kts at 72 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 130 kts at 110 hPa was reported at Bengaluru on 11th July.

Apart from Thiruvananthapuram, Chennai, Aminidivi, Minicoy, Karaikal, Mangaluru and Port Blair, Jet speed winds were reported over Bengaluru, Hyderabad, Machilipatnam, Karaikal and Vishakhapatnam on a few days during the season.

5.5. Sub-Tropical Westerly Jet (STWJ)

Shifted northwards from the last week of May. New Delhi reported 67 knots wind (at 154 hPa) at 0000 UTC of 29 June. Subsequently, the core of STWJ shifted to the north of the Himalayas. However, it was not observed over Indian latitude from 11 June. It made occasional re-appearances along the latitude of Srinagar. In the last week of September, it once again shifted southwards as evident by the 98 knots westerly wind reported over Srinagar at 164 hPa on 2 October (0000 UTC).

6. Other features

6.1. Monthly wind anomalies during Southwest Monsoon 2020

The 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, two anomalous cyclonic circulations were seen at 850 hPa, one over Maharashtra coast extending upto 700 hPa and second over Lakshadweep and neighbourhood extending upto 500 hPa. An anomalous cyclonic circulation was seen at 500 hPa over Madhya Pradesh and neighbourhood extending upto 500 hPa.

In the week ending 10 June, three anomalous cyclonic circulations were seen at 850 hPa, one over Marathwada and adjoining Vidarbha extending upto 500 hPa, second over Tamil Nadu and neighbourhood and third over Lakshadweep and neighbourhood. An anomalous anticyclonic circulation was seen at 850 hPa over eastcentral Arabian sea and an anomalous cyclonic circulation was observed at 500 hPa over northwest Rajasthan and neighbourhood.

In the week ending 17 June, three anomalous cyclonic circulations were seen at 850 hPa, one over Vidarbha and neighbourhood extending upto 500 hPa, second over Northwest Rajasthan and neighbourhood and third over Assam, Meghalaya and neighbourhood. Two anomalous cyclonic circulations were seen at 700 hPa, one over Konkan, Goa and adjoining Coastal Karnataka and second over Lakshadweep area and neighbourhood. A ridge at 200 hPa extended along 20°N.

In the week ending 24 June, two anomalous cyclonic circulations were seen at 850 hPa, one over northeast Arabian sea off Maharashtra-Gujarat coast

extending upto 700 hPa and second over west Madhya Pradesh and neighbourhood extending upto 500 hPa. Two anomalous cyclonic circulation were seen at 700 hPa, one over Lakshadweep area and neighbourhood and second over Assam, Meghalaya and neighbourhood. An anomalous cyclonic circulation was seen at 500 hPa over Gujarat Region and neighbourhood. A ridge at 200 hPa extended along 10°N.

In the week ending 1 July, two anomalous cyclonic circulations were seen at 850 hPa, one over Lakshadweep area and neighbourhood and second over Jharkhand and neighbourhood extending upto 700 hPa. A ridge at 200 hPa extended along 22°N.

6.1.2. July wind anomaly features

In the monthly wind pattern, three anomalous cyclonic circulations were seen at 850 hPa, one over Lakshadweep area and neighbourhood extending upto 500 hPa, second over northwest Rajasthan and neighbourhood and third over Assam, Meghalaya and neighbourhood extending upto 500 hPa. A ridge at 200 hPa extended along 24°N.

In the week ending 8 July, three anomalous cyclonic circulation were seen at 850 hPa, one over Madhya Pradesh and adjoining Vidarbha extending upto 700 hPa, second over Northeast Arabian sea off Maharashtra-Gujarat coast extending upto 500 hPa and third over Assam, Meghalaya and neighbourhood. Two anomalous cyclonic circulations were seen at 500 hPa, one over Karnataka coast and second over Coastal Andhra Pradesh and neighbourhood.

In the week ending 15 July, three anomalous cyclonic circulation were seen at 850 hPa, one over Vidarbha and adjoining Chhattisgarh extending upto 700 hPa, second over Tamil Nadu and neighbourhood and third over coastal Karnataka and neighbourhood extending upto 700 hPa. A ridge at 200 hPa extended along 23°N.

In the week ending 22 July, an anomalous cyclonic circulation was seen at 850 hPa over Northwest Rajasthan and neighbourhood extending upto 700 hPa. An anomalous anticyclonic circulation was seen at 850 hPa over Northwest Bay of Bengal off Gangetic west Bengal coast. A ridge at 200 hPa extended along 23°N.

In the week ending 29th July, two anomalous cyclonic circulation were seen at 850 hPa, one over Uttar Pradesh and neighbourhood extending upto 700 hPa and second over Eastcentral Arabian sea off Karnataka coast extending upto 700 hPa. A ridge at 200 hPa extended along 26°N.

6.1.3. August wind anomaly features

In the monthly wind pattern, four anomalous cyclonic circulations were seen at 850 hPa, one over Gujarat and neighbourhood coast extending upto 700 hPa, second over Madhya Pradesh and neighbourhood, third over Northwest (NW) Bay of Bengal off Odisha-West Bengal coast extending upto 500 hPa, and fourth over Assam, Meghalaya and neighbourhood extending upto 500 hPa. An anomalous cyclonic circulation was seen at 500 hPa over Coastal Tamil Nadu and neighbourhood. A ridge at 200 hPa extended along 27°N.

In the week ending 05th August, two anomalous cyclonic circulations were seen at 850 hPa, one over Eastcentral (EC) Arabian Sea off Maharashtra coast extending upto 300 hPa and second over Nagaland, Manipur, Mizoram, Tripura and neighbourhood. An anomalous cyclonic circulation was seen at 500 hPa over Coastal Andhra Pradesh and adjoining Telangana. An anomalous anticyclonic circulation was seen at 500 hPa over West Uttar Pradesh and neighbourhood. A ridge at 200 hPa extended along 24°N.

In the week ending 12 August, four anomalous cyclonic circulations were seen at 850 hPa, one over Gujarat and neighbourhood extending upto 500 hPa, second over Madhya Pradesh and neighbourhood, third over coastal Andhra Pradesh and neighbourhood extending upto 500 hPa and third over Assam, Meghalaya and neighbourhood extending upto 500 hPa. An anomalous anticyclonic circulation was seen at 500 hPa over Chhattisgarh and neighbourhood.

In the week ending 19th August, three anomalous cyclonic circulations were seen at 850 hPa, one over Madhya Pradesh and neighbourhood, second over Odisha and neighbourhood extending upto 500 hPa and third over Assam, Meghalaya and neighbourhood extending upto 700 hPa. An anomalous cyclonic circulation was seen at 700 hPa over Gujarat and neighbourhood extending upto 500 hPa. Two anomalous anticyclonic circulations were seen at 700 hPa, one over Uttar Pradesh and neighbourhood and second over Nagaland, Manipur, Mizoram, Tripura and neighbourhood. A ridge at 200 hPa extended along 26°N.

In the week ending 26th August, two anomalous cyclonic circulations were seen at 850 hPa, one over Gujarat and adjoining Rajasthan and second over Northwest Bay of Bengal off Odisha-west Bengal coast extending upto 500 hPa. Two anomalous cyclonic circulations were seen at 700 hPa, one over Haryana and neighbourhood extending upto 500 hPa and second over Assam, Meghalaya and neighbourhood. An anomalous

anticyclonic circulation was seen at 500 hPa over coastal Andhra Pradesh and neighbourhood. A ridge at 200 hPa extended along 15°N.

In the week ending 2 September, three anomalous cyclonic circulations were seen at 850 hPa, one over Gujarat and neighbourhood extending upto 500 hPa, second over Jharkhand and neighbourhood and third over Assam, Meghalaya and neighbourhood extending upto 700 hPa. An anomalous cyclonic circulation was seen at 500 hPa over Marathwada and neighbourhood. Two anomalous anticyclonic circulations were seen at 500 hPa, one over Chhattisgarh and neighbourhood and second over Uttar Pradesh and neighbourhood. A ridge at 200 hPa extended along 26°N.

6.1.4. September wind anomaly features

In the monthly wind pattern, an anomalous cyclonic circulation was seen at 850 hPa over Marathwada and adjoining Telangana extending upto 700 hPa. An anomalous anticyclonic circulation was seen at 850 hPa over Nagaland, Manipur, Mizoram, Tripura and neighbourhood extending upto 500 hPa. An anomalous cyclonic circulation was seen at 500 hPa over coastal Tamil Nadu. A ridge at 200 hPa extended along 28°N.

In the week ending 09th September, two anomalous cyclonic circulations were seen at 850 hPa, one over Haryana and neighbourhood extending upto 500 hPa and second over Sub Himalayan west Bengal and Sikkim extending upto 500 hPa. Two anomalous anticyclonic circulations were seen at 700 hPa, one over Saurashtra and neighbourhood extending upto 500 hPa and second over Gangetic west Bengal and neighbourhood. A ridge at 200 hPa extended along 30°N.

In the week ending 16th September, two anomalous cyclonic circulations were seen at 850 hPa, one over Sub Himalayan west Bengal and Sikkim extending upto 700 hPa and second over coastal Andhra Pradesh and neighbourhood extending upto 300 hPa. Two anomalous anticyclonic circulations were seen at 700 hPa, one over Haryana and neighbourhood and second over Nagaland, Manipur, Mizoram, Tripura and neighbourhood. A ridge at 200 hPa extended along 30°N.

In the week ending 23rd September, three anomalous cyclonic circulations were seen at 850 hPa, one over Haryana and neighbourhood extending upto 700 hPa, second over Jharkhand and neighbourhood extending upto 700 hPa and third over Marathwada and neighbourhood extending upto 700 hPa. Two anomalous anticyclonic circulations were seen at 700 hPa, one over Rajasthan and neighbourhood extending upto 500 hPa and second over

Bihar and neighbourhood. A ridge at 200 hPa extended along 30°N.

In the week ending 30th September, two anomalous cyclonic circulations were seen at 850 hPa, one over Haryana and neighbourhood extending upto 700 hPa and second over Assam, Meghalaya and neighbourhood extending upto 500 hPa. An anomalous anticyclonic circulation was seen at 500 hPa over Maharashtra and neighbourhood. A ridge at 200 hPa extended along 28°N.

7. Disastrous weather events and damage during Monsoon months

7.1. June

As per media reports, the severe cyclonic storm, "NISARGA" which made landfall in Raigad district of Maharashtra, left at least 6 dead, 16 injured and nearly 13000 hectares of cropland damaged in northern parts of the state as well as its coastal districts. It also damaged nearly 500 mobile towers, more than 100,000 trees were uprooted and a similar number of homes sustained damage in Raigad district. Extensive damage to crops, particularly grapes in the Nashik-Ahmednagar belt was also reported.

Lightning strikes took toll of 83 people in 23 districts of Bihar on 25th June. Thunderstorm caused death of 11 persons in Saran, Patna, Nawada, Lakhisarai and Jamui districts of Bihar. As reported by media, lightning also claimed 10 lives in Odisha, Tamil Nadu, Telangana and Andhra Pradesh. A massive tornado triggered rainfall in Kendrapara district of Odisha, damaging 20 houses and uprooting many trees and electric poles due to strong wind on 15th. Heavy rain which lashed Mumbai city of Maharashtra on 18th caused death of 1 person. Two persons drowned in Sivasagar district of east Assam due to heavy rainfall which triggered floods. More than 25 districts of Assam heavily affected by thunderstorm, lightning, heavy rain and flooding due to which 27 people died and more than 20 Lakh big / small lives stock perished (including poultry). In the first week of the month at least 21 people lost their lives in landslides triggered by incessant rain in Barak Valley of Assam

7.2. July

As per the Assam Disaster Management Authority during the entire month of July, lightning, thunderstorm, heavy rain, flood, river flowing above danger level and landslide took toll of 81 people in Assam. Due to which about 35 lakhs big / small livestock (including poultry) perished and 1,31,300 hectare of cropland area left submerged/damaged. It also affected more than

39.79 Lakh people across 28 districts of Assam and disrupted National Highways. Due to raised water level in the Kaziranga National park and tiger reserve 3 people drowned, 129 animals including 20 rhinos died in this flood. Flooded water and landslide caused damage to many RCC bridges and culverts. As per media reports, thunderstorms took toll of 104 people in various districts of Bihar in the entire month. Heavy rain and floods in the last week wreaked havoc on 11 districts in northeastern Bihar due to which 49 persons died and over 14 lakh people were affected in Aurangabad, Darbhanga, Jamui, Khagadia, Sheikhpura, east and west Champaran districts of Bihar.

Landslides and floods caused death of 20 people in Arunachal Pradesh and Meghalaya. One youth from Pulloorampara in Kozhikode district of Kerala was reported missing in an incident of flash flood. Heavy rain killed one in Delhi and two in Gundlabanda waterfall in Raichur district of Karnataka. Lightning took toll of 2 people in Prakasam district of Andhra Pradesh.

7.3. August

As reported by the disaster management department officials, total of 69 lakh people were affected by floods across 16 districts of Bihar in the beginning of the month and caused death of 2 people in Siwan district and in Muzaffarpur district each. As per media reports, heavy rain triggered landslide, which took toll of 70 in the high ranges of Idukki district in Kerala. Heavy rainfall caused death of 1 person in Kottayam district, while 2 died in Alappuzha district in the second week of the month. In Karnataka a man was killed due to the floods in Belagavi district. Landslip in Bhagamandala, Kodagu district of Karnataka caused death of 9 persons. Heavy rains in Jaipur city of Rajasthan left 3 people dead as the low-lying areas inundated and brought the city to a standstill. Due to heavy rains 1 person drowned in Siddipet district of Telangana. Flood in Assam killed 9 people in Lakhimpur district. In Gujarat 36 people were killed in rain-related incidents in 8 districts of the state due to incessant rain which caused flooding and water-logging. Heavy rain in Gurugram of Haryana submerged the city causing death of 1 due to electrocution. 1 man died when a roof collapsed due to heavy rain in Belagavi district of Karnataka. Heavy rains damaged standing crop on 16,170 hectares in Bidar district of Karnataka. Heavy rains and related incidences caused death of 29 people, in Mayurbhanj, Keonjhar, Bolangir and Deogarh districts of Odisha. As many as 11,942 houses were partially / completely damaged in 4 districts of Chhattisgarh due to continuous rainfall. Heavy rain took toll of 7 people in various districts of Madhya Pradesh. Landslip triggered by heavy rain caused death of 1 person in Rajouri district of

Jammu. At least 55 houses washed away due to erosion in river Ganga in Malda district of West Bengal due to flooding.

7.4. September

According to media reports, heavy rains, floods/flash floods and landslides took a toll of 6 in Andhra Pradesh and one each in Maharashtra, Karnataka and Assam. Lightning killed 29 in Bihar, 13 in Uttar Pradesh, 12 in Jharkhand and 8 in Andhra Pradesh. Incessant rain caused heavy floods in many states in this month causing huge damage to life and property particularly in Assam, Karnataka and Kerala. Assam State Disaster Management Authority officials reported over 19,000 people affected in the state in the second week of the month. Several houses were damaged and earth caved at many places in Kozhikode district of Kerala resulting in large-scale agricultural losses and evacuation of families living in areas vulnerable to landslides and flooding. In various parts of the Kasaragod district heavy rain related incidents caused estimated crop loss of Rs. 6.91 crores as reported by Principal Agricultural Officer. Strong wind partially damaged 12 houses in Pilicode and nearly 60 houses were flooded at Maliyath Road. Heavy rain also lashed Kannur and Kasaragod districts of Kerala. It continued to wreak havoc in many parts of Kannur district of Kerala which caused damage to 23 houses while 11 were partially damaged also report of a landslip near Thalassery, Kuttimakkool of the State. Incessant rain caused heavy crop loss of about 10,000 acres which included rice, cotton, red gram, sugarcane, soya bean and greengram in Sangareddy district of Telangana. Heavy rain lashing the coastal belt flooded several low lying areas in Udupi and Dakshina Kannada districts of Karnataka causing extensive damage to more than 1,100 houses and public properties. The massive landslide triggered by incessant rainfall at 3 locations of Shillong in east Khasi hills district of Meghalaya.

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Appendix

Definitions of the terms given in 'Italics'

Rainfall

Very light

- 0.1 to 2.4mm

Light - 2.5 to 15.5mm

Moderate - 15.6 to 64.4mm

Heavy - 64.5 to 115.5 mm

Very heavy - 115.6 to 204.4mm

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 % or less

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 cms along the west coast and 5 cms elsewhere in at least two stations in the sub-division