MAUSAM, **71**, 3 (July 2020), 523-552

Weather in India

MONSOON SEASON (June - September 2019)†

1. Introduction

The rainfall over the country as a whole during the monsoon season (June-September) was 110% of its Long Period Average (LPA) and thus categorized as a *normal** monsoon year. Seasonal rainfall over Central India region (1263.2 mm) was *large excess* with 129% of LPA rainfallwhich was third highest since 1901 after the years 1994 (1311.3 mm) and 1961 (1297 mm) for the broad geographical region of Central India. Rainfall over South Peninsula (116% of LPA) region was *excess*, over Northwest India (99% of LPA) was *normal* and East and Northeast Region remained *deficient* at 88% of LPA. Southwest monsoon reached parts over the Andaman Sea on 18 May, two days earlier than its normal date. However, it set in over Kerala on 8 June, 7 days later than its normal date and covered the entire country by 19 July with a delay of 4 days. Typically, the monsoon current begins to withdraw around 1 September, with the retreat completed by 15 October. This year, the retreat began on 9 October, marking the longest ever delay and was complete by 16 October in just 8 days. The withdrawal of Southwest monsoon from the entire country and the commencement of the Northeast monsoon rains occurred simultaneously on 16 October. Sometimes there is a gap of 10 days between the two seasons. Due to neutral ENSO conditions and weak Madden Julian Oscillation (MJO), their influence on the monsoon were nearly absent especially in the second half of the season. Positive Indian Ocean Dipole (IOD) episode was observed since the beginning of the monsoon season and its rapid strengthening to the strongest ever was observed by mid of the monsoon season.

2. Various aspects of southwest Monsoon – 2019

2.1. *Onset and advance*

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

Deepening and strengthening of the cross-equatorial flow over the Andaman Sea along with enhanced cloudiness and rainfall in association with a cyclonic circulation at mid-tropospheric levels over Andaman Sea,

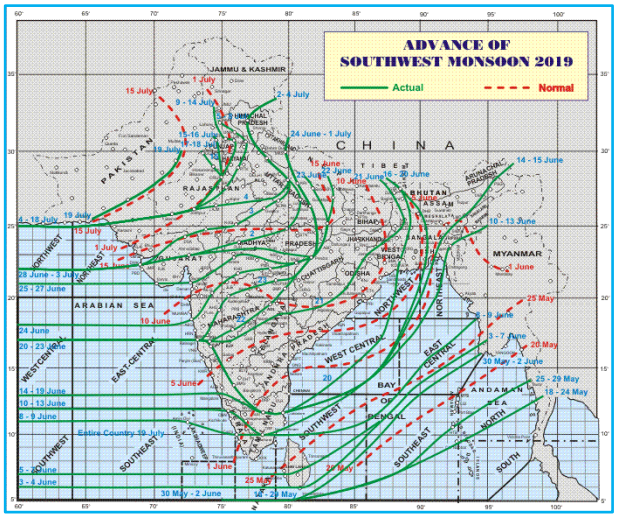

Fig. 1. Isochrones of advance of SW monsoon 2019

led to the arrival of southwest monsoon (SWM) over south Andaman Sea, some parts of South Bay of Bengal and Nicobar Islands on 18 May. Further advance took place over Andaman Sea on 25 May. It covered some more parts of the Bay of Bengal upto 30 May when the Northern Limit of Monsoon (NLM) passed through Lat. 5° N/Long. 75° E, Lat. 5° N/Long. 80° E, Lat. 10° N/Long. 87° E, Lat. 13° N/Long. 90° E and Lat. 16° N/Long. 94.5° E. The NLM continued to be in the same position upto 2 June. Further advance of Southwest Monsoon into southern most parts of the Arabian Sea, some more parts of Maldives-Comorin area, southwest, southeast and east central Bay of Bengal took place on 3 June. Subsequently, in view of the strengthening and deepening of cross equatorial flow and the development of an east-west shear zone in the mid tropospheric levels across south Arabian Sea and Maldives-Comorin area, it further advanced into some more parts of south Arabian Sea, most parts of Maldives-Comorin area and some more parts of Southwest Bay of Bengal on 5 June. Due to strengthening of westerlies and persistent cyclonic circulation in the lower and mid-levels over Lakshadweep area and neighbourhood, the Southwest monsoon further advanced into some more parts of South Arabian Sea, most parts of Lakshadweep area, some parts of Kerala and south Tamil Nadu, remaining parts of Comorin-Maldives area, some more parts of southwest, southeast andeastcentral Bay of Bengal

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

†*Compiled by* : Anupam Kashyapi, P. R. Abhang, J. C. Natuand and P. N. Chopade, Weather Monitoring Unit, IMD, Pune – 411 005, India

TABLE 1

Advance of southwest monsoon 2019

S. No.	Date	Southwest monsoon advanced into	Northern limit of monsoon passed through
1.	18 May	South Andaman Sea, some parts of South Bay of Bengal and Nicobar Islands	Lat. 5° N/Long. 81° E, Lat. 7° N/Long. 88° E, Car Nicobar and Lat. 13° N/Long. 99° E
2.	25 May	Some more parts of southeast Bay of Bengal and north Andaman Sea, remaining parts of Nicobar Islands and southern parts of Andaman Islands	Lat. 5° N/Long. 81° E, Lat. 7° N/Long. 88° E, Hut Bay and Lat. 14° N/Long. 98° E
3.	30 May	Southernmost parts of Maldives-Comorin area, some more parts of southwest and southeast Bay of Bengal, remaining parts of Andaman Sea and Andaman Islands and some parts of eastcentral Bay of Bengal	Lat. 5° N/Long. 75° E, Lat. 5° N/Long. 80° E, Lat. 10° N/Long. 87° E, Lat. 13° N/Long. 90° E and Lat. 16° N/Long. 94.5° E
4.	3 June	Southernmost parts of Arabian Sea, some more parts of Maldives-Comorin area, southwest, southeast and east coast of Bay of Bengal	Lat. 6° N/Long. 60° E, Lat. 6° N/Long. 70° E, Lat. 6° N/Long. 81° E, Lat. 10° N/Long. 86° E, Lat. 13° N/Long. 89° E and Lat. 17° N/Long. 95° E
5.	5 June	Some more parts of south Arabian Sea, most parts of Maldives-Comorin area and some more parts of Southwest Bay of Bengal	Lat. 7° N/Long. 60° E, Lat. 7° N/Long. 70° E, Katunayake (Lat. 7° N/Long. 80° E), Lat. 11° N/ Long. 87° E, Lat. 13° N/Long. 89° E and Lat. 17° N/ Long. 95° E
6.	8 June	Some more parts of south Arabian Sea, most parts of Lakshadweep area,some parts of Kerala and south Tamil Nadu remaining parts of Maldives Comorin area,some more parts of Southwest,southeast and east central Bay of Bengal and some parts of Northeast Bay of Bengal	Lat. 11° N/Long. 60° E, Lat. 11° N/Long. 70° E, Amini Divi, Kochi, Madurai, Lat. 11° N/Long. 86° E, Lat. 16° N/Long. 91° E, Lat. 20° N/Long. 94° E
7.	10 June	Remaining parts of south Arabian Sea & Lakshadweep area, most parts of Kerala, some more parts of Tamilnadu, remaining parts of southeast Bay of Bengal, most parts of southwest & eastcentral Bay of Bengal, some more parts of northeast Bay of Bengal, some parts of westcentral Bay of Bengal, most parts of Mizoram and some parts of Manipur	Lat. 12° N/Long. 60° E, Lat. 12° N/Long. 70° E, Kannur, Madurai, Lat. 12° N/Long. 83° E, Lat. 14° N/ Long. 86° E, Lat. 17° N/Long. 89° E, Lat. 20° N/ Long. 91° E, Aizwal, Lat. 24° N/Long. 93° E and Lat. 25° N/Long. 95° E
8.	14 June	Some parts of central Arabian Sea, remaining parts of Kerala, some parts of Karnataka, Tamilnadu, most parts of southwest Bay of Bengal, some more parts of central & North Bay of Bengal and parts of northeast India	Lat. 13° N/Long. 60° E, Lat. 13° N/Long. 70° E, Mangaluru, Mysuru, Salem, Cuddalore, Lat. 14° N/ Long. 86° E, Lat. 20° N/Long. 90° E, Agartala, Lumding, Passighat and Lat. 29° N/Long. 97° E
9.	16 June	Remaining parts of northeast Bay of Bengal, some more parts of northwest Bay of Bengal, remaining parts of northeast India and some parts of east India	Lat. 13° N/Long. 60° E, Lat. 13° N/Long. 70° E, Mangaluru, Mysuru, Salem, Cuddalore, Lat. 14° N/ Long. 86° E, Goalpara, Alipurduar, Gangtok and Lat. 28° N/Long. 88° E
10.	20 June	Some more parts of central Arabian Sea, remaining parts of Coastal Karnataka, some parts of south Konkan & Goa, south Madhya Maharashtra and Interior Karnataka, some more parts of Bay of Bengal, remaining parts of northeastern states and some more parts of West Bengal	Lat. 17° N/Long. 60° E, Lat. 17° N/Long. 70° E, Ratnagiri, Kolhapur, Shimoga, Salem, Cuddalore, Lat. 16° N/Long. 86° E, Lat. 20° N/Long. 88° E, Kolkata, Lat. 25° N/Long. 89° E, Gangtok and Lat. 28° N/ Long. 88° E
11.	22 June	Remaining parts of Karnataka, Telangana, Odisha, Jharkhand, Gangetic West Bengal & Bihar, most parts of Chhattisgarh and some parts of East Uttar Pradesh	Lat. 17° N/Long. 60° E, Lat. 17° N/Long. 70° E, Ratnagiri, Sholapur, Adilabad, Brahmapuri, Pendra Road, Varanasi, Gorakhpur and Lat. 28° N/ Long. 83° E
12.	23 June	Some more parts of Madhya Maharashtra, most parts of Marathwada and some more parts of Vidarbha and East Uttar Pradesh	Lat. 17° N/Long. 60° E, Lat. 17° N/Long. 70° E, Ratnagiri, Ahmednagar, Aurangabad, Nagpur, Pendra, Varanasi, Bahraich and Lat. 28.5° N/Long. 81° E
13.	24 June	Some more parts of central Arabian Sea, Konkan, most parts of Madhya Maharashtra, remaining parts of Marathwada & Vidarbha, some parts of Madhya Pradesh, some more parts of Chhattisgarh & Uttar Pradesh and some parts of Uttarakhand	Lat. 18° N/Long. 60° E, Lat. 18° N/Long. 70° E, Alibagh, Malegaon, Khandwa, Chindwara, Mandla, Pendra, Sultanpur, Lakhimpur Kheri, Mukteshwar and Lat. 31° N/Long. 80° E
14.	25 June	Remaining parts of central Arabian Sea, Konkan & Madhya Maharashtra, some parts of north Arabian Sea and south Gujarat and some more parts of Madhya Pradesh	Lat. 21° N/Long. 60° E, Lat. 21° N/Long. 65° E, Veraval, Surat, Indore, Mandla, Pendra, Sultanpur, Lakhimpur Kheri, Mukteshwar and Lat. 31° N/ Long. 80° E

TABLE 2 (*Contd.*)

S. No.	Date	Southwest monsoon advanced into	Northern limit of monsoon passed through
15.	28 June	Some more parts of north Arabian Sea, Gujarat & Madhya Pradesh	Lat. 22° N/Long. 60° E, Lat. 22° N/Long. 65° E, Dwaraka, Ahmadabad, Bhopal, Jabalpur, Pendra, Sultanpur, Lakhimpur Kheri, Mukteshwar and Lat. 31° N/Long. 80° E
16.	2 July	Some parts of East Rajasthan, most parts of Madhya Pradesh, remaining parts of Chhattisgarh, some more parts of Uttar Pradesh, most parts of Uttarakhand and some parts of Himachal Pradesh and Jammu & Kashmir	Lat. 22° N/Long. 60° E, Lat. 22° N/Long. 65° E, Dwaraka, Ahmadabad, Rajgarh, Khajuraho, Lucknow, Najibabad, Mandi and Lat. 33° N/Long. 79° E
17.	3 July	Some more parts of Gujarat, Rajasthan, Madhya Pradesh and Uttar Pradesh	Lat. 22° N/Long. 60° E, Lat. 22° N/Long. 65° E, Dwaraka, Deesa, Udaipur, Kota, Gwalior, Shahjahanpur, Najibabad, Mandi and Lat. 33° N/Long. 79° E
18.	4 July	Remaining parts of north Arabian Sea, Gujarat, Madhya Pradesh and some more parts of Rajasthan	Lat. 25° N/Long. 60° E, Lat. 25° N/Long. 65° E, Barmer, Ajmer, Gwalior, Shahjahanpur, Najibabad, Mandi and Lat. 33° N/Long. 79° E
19.	5 July	Some more parts of Rajasthan, remaining parts of Uttar Pradesh, Himachal Pradesh, Uttarakhand and Jammu & Kashmir and some parts of Punjab, Haryana, Chandigarh and entire Delhi	Lat. 25° N/Long. 60° E, Lat. 25° N/Long. 65° E, Barmer, Jodhpur, Sikar, Rohtak, Chandigarh, Una and Amritsar
20.	9 July	Remaining parts of East Rajasthan, most parts of Haryana and some more parts of West Rajasthan & Punjab	Lat. 25° N/Long. 60° E, Lat. 25° N/Long. 65° E, Barmer, Jodhpur, Churu, Ludhiana, Kapurthala and Lat. 33° N/Long. 74.5° E
21.	15 July	Most parts of Haryana and Punjab	Lat. 25° N/Long. 60° E, Lat. 25° N/Long. 65° E, Barmer, Jodhpur, Churu, Ferozpur and Lat. 31° N/Long. 74.5° E
22.	17 July	Remaining parts of Punjab & Haryana and some more parts of west Rajasthan	Lat. 25° N/Long. 60° E, Lat. 25° N/Long. 65° E, Barmer, Jodhpur, Churu, Hanumangarh, Ganganagar and Lat. 30° N/Long. 73.5° E
23.	19 July	Remaining parts of Gujarat state, Rajasthan and north Arabian Sea. Thus, it covered the entire country	

and some parts of northeast Bay of Bengal. Thus the southwest monsoon set in over Kerala, on 8 June with a delay of 7 days. The further advance of monsoon remained sluggish owing to Very Severe Cyclonic Storm (VSCS) 'VAYU' over east central Arabian Sea. The monsoon finally started progressing over northeastern parts of India after the weakening of this system. It further advanced into remaining parts of south Arabian Sea and Lakshadweep area, most parts of Kerala, some more parts of Tamil Nadu, remaining parts of southeast Bay of Bengal, most parts of southwest andeast central Bay of Bengal, some more parts of northeast Bay of Bengal, some parts of westcentral Bay of Bengal, most parts of Mizoram and some parts of Manipur on 10 June. The monsoon moved into some parts of central Arabian Sea, remaining parts of Kerala, some parts of Karnataka, Tamil Nadu, most parts of southwest Bay of Bengal, some more parts of central and North Bay of Bengal and parts of northeast India on and into remaining parts of northeast Bay of Bengal, some more parts of northwest Bay of Bengal, remaining parts of northeast India and some parts of east India on 14 June and 16 June respectively. The southwest monsoon further advanced into remaining parts of central Arabian Sea, Karnataka, Tamil Nadu and Puducherry, Karaikal, Odisha, West Bengal and northeastern states and Bay of Bengal; entire Goa, Maharashtra, Karnataka, Andhra Pradesh, Telangana, Jharkhand and Bihar most parts of Chhattisgarh, Madhya Pradesh and east Uttar Pradesh; some parts of west Uttar Pradesh, Uttarakhand, north Arabian Sea and south Gujarat during 20-26 June. It further covered the remaining parts of North Arabian Sea, Gujarat, Madhya Pradesh and some more parts of Rajasthan till 4 July. It further advanced into some more parts of Rajasthan, remaining parts of Uttar Pradesh, Himachal Pradesh, Uttarakhand, Jammu and Kashmir and some parts of Punjab, Haryana, Chandigarh and entire Delhi on 5 July. Monsoon covered remaining parts of East Rajasthan, most parts of Haryana and some more parts of West Rajasthan and Punjab on 9 July. There was a hiatus like condition till 14 July. Monsoon advanced further on 15 July and covered most parts of Haryana and Punjab and further in remaining parts of Punjab, Haryana along with some more parts of west Rajasthan on 17. Further, it advanced into remaining parts of Rajasthan and north Arabian Sea and thus covered the entire country on 19 July.

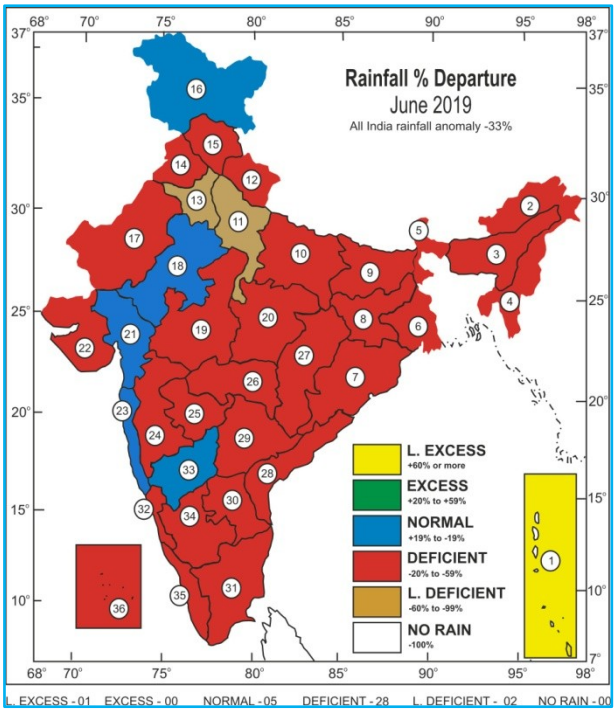

Fig. 2. Rainfall for the month of June 2019 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	60	**7**	-33	**13**	-61	**19**	-26	**25**	-33	**31**	-38
2	-37	**8**	-55	**14**	-50	**20**	-58	**26**	-47	**32**	-32
3	-24	**9**	-41	**15**	-46	**21**	-18	**27**	-33	**33**	1
4	-43	**10**	-56	**16**	7	**22**	-34	**28**	-37	**34**	-28
5	-23	**11**	-71	**17**	-33	**23**	-7	**29**	-35	**35**	-44
6	-58	**12**	-53	**18**	8	**24**	-21	**30**	-23	**36**	-26

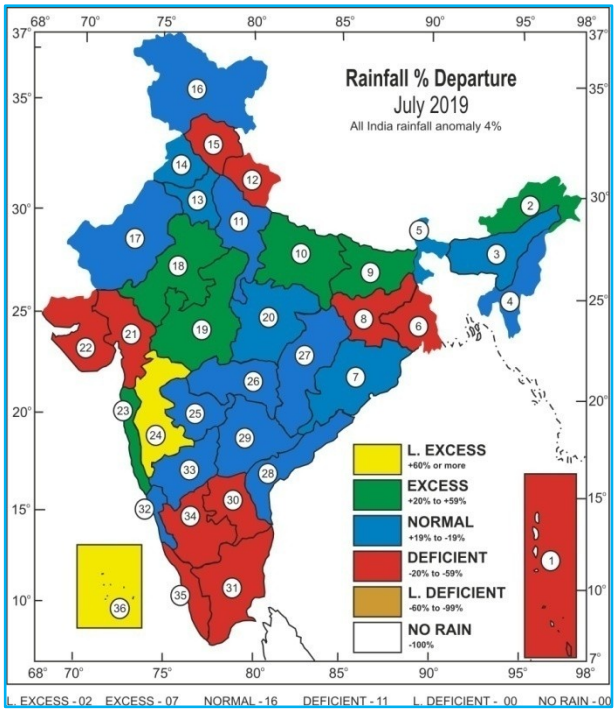

Fig. 3. Rainfall for the month of July 2019 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	-47	**7**	-13	**13**	-16	**19**	31	**25**	-18	**31**	-23
2	37	**8**	-24	**14**	11	**20**	-1	**26**	10	**32**	7
3	17	**9**	20	**15**	-22	**21**	-22	**27**	-2	**33**	6
4	9	**10**	24	**16**	-4	**22**	-33	**28**	8	**34**	-22
5	23	**11**	-9	**17**	-5	**23**	52	**29**	-8	**35**	-20
6	-38	**12**	-29	**18**	23	**24**	64	**30**	-31	**36**	66

2.2. *Monthly rainfall distribution (Analysis based on real time data)*

Figs. 2-5 show the monthly spatial distribution of rainfall. Table 1 gives the monthly and seasonal sub divisional rainfall and percent departures.

Rainfall in June (68% of LPA) was deficient, July (105% of LPA) and August (116% of LPA) being normal and September (152% of LPA) being excess.

In June out of 36 meteorological sub-divisions, 1sub division(Andaman and Nicobar Islands) received *large excess*, 5 sub-divisions received *normal* rainfall and 28 sub-divisions received *deficient* rainfall and remaining 2 sub-divisions (Haryana, Chandigarh and Delhi and West Uttar Pradesh) received large deficient rainfall. Severe heat wave/heat wave conditions were observed over some parts of north India, central India, northwest India and peninsular India on various days during second week of the month. Delay in the advance of monsoon over major parts of central and adjoining south Peninsular India resulted in large rainfall deficiency in the month of June.

In July, rainfall for the month was *deficient* in 11 sub-divisions, *excess* or *large excess* in 9 sub-divisions and normal in remaining 16 sub-divisions. Rainfall activity over the country as a whole was *normal*.

In August, rainfall activity over the country as a whole was *normal*. Most of the meteorological sub-divisions received *large excess/excess/normal* rainfall except some sub-divisions of northeastern/northern regions and Marathwada. Rainfall over Andaman and Nicobar Islands, Rajasthan State, west Madhya Pradesh, Gujarat state, Madhya Maharashtra, Karnataka state, Lakshadweep, Kerala and Mahe was more than 1.5 times of its normal value. Sub-divisions of south peninsular India and Central India received above

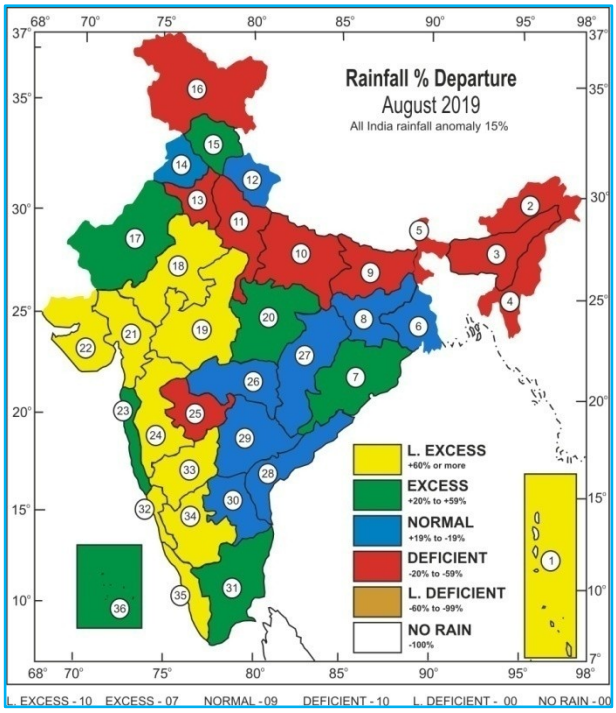

Fig. 4. Rainfall for the month of August 2019 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	110	**7**	22	**13**	-46	**19**	64	**25**	-28	**31**	42
2	-59	**8**	-12	**14**	0	**20**	27	**26**	5	**32**	71
3	-49	**9**	-51	**15**	24	**21**	75	**27**	12	**33**	71
4	-42	**10**	-38	**16**	-30	**22**	118	**28**	9	**34**	102
5	-43	**11**	-31	**17**	59	**23**	43	**29**	14	**35**	123
6	9	**12**	-9	**18**	73	**24**	98	**30**	2	**36**	53

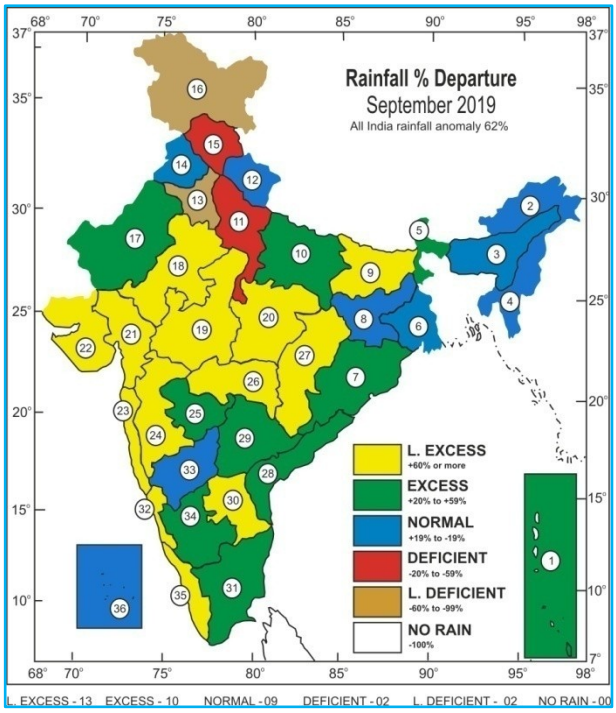

Fig. 5. Rainfall for the month of September 2019 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	39	**7**	50	**13**	-72	**19**	168	**25**	32	**31**	49
2	-1	**8**	16	**14**	-2	**20**	124	**26**	92	**32**	108
3	4	**9**	82	**15**	-28	**21**	100	**27**	67	**33**	13
4	-17	**10**	54	**16**	-61	**22**	343	**28**	41	**34**	44
5	24	**11**	-26	**17**	40	**23**	191	**29**	47	**35**	64
6	3	**12**	17	**18**	104	**24**	65	**30**	66	**36**	-5

normal rainfall except Marathwada while northwest India received normal rainfall, while east and northeast India received deficient rainfall. Out of 36 meteorological sub-divisions, 10 received large excess rainfall, 7 received excess rainfalls, 10 received normal rainfall and 9 received deficient rainfall.

In September, rainfall activity over the country as a whole was above normal. Many sub-divisions of west and Central India *viz*., East Rajasthan, Madhya Pradesh, Gujarat region, Saurashtra and Kutch, Konkan and Goa and coastal Karnataka received twice of its normal rainfall. Some sub-divisions *viz*., Jammu, Kashmir and Ladakh, Himachal Pradesh, Haryana, Chandigarh, Delhi and west Uttar Pradesh received deficient rainfall. Out of 36 meteorological sub-divisions 13 received large excess rainfall, 10 received excess rainfall, 9 received normal rainfall, 3 received deficient rainfall and 1 received large deficient.

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 (west Madhya Pradesh, Saurashtra and Kutch) received large excess rainfall, in 10 sub-divisions *excess*, *normal* in 21 sub-divisions and *deficient* in 3 sub-divisions no sub-division reported *large deficient* rainfall by the end of the season. All of the excess or *large excess* sub-divisions were in west Central India and western Peninsula except for Andaman and Nicobar Islands. Exceptionally heavy rainfall was recorded at Vadodara 56 cms (1 August), Pen 49 cms (4 August), Umerpada 59 cms (5 August) and Kottigehara 57 cms (10 August) (Table 3).

Table 3 contains the representative amounts of very heavy & extremely heavy rainfall observed during the season.

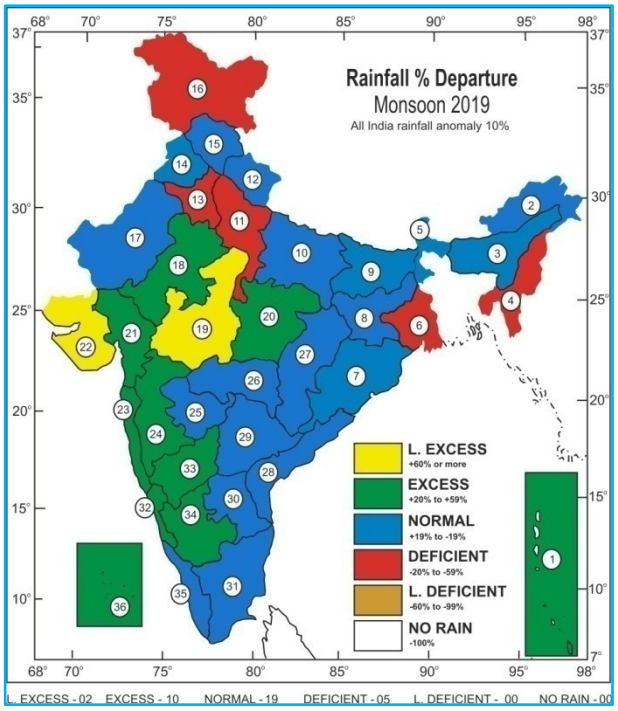

Fig. 6. Rainfall for the month of monsoon 2019 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	41	**7**	7	**13**	-42	**19**	17	**25**	-12	**31**	18
2	-11	**8**	-18	**14**	-5	**20**	66	**26**	12	**32**	23
3	-12	**9**	3	**15**	-10	**21**	29	**27**	10	**33**	23
4	-22	**10**	1	**16**	-21	**22**	66	**28**	9	**34**	23
5	-4	**11**	-27	**17**	19	**23**	53	**29**	6	**35**	13
6	-20	**12**	-18	**18**	53	**24**	55	**30**	12	**36**	22

2.4. *Withdrawal of southwest monsoon*

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

Due to the prevalence of an active Inter Tropical Convergence Zone (ITCZ), across central India, north Indian Ocean, extending upto western North Pacific Ocean, anti-cyclonic circulation in lower levels over Rajasthan could only be established after 5 October and therefore the withdrawal of Southwest monsoon was delayed upto the 1st week of October. In view of establishment of an anti-cyclone in the lower tropospheric levels, substantial reduction in moisture content and prevalence of dry weather over West Rajasthan and Kutch; the Southwest monsoon withdrew from some parts of Punjab, Haryana and north Rajasthan, on 9 October, 2019 making it the most delayed withdrawal of the monsoon in its documented

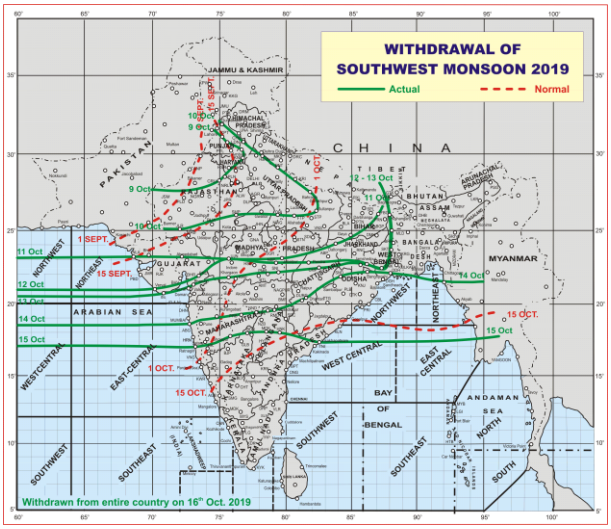

Fig. 7. Isochrones of withdrawal of SW monsoon 2019

history, previous being 1 October, 1961 followed by 30th September, 2007 (Table 4).

It further withdrew from most parts of Punjab, entire Haryana including Chandigarh and Delhi, some parts of Uttarakhand, some parts of Uttar Pradesh, west Madhya Pradesh, east Rajasthan and most parts of west Rajasthan on 10 October. Thereafter it withdrew gradually further south and on 14 October, it withdrew from entire north Bay of Bengal, some parts of central Bay of Bengal, entire Odisha, Chhattisgarh, some parts of Coastal Andhra Pradesh, some more parts of Telangana, entire Vidarbha, Marathwada, some parts of North Interior Karnataka, most parts of Madhya Maharashtra, some more parts of Konkan, entire north Arabian Sea and some parts of central Arabian Sea. The Southwest monsoon withdrew from the entire country and simultaneously northeast monsoon rains commenced over Tamil Nadu and adjoining areas of Andhra Pradesh, Karnataka and Kerala on 16 October, 2019.

3. Chief synoptic features of southwest Monsoon 2019

The synoptic features which affected the Indian Monsoon region during June, July, August and September are given in Tables 5 to 8 respectively.

In all 14 low pressure areas formed during the season. Out of which two intensified into very severe Cyclonic Storm over Arabian Sea, one intensified as Deep Depression over northwest Bay of Bengal off north Odisha-West Bengal coasts and one intensified as a Depression. Of 10 low pressure areas, three became well marked low pressure area.

TABLE 2

Rainfall figures (mm) for each month and season as a whole (June-September 2019)

S. No.	Meteorological Sub-divisions	June			July			August			September			Season		
		Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)
1.	Andaman & Nicobar Islands	662.2	413.7	60	212.0	402.0	-47	860.4	409.0	110	596.8	429.1	39	2331.3	1653.8	41
2.	Arunachal Pradesh	323.1	490.7	-34	719.9	523.8	37	150.9	360.6	-58	347.5	351.5	-1	1541.4	1726.6	-11
3.	Assam & Meghalaya	381.7	496.9	-23	653.4	557.7	17	206.4	404.3	-49	326.3	314.8	4	1567.7	1773.7	-12
4.	Naga., Mani., Mizo. and Tri.	245.7	398.0	-38	443.5	389.5	14	206.6	355.4	-42	235.7	283.8	-17	1133.2	1426.7	-21
5.	Sub-Himalayan West Bengal & Sikkim	361.8	483.3	-25	765.7	625.9	22	271.9	480.7	-43	483.2	380.9	27	1882.6	1970.8	-4
6.	Gangetic West Bengal	109.2	256.2	-57	214.0	334.7	-36	333.3	314.1	6	295.9	276.5	7	952.4	1181.5	-19
7.	Orissa	146.6	217.7	-33	300.7	344.6	-13	445.2	366.4	22	339.9	226.6	50	1232.5	1155.3	7
8.	Jharkhand	89.3	199.9	-55	243.1	322.3	-25	260.5	297.8	-13	265.9	234.7	13	858.9	1054.7	-19
9.	Bihar	97.8	167.7	-42	418.5	349.0	20	140.4	285.2	-51	392.7	215.3	82	1049.4	1017.2	3
10.	East Uttar Pradesh	52.3	108.2	-52	349.1	281.2	24	164.6	263.8	-38	286.4	186.2	54	852.4	839.4	2
11.	West Uttar Pradesh	22.2	76.0	-71	219.5	243.9	-10	175.6	256.7	-32	106.4	144.7	-26	523.8	721.3	-27
12.	Uttaranchal	84.3	177.8	-53	288.8	407.7	-29	360.1	397.7	-9	228.6	193.7	18	961.8	1176.9	-18
13.	Haryana, Chandigarh & Delhi	18.6	48.1	-61	132.1	156.8	-16	85.2	159.2	-46	22.7	79.9	-72	258.6	444.0	-42
14.	Punjab	24.9	50.4	-51	183.6	176.2	4	156.4	160.0	-2	69.6	80.7	-14	434.5	467.3	-7
15.	Himachal Pradesh	55.5	100.5	-45	213.9	273.0	-22	320.6	262.3	22	93.1	127.7	-27	683.0	763.5	-11
16.	Jammu & Kashmir	84.3	73.9	14	194.1	204.9	-5	163.7	185.3	-12	43.1	103.4	-58	486.5	567.5	-14
17.	West Rajasthan	25.2	36.9	-32	96.8	101.7	-5	140.1	88.0	59	54.0	38.7	40	316.1	265.3	19
18.	East Rajasthan	72.8	66.8	9	269.9	218.9	23	384.3	222.2	73	193.5	95.0	104	920.6	602.9	53
19.	West Madhya Pradesh	78.8	105.9	-26	376.9	287.2	31	496.9	303.8	64	430.4	160.8	168	1383.0	857.7	61
20.	East Madhya Pradesh	59.5	140.4	-58	339.2	342.4	-1	464.1	366.2	27	446.9	199.4	124	1309.7	1048.4	25
21.	Gujarat region	114.0	138.6	-18	264.7	340.1	-22	517.4	295.3	75	297.2	148.9	100	1193.4	922.9	29
22.	Saurashtra & Kutch	61.7	94.0	-34	130.9	195.6	-33	307.6	141.0	118	339.4	76.6	343	839.7	507.2	66
23.	Konkan & Goa	642.1	689.7	-7	1618.4	1068.1	52	1083.6	759.0	43	1041.7	358.5	191	4385.8	2875.3	53
24.	Madhya Maharashtra	123.3	157.0	-21	394.8	240.8	64	390.4	197.1	98	258.4	156.3	65	1166.9	751.2	55
25.	Marathawada	92.3	138.0	-33	146.7	179.1	-18	134.1	186.5	-28	217.6	165.2	32	590.7	668.8	-12
26.	Vidarbha	91.8	170.6	-46	340.5	307.1	11	321.5	306.6	5	305.1	158.8	92	1058.8	943.1	12
27.	Chattisgarh	129.4	193.5	-33	369.1	375.5	-2	409.1	364.2	12	348.1	208.9	67	1255.7	1142.1	10
28.	Coastal Andhra Pradesh	66.4	105.2	-37	170.2	157.9	8	177.4	162.1	9	227.5	161.7	41	641.5	586.9	9
29.	Telangana	85.8	132.0	-35	219.9	236.2	-7	260.0	227.5	14	241.2	163.9	47	806.9	759.6	6
30.	Rayalaseema	54.4	70.9	-23	63.7	92.6	-31	110.6	108.5	2	231.2	139.6	66	460.0	411.6	12
31.	Tamil Nadu	33.6	54.1	-38	58.8	76.0	-23	133.4	93.7	42	176.1	118.2	49	401.9	342.0	18
32.	Coastal Karnataka	578.5	866.7	-33	1196.6	1116.3	7	1375.8	806.3	71	636.9	305.8	108	3787.7	3095.1	22
33.	North interior Karnataka	108.5	107.1	1	131.3	123.5	6	207.8	122.0	70	163.9	144.5	13	611.6	497.1	23
34.	South interior Karnataka	102.1	144.1	-29	166.3	213.3	-22	360.1	178.0	102	210.6	146.4	44	839.1	681.8	23
35.	Kerala	359.0	643.0	-44	574.4	720.1	-20	950.6	426.7	123	426.0	259.5	64	2310.0	2049.3	13
36.	Lakshadweep	242.5	330.3	-27	489.4	294.0	66	338.4	223.2	52	156.7	165.6	-5	1227.0	1013.1	21

TABLE 3

Representative amounts of rainfall in cm during June-September 2019

Date	Some representative amounts of rainfall in cm for June, July, August September 2019 (25 cm and above)
4 Jun	Mawsynram (Assam & Meghalaya) 23, Sohra (Assam & Meghalaya) 21
5 Jun	Mawsynram (Assam & Meghalaya) 22
10 Jun	Long Islands (Andaman & Nicobar Islands) 21
13 Jun	Long Islands (Andaman & Nicobar Islands) 31
16 Jun	Mangan (Sub-Himalayan W B & Sikm.) 26, Sankalan (Sub-Himalayan W. B. & Sikm.) 22
17 Jun	Sohra (Rkm) (Assam & Meghalaya) 40, Mawsynram (Assam & Meghalaya) 38, Sohra (Assam & Meghalaya) 36
19 Jun	Pratapgarh (east Rajasthan) 28
20 Jun	Rameshwar agri (Konkan & Goa) 24
22 Jun	Bagaha (Bihar) 43
25 Jun	Baheri (west Uttar Pradesh) and Buxaduar (Sub-Himalayan W. B. & Sikm.) 31 each
26 Jun	Alipurduar Cwc and Alipurduar PTO (Sub-Himalayan W. B. & Sikm.) 41 each, Kumargram (Sub-Himalayan W. B. & Sikm.) 33, Gossaigaon (Assam & Meghalaya) 32, Kokrajhar (Assam & Meghalaya) 30, Barobhisha (Sub-Himalayan W. B. & Sikm.) 27, Hasimara (Sub-Himalayan W. B. & Sikm.) 25, Chepan (Sub-Himalayan W. B. & Sikm.) 24, Alipurduar (Sub-Himalayan W. B. & Sikm.) and Williamnagar (Assam & Meghalaya) 23 each, Melabazar/Matunga (Assam & Meghalaya) 21
27 Jun	Mawsynram (Assam & Meghalaya) 40, Sohra (Rkm) (Assam & Meghalaya) 31, Sohra (Assam & Meghalaya) 29, Williamnagar (Assam & Meghalaya) 23
28 Jun	Mawsynram (Assam & Meghalaya) 33, Sohra (Assam & Meghalaya) 31, Sohra (Rkm) (Assam & Meghalaya) 26
29 Jun	Palghar agri (Konkan & Goa) 45, Matheran (Konkan & Goa) 35, Lonavala agri (Madhya Maharashtra) and Khalapur (Konkan & Goa) 33 each, Vasai (Konkan & Goa) 32, Vapi (Gujarat Region) 31, Karjat agri (Konkan & Goa) 29, Pen (Konkan & Goa) 28, Panvel agri and Bhira (Konkan & Goa) 27 each, Bhiwandi (Konkan & Goa) 25, Roha and Kalyan (Konkan & Goa) 24 each, Mumbai (SCZ) and Thane (Konkan & Goa) 23 each, Dahanu and Ulhasnagar (Konkan & Goa) 21 each
30 Jun	Khergam (Gujarat Region) 26, Tala (Konkan & Goa) 23, Bhiwandi and Shriwardhan (Konkan & Goa) 21 each
1 Jul	Palghar agri (Konkan & Goa) 34, Dahanu (Konkan & Goa) 30, Talasari (Konkan & Goa) and Umergam (Gujarat Region) 29 each, Daman FMO, Daman, Khanvel and Valsad (Gujarat Region) 28 each, Pardi (Gujarat Region) 25, Vapi and Madhbun (Gujarat Region) 23 each, Silvassa (Gujarat Region), Panvel agri (Konkan & Goa) and Khergam (Gujarat Region) 21 each
2 Jul	Palghar agri (Konkan & Goa) 38, Mumbai (SCZ) (Konkan & Goa) 37, Vasai (Konkan & Goa) 32, Thane (Konkan & Goa) 28, Mangaon (Konkan & Goa) 27, Mhasla (Konkan & Goa) 26, Tala , Panvel agri and Uran (Konkan & Goa) 23 each, Pen (Konkan & Goa) 21
3 Jul	Lunglei (Naga. Mani. Mizo. & Trip.) 21
6 Jul	Bhinga (east Uttar Pradesh) 23, Umerpada (Gujarat Region) 22, Matheran (Konkan & Goa) 21
7 Jul	Vapi (Gujarat Region) 38, Daman FMO and Silvassa (Gujarat Region) 30 each, Mawsynram (Assam & Meghalaya) 28, Daman (Gujarat Region) and Mahabaleshwar* (Madhya Maharashtra) 24 each, Wada (Konkan & Goa) 23, Neemsar (east Uttar Pradesh) and Khanvel (Gujarat Region) 22 each, Kaprada , Valsad (Gujarat Region), Sohra (Rkm) (Assam & Meghalaya) and Madhbun (Gujarat Region) 21 each
8 Jul	Khanvel (Gujarat Region) 31, Umergam (Gujarat Region) 24, Talasari (Konkan & Goa) 22
9 Jul	Sohra (Rkm) (Assam & Meghalaya) 38, Sohra (Assam & Meghalaya) 33, Mawsynram (Assam & Meghalaya) 29, Williamnagar (Assam & Meghalaya) 23, Parbatta (Bihar) 22
10 Jul	Mawsynram (Assam & Meghalaya) 44, Sohra (Rkm) (Assam & Meghalaya) 39, Kumargram (Sub-Himalayan W. B. & Sikm.) and Sohra (Assam & Meghalaya) each 26, Basti Cwc (east Uttar Pradesh) 24, Murliganj (Bihar) 23, Maudaha (west Uttar Pradesh) and Ayoadhya (east Uttar Pradesh) 22 each
11 Jul	Sohra (Rkm) (Assam & Meghalaya) 40, Sohra (Assam & Meghalaya) 37, Mawsynram (Assam & Meghalaya) 33, Lonavala agri (Madhya Maharashtra) 29, Jaunpur Tehsil (east Uttar Pradesh) 26, Ballia (east Uttar Pradesh) 25, Bagrakote (Sub-Himalayan W. B. & Sikm.), Matheran (Konkan & Goa) and Khliehriat (Assam & Meghalaya) 23 each, Jaunpur (east Uttar Pradesh), Sevoke (Sub-Himalayan W B & Sikm.) and Sanguem (Konkan & Goa) 22 each, Pen and Quepem (Konkan & Goa) 21 each
12 Jul	Lalbegiaghat (Bihar) 36, Dhengbridge (Bihar) 32, Motihari and Minapur (Bihar) 28 each, Maharajganj (Bihar) 27, Taibpur (Bihar) 26, Darauli (Bihar) 25, Pachrukhi, Patahi and Sahebganj (Bihar) 24 each, Mawsynram (Assam & Meghalaya) 23, Thakurganj (Bihar) 22
13 Jul	Sonbarsa (Bihar) 25, Jainagar (Bihar) 23
14 Jul	Taibpur (Bihar) 24

TABLE 3 (*Contd.*)

Date	Some representative amounts of rainfall in cm for June, July, August September 2019 (25 cm and above)
15 Jul	Abhayapuri AWS (Assam & Meghalaya) 23, Bahalpur (Assam & Meghalaya) 22, Sohra (Assam & Meghalaya) 21
17 Jul	Vengurla (Konkan & Goa) 23
20 Jul	Kudulu (Kerala) 31, Hosdurg (Kerala) 28, Kannur (Kerala) 22, Mahe (Kerala) 21
22 Jul	Gossaigaon (Assam & Meghalaya) 30, Alipurduar Cwc and Alipurduar PTO (Sub-Himalayan W. B. & Sikm.) 27 each, Amfu Pundibari (Sub-Himalayan W. B. & Sikm.) 24, Mawsynram (Assam & Meghalaya) 22, Chepan and Barobhisha (Sub-Himalayan W. B. & Sikm.) 21 each
23 Jul	Gossaigaon (Assam & Meghalaya) 35, Kokrajhar (Assam & Meghalaya) 32, Beki Mathungari (Assam & Meghalaya) 29, Buxaduar (Sub-Himalayan W. B. & Sikm.), Ratnagiri (Konkan & Goa) and Kajolgaon AWS (Assam & Meghalaya) 28 each, Rajapur (Konkan & Goa) 25, Bhatkal (coastal Karnataka) and Williamnagar (Assam & Meghalaya) 23 each, Panbari (Assam & Meghalaya) 22, Sohra (Assam & Meghalaya) and Kollur (coastal Karnataka) 21 each
24 Jul	Barobhisha (Sub-Himalayan W. B. & Sikm.) 40, Neora (Sub-Himalayan W. B. & Sikm.) 29, Gossaigaon (Assam & Meghalaya) 27, Murti (Sub-Himalayan W. B. & Sikm.) 26, Chepan (Sub-Himalayan W. B. & Sikm.) and Guhagarh (Konkan & Goa) 25 each, Gajoldoba and Nagarkata (Sub-Himalayan W. B. & Sikm.) 24 each, Bagrakote (Sub-Himalayan W. B. & Sikm.) 23, Chakia (Bihar) 22, Champasari (Sub-Himalayan W. B. & Sikm.) 21
26 Jul	Waghai (Gujarat Region) 29, Kollur (coastal Karnataka) 25
27 Jul	Matheran (Konkan & Goa) 44, Pen (Konkan & Goa) 40, Murbad (Konkan & Goa) 33, Ulhasnagar (Konkan & Goa) 30, Lonavala agri (Madhya Maharashtra) 29, Ambernath (Konkan & Goa) 28, Karjat agri (Konkan & Goa) 27, Wakwali agri (Konkan & Goa) 26, Khalapur, Roha, Panvel agri (Konkan & Goa), Mahabaleshwar (Madhya Maharashtra) and Belapur (Thane) (Konkan & Goa) 24 each, Chiplun, Kalyan and Dapoliagri (Konkan & Goa) 23 each, Tala, Mumbai (SCZ) and Bhira (Konkan & Goa) 22 each, Igatpuri (Madhya Maharashtra), Bassi (east Rajasthan), Poladpur and Mandangad (Konkan & Goa) 21 each
28 Jul	Lonavala agri (Madhya Maharashtra) 29, Karjat agri (Konkan & Goa) 28, Panvel agri (Konkan & Goa) 27, Bundi (east Rajasthan) 26, Matheran (Konkan & Goa) 24, Khalapur (Konkan & Goa) 23, Nusrulgunj - Arg (west Madhya Pradesh) 21
29 Jul	Mahabaleshwar (Madhya Maharashtra) 24, Wav (Gujarat Region), Vaibhavwadi (Konkan & Goa) and Igatpuri (Madhya Maharashtra) 23 each, Pali (west Rajasthan) 22
30 Jul	Dharampur (Gujarat Region) 29, Lonavala agri (Madhya Maharashtra) 28, Mulchera (Vidarbha) 27, Sehore - AWS (west Madhya Pradesh) 25, Mahabaleshwar and Gaganbawada (Madhya Maharashtra) 23 each, Rajkot (Saurashtra & Kutch) 22, Waghai (Gujarat Region) and Bejjur (Telangana) 21 each
31 Jul	Udhampur IAF (Jammu & Kashmir) 34, Katra (Jammu & Kashmir) 29, Wada (Konkan & Goa) 23, Sohra (Rkm) (Assam & Meghalaya) 21
1 Aug	Vadodara City (Gujarat Region) 56
2 Aug	Mahabaleshwar (Madhya Maharashtra) 27, Una (Himachal Pradesh) 23, Venkatapur (Telangana) 22, Bijapur (Chattisgarh) 21
3 Aug	Bhira (Konkan & Goa) 33, Roha (Konkan & Goa) 29, Mahabaleshwar (Madhya Maharashtra) 28, Pauni (Vidarbha) 27, Kaprada (Gujarat Region) 26, Bijapur (Chattisgarh), Kottigehara (south interior Karnataka) and Poladpur (Konkan & Goa) 25 each, Vapi (Gujarat Region), Lonavalaagri (Madhya Maharashtra), Daman FMO (Gujarat Region) and Palghar agri (Konkan & Goa) 24 each, Mangaon (Konkan & Goa) 23, Igatpuri (Madhya Maharashtra) 22, Bhairamgarh (Chattisgarh), Daman (Gujarat Region), Tala and Matheran (Konkan & Goa) 21 each
4 Aug	Pen (Konkan & Goa) 49, Matheran (Konkan & Goa) 44, Umerpada (Gujarat Region) 42, Alibag (Konkan & Goa) 41, Khambhat (Gujarat Region) 39, Thane (Konkan & Goa) 37, Belapur (Thane) (Konkan & Goa) 34, Olpad (Gujarat Region) 33, Trimbakshwar (Madhya Maharashtra), Kalyan (Konkan & Goa), Mahabaleshwar (Madhya Maharashtra), Vikramgad and Wada (Konkan & Goa) 31 each, Waghai (Gujarat Region), Lonavala agri (Madhya Maharashtra) and Daman (Gujarat Region) 30 each, Karjat agri (Konkan & Goa) 29, Bhira, Ambernath (Konkan & Goa), Daman FMO, Vansda (Gujarat Region) and Tala (Konkan & Goa) 27 each, Kaprada, Dharampur (Gujarat Region), Harsul - FMO (Madhya Maharashtra) and Anand (Gujarat Region) 26 each, Nanipalson, Vapi (Gujarat Region) and Sudhagad Pali (Konkan & Goa) 25 each, Jawhar , Khalapur, Ulhasnagar and Dapoli agri (Konkan & Goa) 24 each, Murud (Konkan & Goa) and Pardi (Gujarat Region) 23 each, Khergam (Gujarat Region), Igatpuri (Madhya Maharashtra), Dangs (Ahwa), Vallabh Vidyanagar (Gujarat Region), Shriwardhan and Mokheda - FMO (Konkan & Goa) 22 each, Mhasla and Roha (Konkan & Goa) 21 each
5 Aug	Umerpada (Gujarat Region) 59, Mangrol (Gujarat Region) and Jawhar (Konkan & Goa) 45 each, Trimbakshwar (Madhya Maharashtra) 40, Mahabaleshwar (Madhya Maharashtra) 38, Igatpuri (Madhya Maharashtra) 37, Kaprada (Gujarat Region) 36, Hansot (Gujarat Region) 35, Dediapada (Gujarat Region) 32, Wada (Konkan & Goa) 29, Mokheda - FMO (Konkan & Goa), Gaganbawada (Madhya Maharashtra) and Ukai (Gujarat Region) 28 each, Ratnagiri (Konkan & Goa) 27, Harsul - FMO (Madhya Maharashtra) 26, Thandla (west Madhya Pradesh) and Matheran (Konkan & Goa) 25 each, Peth (Madhya Maharashtra) 24, Lonavala agri and Ozharkheda - FMO (Madhya Maharashtra) 23 each, Chiplun and Poladpur (Konkan & Goa) 22 each, Dindori (Madhya Maharashtra) and Lanja (Konkan & Goa) 21 each
6 Aug	Sawantwadi (Konkan & Goa) 37, Gaganbawada and Mahabaleshwar (Madhya Maharashtra) 33 each, Radhanagari (Madhya Maharashtra) 32, Hosanagar (south interior Karnataka) and Siddapur (coastal Karnataka) 28 each, Waghai (Gujarat Region), Banbasa (Uttarakhand), Kollur, Manki (coastal Karnataka) and Kankavli (Konkan & Goa) 27 each, Vaibhavwadi (Konkan & Goa) 26, Yellapur (coastal Karnataka) and Valpoi (Konkan & Goa) 24 each, Mulde Agri (Konkan & Goa) and Vansda (Gujarat Region) 23 each, Hunchadakatte (south interior Karnataka), Gersoppa (coastal Karnataka) and Ajra (Madhya Maharashtra) 22 each, Linganamakki HMS , Kottigehara (south interior Karnataka) and Mapusa (Konkan & Goa) 21 each

TABLE 3 (*Contd.*)

Date	Some representative amounts of rainfall in cm for June, July, August September 2019 (25 cm and above)
7 Aug	Lanjigarh (Odisha) 38, Kashipur (Orissa) and Mangaon (Konkan & Goa) 32 each, Kotagarh (Odisha) 31, Phiringia ARG (Odisha) and Bhagamandala (south interior Karnataka) 29 each, Mahabaleshwar (Madhya Maharashtra) and Kottigehara (south interior Karnataka) 28 each, Kotraguda (Odisha) 26, Hosanagar (south interior Karnataka) 25, Tarva ARG (Orissa) 24, Muniguda ARG (Odisha) and Gaganbawada (Madhya Maharashtra) 23 each, Tala (Konkan & Goa), Kollur (coastal Karnataka), Bagrakote (Sub-Himalayan W. B. & Sikm.), Yellapur (coastal Karnataka) and Katra (Jammu & Kashmir) 22 each, Kammardi (south interior Karnataka), Kalinga (Orissa), Chintur (coastal Andhra Pradesh), Mahad (Konkan & Goa), Hunchadakatte (south interior Karnataka), Sawantwadi (Konkan & Goa) and Ponnampet Pwd (south interior Karnataka) 21 each
8 Aug	Kottigehara and Ponnampet Pwd (south interior Karnataka) 31 each, Deobhog (Chattisgarh) 30, Londa (north interior Karnataka), Bhagamandala (south interior Karnataka), Lohandiguda (Chattisgarh) and Mahabaleshwar (Madhya Maharashtra) 27 each, Quant (Gujarat Region), Mananthavady (Kerala), Kalasa and Sringeri HMS (south interior Karnataka) 26 each, Laikera and Deogaon (Orissa) 25 each, Vythiri (Kerala) and G Bazar (Tamil Nadu & Puduchhery) 24 each, Binjharpur ARG (Orissa), Napoklu (south interior Karnataka), Mana AP (Chattisgarh) and Chinnakalar (Tamil Nadu & Puduchhery) 23 each, Kirmira ARG (Orissa) and Hosanagar (south interior Karnataka) 22 each, Jajpur, Bolangir (Odisha), Yellapur (coastal Karnataka), Devala (Tamil Nadu & Puduchhery) and Chandgad (Madhya Maharashtra) 21 each
9 Aug	Bhagamandala (south interior Karnataka) and Alathur (Kerala) 40 each, Chinnakalar (Tamil Nadu & Puduchhery) 37, Valparai (Tamil Nadu & Puduchhery) 35, Chhota Udepur (Gujarat Region) and Ottapalam (Kerala) 34 each, Kollamkode (Kerala) 32, Mannarkad (Kerala) 31, Yellapur (coastal Karnataka) and Vadakara (Kerala) 30 each, Angadipuram (Kerala), Hunchadakatte (south interior Karnataka), Palakkad and Vythiri (Kerala) 29 each, Quant (Gujarat Region) and Parumbikulam (Kerala) 28 each, Kottigehara (south interior Karnataka), Dhadgaon/Akrani - Hydro (Madhya Maharashtra), Peermade To (Kerala), Virajpet and Kalasa (south interior Karnataka) 27 each, Valparai Taluk Office (Tamil Nadu & Puduchhery), Ponnampet Pwd (south interior Karnataka), Ambalavayal (Kerala) and Devala (Tamil Nadu & Puduchhery) 26 each, G. Bazar (Tamil Nadu & Puduchhery) and Mananthavady (Kerala) 25 each, Chittur, Manjeri, Pattambi (Kerala) and Sargur (south interior Karnataka) 23 each, Naduvattam (Tamil Nadu & Puduchhery), Chalakudi (Kerala) and Mudigere (south interior Karnataka) 22 each, Perinthalamanna, Thrithala, CIAL Kochi (Kerala), Tarana (west Madhya Pradesh), Munnar KSEB (Kerala), Shirpur (Madhya Maharashtra) and Sringeri HMS (south interior Karnataka) 21 each
10 Aug	Kottigehara (south interior Karnataka) 57, Hunchadakatte (south interior Karnataka) 39, Barvala (Saurashtra & Kutch) 38, Mahudha (Gujarat Region) 34, Dhandhuka (Gujarat Region) and Kalasa (south interior Karnataka) 32 each, Subramanya (coastal Karnataka) 31, Kadi (Gujarat Region) and Vadakara (Kerala) 30 each, Gadhda (Saurashtra & Kutch), Mudigere (south interior Karnataka), Botad (Saurashtra & Kutch) and Ottapalam (Kerala) 29 each, Linganamakki HMS (south interior Karnataka) 27, Ranpur (Saurashtra & Kutch), Bhagamandala (south interior Karnataka) and Galteshwar (Gujarat Region) 26 each, Chuda (Saurashtra & Kutch) and Dholera (Gujarat Region) 24 each, Hosanagar (south interior Karnataka), Kalol (G) (Gujarat Region) and Dharmasthala (coastal Karnataka) 23 each, Belthangadi (coastal Karnataka) and Hosdurg (Kerala) 22 each, New Kandla (Saurashtra & Kutch), Kammardi (south interior Karnataka), Siddapur (coastal Karnataka), Dhrangadhra (Saurashtra & Kutch), Jayapura (south interior Karnataka), Irikkur (Kerala), Jotana (Gujarat Region), Vythiri (Kerala), Surendranagar and Vallabhipur (Saurashtra & Kutch) 21 each
11 Aug	Nakhatrana (Saurashtra & Kutch) 32, Naliya and Tankara (Saurashtra & Kutch) 27 each, Morbi (Saurashtra & Kutch) 26, Abdasa (Saurashtra & Kutch) 25, Kammardi (south interior Karnataka) 23, Rapar (Saurashtra & Kutch), Vadakara (Kerala), Dhrangadhra and Lakhpat (Saurashtra & Kutch) 21 each
13 Aug	Madanpur Rampur (Odisha) 45, Kantamal (Odisha) 35, Baliguda (Odisha) 32, Saintala ARG (Odisha) 31, Belgaon (Odisha) 29, Bolangir (Odisha) 26, Narla ARG (Odisha) 24
14 Aug	Bolangir (Odisha) 55, Bemetara (Chattisgarh) 21
15 Aug	Patan (east Madhya Pradesh) 24, Ponda (Konkan & Goa) and Khurai (east Madhya Pradesh) 23 each, Mawsynram (Assam & Meghalaya) 22, Sanguem (Konkan & Goa), Agumbe (south interior Karnataka), Valpoi (Konkan & Goa) and Dug (east Rajasthan) 21 each
16 Aug	Begu (east Rajasthan) 30, Pali (west Rajasthan) 28, Chabra (east Rajasthan) 26, Atru and Mandalgarh (east Rajasthan) 24 each, Pratapgarh (east Rajasthan) 22, Dug (east Rajasthan) 21
18 Aug	Naina Davi (Himachal Pradesh) 36, Ghumarwin (Himachal Pradesh) 32, Berthin AGRO (Himachal Pradesh) 28, Jhandutta (Himachal Pradesh) and Balachaur (Punjab) 27 each, Khanna (Punjab) 25, Barthin (Himachal Pradesh) and Chandanpur (Odisha) 24 each, Rohru and Nahan (Himachal Pradesh) 23 each, R. L. Bbmb (Himachal Pradesh), Nawanshahr , Nabha (Punjab) and Chakradharpur (Jharkhand) 21 each
24 Aug	Rosera (Bihar) 21
26 Aug	Kharagpur (I.I.T) (Gangetic West Bengal) 25, Vadakara (Kerala) 23
28 Aug	Paren (Naga. Mani. Mizo. & Trip.) 22
31 Aug	Khandwa (west Madhya Pradesh) and Manki (coastal Karnataka) 24 each
1 Sep	Belpada ARG (Odisha) 22
3 Sep	Kollur (coastal Karnataka) 21
4 Sep	Khalapur (Konkan & Goa) 27, Mangaon and Roha (Konkan & Goa) 26 each, Bhamragad (Vidarbha) 24, Uran (Konkan & Goa) 23, Lonavala agri (Madhya Maharashtra) 22

TABLE 3 (*Contd.*)

Date	Some representative amounts of rainfall in cm for June, July, August September 2019 (25 cm and above)
5 Sep	Vapi (Gujarat Region) and Vasai (Konkan & Goa) 27 each, Bhagamandala (south interior Karnataka) 26, Mumbai (SCZ) (Konkan & Goa) and Pardi (Gujarat Region) 24 each, Belapur (Thane) (Konkan & Goa) 22
6 Sep	Jagdalpur (Chattisgarh) 29, Bramhapuri (Vidarbha) 22, Desaiganj (Vidarbha) and Gaganbawada (Madhya Maharashtra) 21 each
7 Sep	Bhiwapur (Vidarbha) 29, Anandpur (Odisha) 25
8 Sep	Gaganbawada (Madhya Maharashtra) 25, Baramkela (Chattisgarh) and Jujumura ARG (Odisha) 23 each, Palghar agri (Konkan & Goa), Gondia AP (Vidarbha) and Manpur (Chattisgarh) 21 each
9 Sep	Seoni (east Madhya Pradesh) 31
10 Sep	Umerpada (Gujarat Region) 39, Mawsynram (Assam & Meghalaya) 23
14 Sep	Pratapgarh (east Rajasthan) 27, Sohra (Assam & Meghalaya) and Susner (west Madhya Pradesh) 25 each, Dug (east Rajasthan) and Sohra (Rkm) (Assam & Meghalaya) 22 each
15 Sep	Manasa (west Madhya Pradesh) and Palghar agri (Konkan & Goa) 24 each, Gangdhar (east Rajasthan), Mandsaur - AWS (west Madhya Pradesh) and Dahanu (Konkan & Goa) 22 each, Kannauj (east Uttar Pradesh) 21
18 Sep	Nalgonda (Telangana) 22, Guntur (coastal Andhra Pradesh) 21
19 Sep	Tiruvallur (Tamil Nadu & Puduchhery) 22, Poondi (Tamil Nadu & Puduchhery) 21
27 Sep	Kunda (east Uttar Pradesh) 21
28 Sep	Jaunpur Tehsil (east Uttar Pradesh) 30, Jandhaha (Bihar) 23, Rajauli (Bihar), Azamgarh and Jaunpur (east Uttar Pradesh) 22 each
29 Sep	Rosera (Bihar) 29, Rajmahal (Jharkhand), Bihpur (Bihar), Gyanpur (east Uttar Pradesh) and Koilwar (Bihar) 21 each
30 Sep	Bhanvad (Saurashtra & Kutch) 33, Rajmahal (Jharkhand) 28, Rosera (Bihar) 25, Udai Kishanganj (Bihar) and Gaighat (Bla FMO) (east Uttar Pradesh) 24 each, Baltara (Bihar), Pali (Chattisgarh) and Jamjodhpur (Saurashtra & Kutch) 22 each

Out of the two Very Severe Cyclonic Storms, one formed over southeast and adjoining eastcentral Arabian Sea and Lakshadweep area (VAYU) in June and the other in September over eastcentral and adjoining northeast Arabian Sea (HIKAA). Though the frequency of cyclonic storms is less during the southwest monsoon period, there had been 3 more such years in the recent 30 years, *viz*., 1996 (2 in June, one each over the Bay of Bengal and the Arabian Sea), 2007 (2 in June over the Arabian Sea) and 2015 (1 in June over the Arabian Sea and the other in July, over the Bay of Bengal). One intensified as Deep Depression over northwest Bay of Bengal off north Odisha - West Bengal coasts, one as a depression over Gulf of Kutch and neighbourhood. Tracks of these systems are shown in Fig. 8. This year, June and September witnessed the formation of one VSCS each, while 1 DD formed during August and 1 D during September.

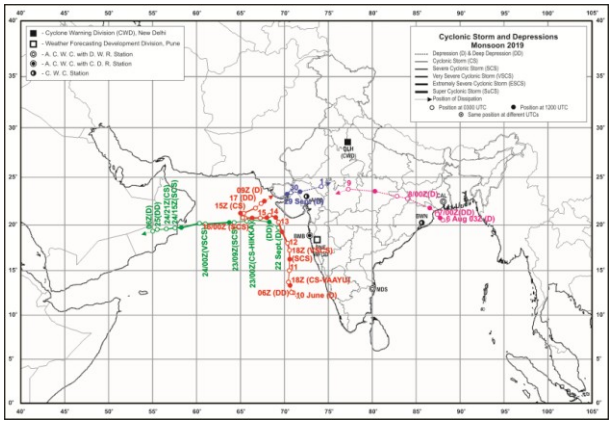

Fig. 8. Tracks of the intense low pressure systems during SW Monsoon 2019

The first intense system of the season VSCS "VAYU" formed over southeast and adjoining eastcentral Arabian Sea and Lakshadweep (10-17 June, 2019). The system caused light to moderate rainfall at many places with isolated heavy to very heavy rainfall over Saurashtra & Kutch on 13 and 14 and over Gujarat region on 14 June. It also caused light to moderate rainfall at many places with isolated heavyto very heavy falls over Kerala, coastal Karnataka, Konkan and Goa during 10-14 June (Table 5).

A low pressure area formed over southeast Arabian Sea and adjoining Lakshadweep area and east central Arabian Sea on 8 June. It lay as a well marked low pressure area over the same region on 9 June and concentrated into a Depression over southeast and adjoining Lakshadweep and east central Arabian Sea. It moved north-northwest wards, intensified into a Deep Depression and lay centred on the 10 June, over east central and adjoining south east Arabian Sea and

TABLE 4

Withdrawal of southwest monsoon 2019

S. No.	Date	Southwest monsoon withdrew from	Withdrawal line passed through
1.	9 Oct	Some parts of Punjab, Haryana and north Rajasthan	Lat. 31.5° N/Long. 74.5° E, Kapurthala, Ambala, Karnal, Churu and Lat. 27.5° N/Long. 70.0° E
2.	10 Oct	Most parts of Punjab, entire Haryana including Chandigarh & Delhi, some parts of Uttarakhand, some parts of Uttar Pradesh, west Madhya Pradesh, east Rajasthan and most parts of west Rajasthan	Gurdaspur, Chandigarh, Haridwar, Bahraich, Sultanpur, Orai, Sawai Madhopur and Jalore
3.	11 Oct	Entire Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Punjab, Uttar Pradesh, some parts of Bihar, Jharkhand, Chhattisgarh and East Madhya Pradesh and some more parts of West Madhya Pradesh, entire Rajasthan and some parts of Saurashtra & Kutch and Gujarat region	Lat. 26.5° N/Long. 87.5° E, Forbesganj, Daltonganj, Jabalpur, Ujjain, Ahmedabad, Naliya and Lat. 23.2° N/Long. 68.5° E
4.	12 Oct	Some parts of north Arabian Sea, some more parts of Gujarat, West Madhya Pradesh, Chhattisgarh, Jharkhand, Bihar and some parts of West Bengal	Lat. 28.0° N/Long. 87.5° E, Kishanganj, Bankura, Jamshedpur, Pendra Road, Narsingpur, Ujjain, Baroda, Veraval, Lat. 21° N/Long. 65° E and Lat. 21° N/Long. 60° E
5.	13 Oct	Some more parts of north Arabian Sea, Gujarat, Madhya Pradesh and Chhattisgarh	Lat. 28.0° N/Long. 87.5° E, Kishanganj, Bankura, Jamshedpur, Champa, Seoni, Khargone, Bharuch, Diu and Lat. 20.7° N/Long. 70° E, Lat. 20.7° N/ Long. 65° E and Lat. 20.7° N/Long. 60° E
6.	14 Oct	Remaining parts of north Arabian Sea, some parts of Central Arabian Sea, remaining parts of Gujarat & Madhya Pradesh, some parts of Konkan, Madhya Maharashtra, Marathwada, most parts of Vidarbha, some parts of south India, some more parts of Chhattisgarh, some parts of Odisha, entire Jharkhand, Bihar and Sub-Himalayan West Bengal & Sikkim, some more parts of Gangetic West Bengal, entire northeast India and some parts of north Bay of Bengal	Lat. 21.5° N/Long. 95.0° E, Lat. 21.5° N/ Long. 92.0° E, Diamond Harbour, Bangriposhi (Odisha), Sundargarh, Dhamtari, Ramagundam, Nanded, Alibagh, Lat. 18.0° N/Long. 70° E, Lat 18.0° N/Long. 65° E and Lat. 18.0° N/Long. 60° E
7.	15 Oct	From entire north Bay of Bengal, some parts of central Bay of Bengal, entire Odisha, Chhattisgarh, some parts of Coastal Andhra Pradesh, some more parts of Telangana, entire Vidarbha, Marathwada, some parts of North Interior Karnataka, most parts of Madhya Maharashtra, some more parts of Konkan, entire north Arabian Sea and some parts of central Arabian Sea	Lat. 17.5° N/Long. 95.0° E, Lat. 17.5° N/ Long. 90.0° E, Tuni, Hanamkonda, Bidar, Solapur, Ratnagiri, Lat. 17.0° N/ Long. 70° E, Lat 17.0° N/Long. 65° E and Lat. 17.0° N/Long. 60° E
8.	16 Oct	Withdrawn from the entire country and simultaneously Northeast monsoon rains commenced over Tamil Nadu and adjoining areas of Andhra Pradesh, Karnataka and Kerala	

Lakshadweep area. It then intensified into Cyclonic Storm 'VAYU' on 10 June evening and lay centred near Lat. 13.9° N and Long. 70.6° E over eastcentral and adjoining southeast Arabian Sea. It moved further northwards and intensified into Severe Cyclonic Storm and lay centred on 11 June over eastcentral Arabian Sea. It then moved north-northwestwards till 13 June and then westwards and weakened into an SCS in the early morning of 16 June over northeast Arabian Sea. It gradually started recurving northeastwards from the evening of 16 June and weakened into a CS in the same night over northeast Arabian Sea. Thereafter, it moved eastnortheastwards and weakened into a Deep Depression in the morning of 17 June and into a depression in the same afternoon over northeast Arabian Sea. It further moved eastnortheastwards and weakened into a well marked low pressure area over northeast Arabian Sea & adjoining Saurashtra and Kutch on 17 June.

Subsequent to this system, a low pressure area formed over northeast Bay of Bengal and neighbourhood on 20 June. Further moving north westwards it lay over north Bay of Bengal and adjoining areas of Bangladesh and West Bengal on 21 June. It lay over interior Odisha and adjoining areas of Jharkhand and north Chhattisgarh on 22 June. It became less marked on 23 June. One more low pressure area (30 June - 6 July) formed over northeast Bay of Bengal and neighbourhood on 30 June. It then intensified as a well marked low pressure area over northwest Bay of Bengal and adjoining areas of West Bengal and Odisha coasts on 1 July. It moved

TABLE 5

Details of the weather systems during June 2019

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.	VSCS (VAYU)	10-17	Southeast & adjoining eastcentral Arabian Sea and Lakshadweep Lat. 11.7° N and Long. 71.0° E	North, northeast, re-curved northwest and then again northeast	Northeast Arabian Sea	Details are given in the article on Storms & Depressions over the north Indian Ocean 2019
(**B**)	*Low Pressure Area*					
1.	Low	20-22	Northeast Bay of Bengal and neighbourhood	North west	Interior Odisha and adjoining areas of Jharkhand and north Chhattisgarh	It formed under the influence of the cyclonic circulation over eastcentral & adjoining northeast Bay of Bengal, It became less marked on 23. Associated cyclonic circulation extending upto 5.8 km above m.s.l. tilting southwestwards with height and became less marked on 25
(**C**)	*Western disturbances/Eastward moving systems*					
(*i*)	*Upper air cyclonic circulation*					
1.	Upto mid tropospheric levels	20-21	North Pakistan and adjoining Jammu & Kashmir	Stationary	*In situ*	It moved away east northeast wards on 22
2.	Between 3.1 & 3.6 kms a.s.l.	23-24	North Pakistan & neighbourhood	East	North Pakistan & adjoining Jammu & Kashmir	A trough aloft ran with its axis at 5.8 km a.s.l. roughly along Long. 68° E to the north of Lat. 30° N on 24. Moving eastward it lay roughly along Long. 74° E on 26th and moved away eastward on 27. Cyclonic circulation became less marked on 25
(*ii*)	*As a trough*					
1.	Upto Mid tropospheric levels	1-7	Along Long. 64° E to the north of Lat. 32° N (axis at 5.8 kms a.s.l.)	East	Along Long. 75° E to the north of Lat. 34° N (axis at 5.8 kms a.s.l.)	It lay as a cyclonic circulation at 3.1 kms a.s.l. over West Iran & neighbourhood on 1 and over east Iran and neighbourhood on 2. Moved away northeastwards
2.	Upto mid and upper tropospheric levels	10-12	Along Long. 66° E to the north of Lat. 34° N (axis at 5.8 kms a.s.l.)	Northeast	Along Long. 68° E to the north of Lat. 32° N (axis at 5.8 kms a.s.l.)	It lay as a cyclonic circulation at 3.1 kms a.s.l. over east Afghanistan and adjoining Pakistan on 10. Moved away northeastwards
3.	Do	13-16	Along Long. 65° E to the north of Lat. 25° N (axis at 5.8 kms a.s.l.)	East northeast wards	Along Long. 76° E to the north of Lat. 28° N (axis at 5.8 kms a.s.l.)	A cyclonic circulation over Central Pakistan & neighbourhood between 1.5 and 2.1 kms a.s.l. on 15. Moved away east northeast wards
(**D**)	*Other upper air cyclonic circulations*					
1.	At 1.5 kms a.s.l.	1	North Gangetic West Bengal & adjoining Bangladesh	Stationary	*In situ*	became less marked on 2
2.	Between 0.9 & 2.1 kms a.s.l.	1	North Coastal Andhra Pradesh & neighbourhood	Do	Do	became less marked on 2
3.	Between 2.1 & 5.8 kms a.s.l.	2-5	Southeast Bay of Bengal and neighbourhood	West	Southwest Bay of Bengal	It merged with the east-west shear zone running roughly along Lat. 7° N across Maldives-Comorin area on 6

TABLE 5 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
4.	Between 3.1 & 4.5 kms a.s.l.	2-3	Lakshadweep and adjoining southeast Arabian Sea	North	Southeast Arabian Sea and adjoining Lakshadweep	Became less marked on 4
5.	Upto 1.5 kms a.s.l.	2-6	Northwest Rajasthan and neighbourhood	Do	North Haryana and neighbourhood	A trough at 0.9 kms a.s.l. ran from the cyclonic circulation over north Haryana & neighbourhood to northwest Madhya Pradesh across West Uttar Pradesh on 6^{th} and became less marked on 7. Cyclonic circulation Became less marked on 7
6.	Between 2.1 & 5.8 kms a.s.l.	2	Sub-Himalayan West Bengal & Sikkim and neighbourhood	South	Bangladesh & adjoining West Bengal	It merged with the cyclonic circulation over Bangladesh & adjoining West Bengal on 3
7.	Upto 4.5 kms a.s.l.	3-4	Bangladesh & adjoining West Bengal	North	Bangladesh and adjoining Sub-Himalayan West Bengal & Sikkim and Assam	Trough lay aloft that ran roughly along Long. 90° E to the north of Lat. 24° N on 4. It became less marked on 5
8.	Between 1.5 & 2.1 kms a.s.l.	3 -6	Jharkhand and neighbourhood	Northwest	East Uttar Pradesh and neighbourhood	Became less marked on 7
9.	Between 3.6 and 4.5 kms a.s.l.	3	Bay of Bengal off north Andhra Pradesh-south Odisha coasts.	Stationary	*In situ*	Became less marked on 4
10.	Upto 2.1 kms a.s.l.	4-5	Central Pakistan and neighbourhood.	Do	Do	Became less marked on 6
11.	At 5.8 kms a.s.l.	4	Lakshadweep and neighbourhood	Do	Do	Became less marked on 5
12.	between 3.1 & 4.5 kms a.s.l.	4 -5	Malay peninsula and neighbourhood	Do	Do	It became less marked on 6
13.	upto 0.9 kms a.s.l.	5	West Uttar Pradesh and adjoining northwest Madhya Pradesh	Do	Do	Merged with the trough at 0.9 kms a.s.l. from the cyclonic circulation over north Haryana and neighbourhood to northwest Madhya Pradesh across west Uttar Pradesh on 6
14.	At 0.3 kms a.s.l.	6	Pakistan and adjoining Punjab	Do	Do	Became less marked on 7
15.	Between 1.5 and 3.6 kms a.s.l.	6-12	Northwest Bay of Bengal and adjoining Gangetic West Bengal and Bangladesh	East	North Bangladesh and neighbourhood extends between 2.1 & 3.6 kms a.s.l.	Became less marked on 13
16.	Upto 0.9 kms	7-9	Northeast Rajasthan and neighbourhood	Do	Northwest Madhya Pradesh & adjoining East Rajasthan upto 1.5 kms a.s.l.	Became less marked on 10
17.	Upto 1.5 kms a.s.l.	8	Telangana & adjoining North Interior Karnataka	Stationary	*In situ*	Became less marked on 9
18.	Upto 0.9 kms a.s.l.	9-10	Central Pakistan and adjoining west Rajasthan	East	Northwest Rajasthan and neighbourhood	Became less marked on 11
19.	Upto mid tropospheric levels	9-13	Westcentral Bay of Bengal and neighbourhood	Do	Northeast and adjoining eastcentral Bay of Bengal	Became less marked on 14
20.	Upto 0.9 kms a.s.l.	10-11	Bihar and adjoining Jharkhand	South	Jharkhand and adjoining Bihar	It became less marked on 12
21.	Between 0.9 and 1.5 kms a.s.l.	11	North Pakistan and neighbourhood	Stationary	North Pakistan and neighbourhood	It became less marked on 12

TABLE 5 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
22.	At 1.5 kms a.s.l.	12	North Madhya Pradesh and neighbourhood	Stationary	*In situ*	It became less marked on 13
23.	Between 1.5 & 3.6 kms above m.s.l.	14	South Assam and adjoining Bangladesh	Do	Do	It became less marked on 15
24.	Upto 0.9 kms a.s.l.	16	Bangladesh & neighbourhood	Do	Do	It became less marked on 17
25.	Upto 1.5 kms a.s.l	16	Haryana & neighbourhood	Do	Do	It became less marked on 17
26.	Between 5.8 & 7.6 kms a.s.l.	18	Eastern parts of Jammu & Kashmir and neighbourhood	Do	Do	It became less marked on 19
27.	Upto 0.9 kms a.s.l.	18-19	West Assam & neighbourhood	South-east	South Assam and neighbourhood	Became less marked on 20
28.	At 0.9 kms a.s.l.	19	Gangetic West Bengal & adjoining areas of Jharkhand and north Odisha	Stationary	*In situ*	It became less marked on 20
29.	Do	20	South Chhattisgarh and neighbourhood	Do	Do	Became less marked on 21
30.	Do	20	Eastern parts of Bihar and adjoining areas of West Bengal and Jharkhand	Do	Do	It became less marked on 21
31.	Between 3.1 & 3.6 kms a.s.l.	20	South Rajasthan and adjoining north Gujarat	Do	Do	Became less marked on 21
32.	At 1.5 kms a.s.l.	21	Haryana & neighbourhood	Do	Do	It became less marked on 22
33.	Upto 0.9 kms a.s.l.	22	Central parts of Madhya Pradesh	Do	Do	Merged with the trough at m.s.l. from west Rajasthan to eastcentral Bay of Bengal across Madhya Pradesh, Chhattisgarh and Odisha extending upto 0.9 km above m.s.l. on 23
34.	Between 3.1 & 7.6 kms a.s.l.	23-27	Coastal Karnataka & neighbourhood	North	North Konkan and adjoining south Gujarat	It became less marked on 28
35.	Upto 0.9 kms a.s.l.	24	East Rajasthan & adjoining West Madhya Pradesh	Stationary	*In situ*	It became less marked on 25
36.	Between 1.5 & 2.1 kms a.s.l.	24-25	South Gujarat & neighbourhood	Southeast	Over Gujarat region & adjoining areas of north Madhya Maharashtra and West Madhya Pradesh	Became less marked on 26
37.	Upto 0.9 kms a.s.l.	26	Central parts of Rajasthan	Stationary	*In situ*	It became less marked on 27
38.	Do	27 Jun - 8 Jul	South Pakistan & neighbourhood	East	Punjab and neighbourhood	Merged with the trough at mean sea level from Punjab to Nagaland on 9
39.	Upto 3.1 kms a.s.l.	28-30	South Madhya Pradesh and neighbourhood	Do	South Chhattisgarh and neighbourhood	It merged with the cyclonic circulation associated with the well marked low pressure area on 1st July
40.	Upto 0.9 kms a.s.l.	29	East Assam & neighbourhood	North	East central Arabian Sea off south Maharashtra-Goa coasts	Became less marked on 30
41.	Upto 5.8 kms a.s.l.	29	Southwest Rajasthan & neighbourhood	South	South Konkan and neighbourhood	Became less marked on 30

TABLE 5 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
42.	Between 3.1 & 4.5 kms a.s.l.	29 Jun - 8 Jul	South Gujarat & neighbourhood	Oscillatory	South Gujarat Region and neighbourhood	Became less marked on 9
43.	Upto 1.5 kms a.s.l.	30 Jun - 2 Jul	Central parts of Uttar Pradesh	Stationary	*In situ*	Merged with the trough at mean sea level from Punjab to northeast Bay of Bengal on 3 July
(E)	*East-West trough*					
1.	Upto 0.9 kms a.s.l.	7-13	Northeast Rajasthan and neighbourhood to northwest Bay of Bengal	Oscillatory	Punjab, Haryana, Uttar Pradesh, Gangetic West Bengal to northeast Bay	became less marked on 14
2.	At 0.9 kms a.s.l.	1-5	South Punjab to Manipur	Stationary	West Uttar Pradesh and adjoining northwest Madhya Pradesh to Assam	became less marked on 6
(F)	*Other troughs/Wind Discontinuity*					
1.	At 0.9 kms a.s.l.	6	Southeast Madhya Pradesh to south interior Karnataka across east Vidarbha, Telangana and Rayalaseema	Stationary	*In situ*	Became less marked on 7
2.	Upto 3.1 kms a.s.l.	15-16	Northwest Bihar to Gangetic West Bengal across Jharkhand	North	Sub Himalayan West Bengal & Sikkim to north Odisha	Became less marked on 17
3.	At 1.5 kms a.s.l.	17	Sikkim to North Bay of Bengal	Stationary	*In situ*	Became less marked on 18
4.	At 3.1 kms a.s.l.	18	North Pakistan to the Low Pressure Area over Kutch and adjoining areas of southwest Rajasthan and South Pakistan	Do	Do	Became less marked on 19
(G)	*East-west shear zone*					
1.	Between 3.1 and 4.5 kms a.s.l.	5-10	Along Lat. 7° N	North	Along Lat. 12° N	Became less marked on 11
2.	Between 4.5 and 5.8 kms a.s.l	19-20	Eastcentral & adjoining northeast Bay of Bengal to Lat.14° N (At 7.6 km a.s.l. along 11° N)	South	Along Lat.14° N	It became less marked on 21
3.	Between 3.1 and 3.6 kms a.s.l.	25-26	Along Lat. 16° N	Stationary	*In situ*	It became less marked on 27

northwestwards and weakened into a low pressure area over southeast Uttar Pradesh and adjoining northeast Madhya Pradesh on 5 and became less marked on 6 July.

Another low pressure area formed over western parts of Bihar and adjoining Jharkhand on 6 July. It intensified into a well marked low pressure area in the evening of the same day over East Uttar Pradesh and adjoining Bihar. It weakened and lay as a low pressure area over northeast Uttar Pradesh and adjoining Bihar on 11 July and became less marked on 12 July. Second low of July formed over Northwest Bay of Bengal and adjoining coastal areas of West Bengal on 26. It became less marked on 28 over Jharkhand and adjoining Gangetic West Bengal. One more low pressure area formed over east Madhya Pradesh and adjoining Chhattisgarh on 30 July and became less marked over central parts of north Madhya Pradesh and neighbourhood on 1st August.

A low pressure area formed over Northwest Bay of Bengal and adjoining West Bengal-Bangladesh coasts on 12 August; it moved inland and lay over southern parts of Gangetic West Bengal and adjoining north Odisha on 13 August and over north western parts of Chhattisgarh

TABLE 6

Details of the weather systems during July 2019

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	1-4 (0300 UTC)	Northwest Bay of Bengal & adjoining areas of West Bengal and Odisha coasts	North west	Central parts of south Uttar Pradesh and adjoining north Madhya Pradesh	Low formed under the influence of the cyclonic circulation over north Bay of Bengal off West Bengal coast, on 30th June. Weakened as a low pressure area over central parts of south Uttar Pradesh and adjoining north Madhya Pradesh, on 5th morning and became less marked in the evening of 6
2.	Do	9-11	East Uttar Pradesh & adjoining Bihar	Stationary	East Uttar Pradesh & adjoining Bihar	Under the influence of a cyclonic circulation over West Bengal & adjoining Jharkhand extending upto 7.6 km above m.s.l., a feeble Low formed over western parts of Bihar & adjoining Jharkhand in the evening of 6. Weakened as a low pressure area over northeast Uttar Pradesh and adjoining Bihar on 11 and became less marked on 12. Associated cyclonic circulation lay as a trough in westerlies between 3.1 & 4.5 km above mean sea level roughly along Long. 87° E till 17
3.	Low Pressure area	26-27 (1200 UTC)	Northwest Bay of Bengal & adjoining coastal areas of West Bengal	Southwest	Jharkhand and adjoining Gangetic West Bengal	It became less marked on 28. The associated cyclonic circulation merged with the trough at mean sea level from central parts of northwest Rajasthan to northwest Bay of Bengal
4.	Do	30-31	East Madhya Pradesh and adjoining Chhattisgarh	West	Central parts of north Madhya Pradesh and neighbourhood	It Became less marked on 1st August. The associated cyclonic circulation lay over northwest Madhya Pradesh and neighbourhood between 1.5 & 3.6 km above m.s.l. and merged with the monsoon trough on 3rd August
(**B**) *Western disturbances /eastward moving systems*						
(*i*) *Upper air cyclonic circulation*						
1.	At 5.8 kms a.s.l.	7-8	Over north Pakistan & neighbourhood	East	Jammu & Kashmir and neighbourhood	Moved away northeastwards
2.	Between 3.1 & 3.6 km a.s.l.	30 Jun - 3 Jul	North Pakistan and neighbourhood	Do	Northern parts of Jammu & Kashmir	Initially it lay as a trough along Long. 66° E to the north of Lat. 32° N on 29th June. Moved away northeastwards in the evening of 3rd July
3.	Upto 3.1 kms a.s.l.	12-18 (0000 UTC)	Eastern parts of Iran and adjoining Afghanistan	Do	Eastern parts of Jammu & Kashmir and neighbourhood	Moved away northeastwards on 18 (1200 UTC)
4.	Between 4.5 & 5.8 km a.s.l.	25-29	Western parts of Afghanistan & neighbourhood	Do	Jammu & Kashmir and neighbourhood	A trough aloft with its axis at 5.8 km above mean sea level roughly along Long. 73° E to north of Lat. 32° N on 28 and 29. Moved away northeastwards
(*ii*) *Trough in westerlies*						
1.	Mid & upper tropospheric levels	4	Along Long. 70° E to the north of Lat. 32° N	Stationary	*In situ*	It moved away northeastwards

TABLE 6 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.	Upto 1.5 kms a.s.l.	15-16	Along Long. 88° E to the north of Lat. 22° N	East	Along Long. 92° E to the north of Lat. 25° N	It was seen as a cyclonic circulation over central Assam extending upto 0.9 km above mean sea level on 17. Became less marked on 18
(**C**)	*Other upper air cyclonic circulations*					
1.	At 5.8 km a.s.l.	4	North Madhya Maharashtra and adjoining south Gujarat	Stationary	*In situ*	Became less marked on 5
2.	Do	4	South Chhattisgarh & neighbourhood has	Do	Do	Merged with the cyclonic circulation between 3.1 and 7.6 km a.s.l. over Northwest Bay of Bengal & adjoining Gangetic West Bengal tilting southwards with height on 5
3.	Do	8-9	Northeast Rajasthan & adjoining Haryana	Do	Do	Became less marked on 10
4.	At 1.5 km a.s.l.	8	Punjab and neighbourhood	Do	Do	It merged with the trough from Punjab to Nagaland on 9
5.	Upto 1.5 kms a.s.l.	9-11	Central Pakistan & neighbourhood	East	North Pakistan & adjoining Punjab	Became less marked on 12
6.	At 7.6 kms a.s.l.	10-11	South Rajasthan & adjoining north Gujarat	Stationary	*In situ*	Became less marked on 12
7.	Between 4.5 and 5.8 kms a.s.l.	8-13	Gujarat region & adjoining north Maharashtra	Do	South Gujarat and neighborhood	Became less marked on 14
8.	At 7.6 kms a.s.l.	10	Southwest & adjoining Westcentral Bay of Bengal off north Tamilnadu-south Andhra Pradesh coasts	Do	*In situ*	Became less marked on 11
9.	Upto 0.9 kms a.s.l.	13	Northwest Uttar Pradesh and neighborhood	Do	Do	Became less marked on 14
10.	Between 3.1 and 5.8 kms a.s.l.	13	Coastal Tamilnadu & neighborhood	Do	Do	Became less marked on 14
11.	Upto 0.9 kms a.s.l.	14-20	Central Pakistan & adjoining Punjab	East	Western parts of Haryana & neighbourhood	Became less marked on 21
12.	At 5.8 kms a.s.l.	15	Eastcentral Arabian Sea off Karnataka	Stationary	*In situ*	Became less marked on 16
13.	Upto 0.9 kms a.s.l.	16-18	Northeast Rajasthan & adjoining Haryana	East	Southwest Uttar Pradesh and neighbourhood	It lay embeded in trough at mean sea level from northwest Rajasthan to northeast Bay of Bengal. Became less marked on 19
14.	At 5.8 kms a.s.l.	16	Eastcentral Bay of Bengal off Myanmar coast	Northwest	Northwest Bay of Bengal and adjoining coastal Odisha	It merged with cycclonic circulation over northwest Bay of Bengal and adjoining coastal Odisha & Gangetic West Bengal on 17
15.	Between 3.1 & 5.8 km a.s.l.	17-18	Punjab & neighborhood	East	Haryana & neighbourhood	Became less marked on 19
16.	Upto 7.6 kms a.s.l.	17-24	Northwest Bay of Bengal, adjoining Coastal Odisha & Gangetic West Bengal	West	South Gujarat & neighbourhood	Became less marked on 25
17.	At 1.5 kms a.s.l.	18	East Assam & neighbourhood	Stationary	*In situ*	Became less marked on 19
18.	Between 3.1 & 3.6 km a.s.l.	18	Southwest Rajasthan & neighbourhood	Do	Do	Became less marked on 19

TABLE 6 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
19.	At 7.6 kms a.s.l.	19	North Kerala & neighbourhood	Stationary	*In situ*	Became less marked on 20
20.	Between 3.1 & 3.6 km a.s.l.	19-20	Eastcentral Arabian Sea off Maharashtra coast	East	North Madhya Maharashtra & neighbourhood	It merged with the cyclonic circulation over north Madhya Maharashtra & neighbourhood extending upto 5.8 Km above sea level on 21
21.	At 7.6 kms a.s.l.	20-24	South coastal Tamilnadu & neighbourhood	Northwest	Telangana and adjoining areas of Rayalaseema and Interior Karnataka	Became less marked on 25
22.	Between 3.1 & 5.8 kms a.s.l.	20-21	Southeast Bay of Bengal and adjoining South Andaman Sea	Do	Southeast & adjoining Eastcentral Bay of Bengal and north Andaman Sea	Became less marked on 22
23.	Do	21-25	Jammu & Kashmir and adjoining Pakistan	Southeast	South Haryana & neighbourhood	Merged with the trough from the cyclonic circulation associated with the low pressure area over northwest Bay of Bengal & adjoining coastal areas of West Bengal to north Rajasthan on 26
24.	Upto 1.5 kms a.s.l.	21	Central parts of Rajasthan	Stationary	*In situ*	Became less marked on 22
25.	Between 3.6 & 5.8 kms a.s.l.	24	Sub-Himalayan West Bengal & neighbourhood	Do	Do	Merged with the cyclonic circulation over northern parts of West Bengal & neighbourhood on 25
26.	Upto 5.8 kms a.s.l.	25-30	Northeast Uttar Pradesh & neighborhood	West	Southwest Rajasthan & neighbourhood	Moved away westwards on 31
27.	Upto 0.9 kms a.s.l.	30	Central Assam & neighbourhood	Stationary	*In situ*	Became less marked on 31
28.	At 7.6 kms a.s.l.	31 Jul - 1 Aug	Eastcentral Arabian Sea & adjoining Konkan	Do	Eastcentral Arabian Sea and adjoining South Konkan & Goa	Became less marked on 2
29.	Do	31 Jul - 2 Aug	South Odisha & adjoining north Coastal Andhra Pradesh	Quasi-Stationary	Westcentral and adjoining Northwest Bay of Bengal off north Andhra Pradesh-south Odisha coasts	Merged with the cyclonic circulation over Northwest Bay of Bengal & adjoining coastal areas of West Bengal and Odisha on 3
(**D**)	*Other troughs*					
1.	Upto 1.5 kms a.s.l.	22-23	North Madhya Maharashtra & neighbourhood to south Coastal Andhra Pradesh	South	Eastcentral Arabian Sea & adjoining north Konkan to south Coastal Andhra Pradesh	Became less marked on 24
2.	Between 3.1 & 7.6 km a.s.l.	26 Jul - 6 Aug	Northern parts of West Bengal and neighbourhood to north Rajasthan	Do	South Gujarat to north Odisha-West Bengal coasts	Became less marked on 7
(**E**)	*East-west shear zone*					
1.	Between 4.5 & 5.8 kms a.s.l.	1	Along Lat. 20° N	Stationary	*In situ*	Became less marked on 2
2.	Between 3.6 & 4.5 kms a.s.l.	4-5	Along Lat. 21° N	Quasi-Stationary	Do	It was seen at 3.6 km above mean sea level on 5 and has become less marked on 6
3.	Between 4.5 & 5.8 km a. s. l	19-20	Along Lat. 15.0° N	Stationary	Do	Became less marked on 21

TABLE 7

Details of the weather systems during August 2019

S. No.	System	Duration	Place of initial location	Direction of movement	Place of final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**) *Deep depression/depression*						
1.	Deep Depression	6-7	Northwest Bay of Bengal off north Odisha-West Bengal coasts Lat. 20.5° N & Long. 88.0° E	Westnorth-west	North Chhattisgarh & neighbourhood Lat. 23.8° N and Long. 77.3° E	Details are given in the article on Storms & Depressions over the north Indian Ocean - 2019
(**B**) *Well marked low/low pressure area*						
1.	Well marked Low pressure area	15-16	Northwest Madhya Pradesh and adjoining south Uttar Pradesh	West	Haryana and adjoining west Uttar Pradesh	It formed under the influence of the cyclonic circulation over northeast & adjoining eastcentral Bay of Bengal and neighbourhood between 3.1 & 5.8 km above mean sea level. It became a well marked Low over Northeast & adjoining eastcentral Bay of Bengal and neighbourhood. Associated cyclonic circulation extended upto 7.6 km above mean sea level tilting southwestward with height. It weekend as low on 17 and became less marked on 19
2.	Low pressure area	18-22 (1200 UTC)	Central parts of Gangetic West Bengal & adjoining Jharkhand	Northwest	Northeast Madhya Pradesh and adjoining south Uttar Pradesh	It formed under the influence of cyclonic circulation over West Bengal and adjoining Bangladesh. Became less marked on 23
3.	Do	24-25	Coastal Odisha & neighbourhood	West	North Chhattisgarh and adjoining East Madhya Pradesh	The associated cyclonic circulation extended upto 7.6 km above mean sea level tilting westwards with height. It merged with the Monsoon trough on 26
4.	Do	29	Northwest Bay of Bengal and adjoining areas of Gangetic West Bengal & north Odisha	Stationary	*In situ*	It formed under the influence of the cyclonic circulation over north Bay of Bengal & neighbourhood. Associated cyclonic circulation extended upto 7.6 km above mean sea level tilting southwestwards with height. Low pressure area became less marked on 30th and associated cyclonic circulation became less marked on 3rd September
(**C**) *Western disturbances/eastward moving systems*						
(*i*) *Upper air cyclonic circulation*						
1.	At 3.1 kms a.s.l	13-14	Northern parts of Jammu & Kashmir and neighbourhood	South	Jammu & Kashmir and neighbourhood	Initially it lay as a trough along Long. 65° E to the north of Lat. 31° N on 11th. Moved away east-northeastwards
2.	Between 3.1 & 3.6 kms a.s.l.	23-25	North Pakistan & neighbourhood	East	Do	Initially it ran as a trough in westerlies with its axis at 7.6 kms a.s.l. along the Long. 70° E to the north of 30° N on 22. Moved away northeastwards on 26
3.	Between 3.1 & 5.8 kms a.s.l.	26-30 (0300 UTC)	Central parts of Afghanistan	Northeast	Eastern parts of Jammu & Kashmir	A trough lay aloft ran at 5.8 kms a.s.l. roughly along Long. 70° E/Lat. 30° N which became less marked on 29. Moved away northeastwards
(*ii*) *As A trough*						
1.	Upper tropospheric westerlies	3-5	Long. 70° E to the north of Lat. 34° N, (at 7.6 kms a.s.l.)	East	Long. 76° E	It moved away east northeastwards

TABLE 7 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.	Mid-tropospheric westerlies	14-15	Long. 60° E to the north of Lat. 30° N at 5.8 kms a.s.l.	East	Long. 68° E	It moved away east northeastwards
3.	Do	16-21	Long. 62° E to the north of Lat. 30° N at 5.8 kms a.s.l.	Do	Long. 75° E	It moved away east northeastwards
4.	Do	31 - 1 Sep	Long. 65° E to the north of Lat. 30° N at 5.8 kms a.s.l.	Do	Long. 67° E	Became less marked on 2 September
(D)	*Other upper air cyclonic circulations*					
1.	Upto 1.5 kms a.s.l.	1	Central Assam and neighbourhood	Stationary	*In situ*	Became less marked on 2
2.	Between 1.5 & 2.1 kms a.s.l.	2-4	Punjab and neighbourhood	Do	Do	Became less marked on 5
3.	Upto 1.5 kms a.s.l.	3	Central Pakistan & neighbourhood	Do	Do	Became less marked on 4
4.	Do	6	Haryana & neighbourhood	Do	Do	Merged with the monsoon trough on 7
5.	Between 3.1 & 4.5 kms a.s.l.	7	Northwest Madhya Pradesh & neighbourhood	Do	Do	Became less marked on 8
6.	At 1.5 kms a.s.l.	8	Central Pakistan & neighbourhood	East	Punjab & neighbourhood	Became less marked on 10
7.	Between 7.6 & 9.5 kms a.s.l.	8	Southeast Arabian Sea off Kerala coast	Stationary	*In situ*	Became less marked on 9
8.	At 7.6 km kms a.s.l.	10	South coastal Andhra Pradesh & neighbourhood	Do	Do	Became less marked on 11
9.	Between 4.5 & 5.8 km a.s.l.	10	Manipur & neighbourhood	Do	Do	Became less marked on 11
10.	Between 2.1 & 4.5 km a.s.l.	12	South Haryana & neighbourhood	Do	Do	Became less marked on 13
11.	At 7.6 km a.s.l.	12-19	Interior Tamil Nadu & neighbourhood	Northwest	North coastal Tamil Nadu & neighbourhood	Became less marked on 20
12.	At 3.1 kms a.s.l.	14	Southwest Rajasthan & neighbourhood	Stationary	*In situ*	Merged with the trough from northwest Madhya Pradesh and adjoining south Uttar Pradesh to north Gujarat Region across East Rajasthan on 15
13.	Upto 0.9 kms a.s.l.	16	Central Assam & neighbourhood	Do	Do	Became less marked on 17
14.	Between 1.5 & 3.1 km a.s.l.	17	Kutch & neighbourhood	Do	Do	Became less marked on 18
15.	Between 2.1 & 4.5 kms a.s.l.	19-25	Saurashtra & neighbourhood	Oscillatory	Northeast Arabian Sea & neighbourhood	Became less marked on 26
16.	At 1.5 kms a.s.l.	20	West Assam and neighbourhood	Stationary	*In situ*	Became less marked on 21
17.	Upto 1.5 kms a.s.l.	21-22	Central Pakistan & neighbourhood	Do	Do	Became less marked on 23
18.	Between 3.1 & 3.6 kms a.s.l.	21	West Assam & neighbourhood	Do	Do	Became less marked on 22
19.	Between 5.8 & 7.6 kms a.s.l.	22-23	East Vidarbha & neighbourhood	Do	Do	Merged with the cyclonic circulation associated with the low pressure area over coastal Odisha & neighbourhood on 24

TABLE 7 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
20.	Upto 0.9 kms a.s.l.	24	South Bangladesh & adjoining Gangetic West Bengal	Northwest	East Madhya Pradesh & adjoining Chhattisgarh	Merged with the monsoon trough and the shear zone between 3.1 and 5.8 km above mean sea level along Lat. 22° N on 27
21.	At 3.1 kms a.s.l.	26	Eastcentral Arabian Sea & adjoining south Konkan	Stationary	*In situ*	Merged with the east west shear zone along Lat. 22° N between 3.1 and 5.8 km above mean sea level on 27
22.	Do	26	South Punjab & neighbourhood	Do	Do	Became less marked on 27
23.	At 0.9 kms a.s.l.	27	West Rajasthan & neighbourhood	Do	Do	Merged with the monsoon trough on 28
24.	At 5.8 kms a.s.l.	28	Saurashtra & neighbourhood	Do	Do	Became less marked on 29
25.	Upto 3.1 kms a.s.l.	29-3 Sep	North Gujarat & neighbourhood	West	Kutch & neighbourhood	Became less marked on 4
26.	At 5.8 kms a.s.l.	30	Southeast Arabian Sea, along & off Kerala and Lakshadweep coasts	Stationary	*In situ*	Became less marked on 31
27.	Upto 1.5 kms a.s.l.	31 (0530 IST)	East Madhya Pradesh & adjoining Chhattisgarh	Do	Do	Merged with the cyclonic circulation over north Chhattisgarh & adjoining East Madhya Pradesh on 31 (0830 IST)
28.	Upto 0.9 kms a.s.l.	31-1 Sep	North Harayana & neighbourhood	Do	Do	Became less marked on 2 September
29.	Do	31	South Assam & neighbourhood	Do	Do	Became less marked on 1 September
(E)	*North-south trough/other trough*					
1.	Between 3.1 & 7.6 kms a.s.l.	8-10	Southwest Rajasthan to northwest Bay of Bengal	Eastward	Northern parts of Gujarat region & adjoining south Rajasthan to Jharkhand	Became less marked on 11
2.	At 1.5 kms a.s.l.	9	Along Long. 92° E to the north of Lat. 24° N	Stationary	*In situ*	Became less marked on 10
3.	Between 3.1 & 3.6 kms a.s.l.	15-16	From the cyclonic circulation associated with the Well Marked Low Pressure Area over northwest Madhya Pradesh and adjoining south Uttar Pradesh to north Gujarat Region	East	Low pressure area to Gujarat Region	Became less marked on 17
4.	Upto 0.9 km above m.s.l.	20-21	Centre of low pressure area over southeast Uttar Pradesh & adjoining Jharkhand and Bihar to north Tamil Nadu	Do	Centre of Low Pressure area over southeast Uttar Pradesh & neighbourhood to Coastal Andhra Pradesh	Became less marked on 22
(F)	*East-west shear zone*					
1.	Between 5.8 & 7.6 km a.s.l.	19	Along Lat. 14° N	Stationary	*In situ*	Became less marked on 20
2.	Do	26-28	Along Lat. 22° N	Do	Do	Became less marked on 29

TABLE 8

Details of the weather systems during September 2019

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.	VSCS (HIKKA)	22-25 (0830 IST)	Northeast Arabian Sea off Gujarat coast 19.8° E/69.4° N	West	Lat. 19.3° N/ Lomg. 55.0° E	Weakened into a well marked low pressure area and lay centred over south Oman and adjoining Saudi Arabia on 25
(**B**)	*Deep depression/depression*					
1.	Depression	29 (1730 IST) - 30	Kutch and neighbourhood Lat. 23.1° N/Long. 70.2° E	East	Rajasthan & neighbourhood	Weakened over southeast Rajasthan & neighbourhood
(**C**)	*Well marked low/low pressure area*					
1.	Low	2-16	Northwest Bay of Bengal & neighbourhood	North west	North Madhya Pradesh & adjoining south Uttar Pradesh	It formed under the influence of a cyclonic circulation over Northwest Bay of Bengal & adjoining areas of Westcentral Bay of Bengal and south Odisha-north Andhra Pradesh coasts. Became less marked on 17. However the associated cyclonic circulation extending upto 3.1 km above m.s.l. lay over east Madhya Pradesh and neighbourhood
(**D**)	*Western disturbances/eastward moving systems*					
(*i*)	*Upper air cyclonic circulation*					
1.	At 3.1 kms a.s.l.	7-8	West Afghanistan & neighbourhood	Northeast	North Pakistan & adjoining Jammu & Kashmir	Moved away east-northeastwards
2.	Between 1.5 & 3.1 kms a.s.l	16-18	Central parts of Pakistan & neighbourhood	Stationary	*In situ*	Became less marked on 19
3.	At 5.8 km a.s.l.	20-22	North Pakistan & neighbourhood	Do	North Pakistan & neighbourhood	Seen as a trough in westerly at 5.8 km above mean sea level along 78° E to the North of 30° N on 22. Moved away northeastwards
4.	Upto 3.1 km a.s.l.	25-27	Jammu & Kashmir and adjoining Pakistan	East	Eastern parts of Jammu & Kashmir	Moved away east-northeastwards
(**D**)	*Other upper air cyclonic circulations*					
1.	At 1.5 km a.s.l.	2	East Madhya Pradesh and adjoining areas of Chhattisgarh and southeast Uttar Pradesh	Stationary	*In situ*	It became Less marked on 3
2.	Do	4	East Assam & neighbourhood	Do	Do	It became Less marked on 5
3.	Upto 1.5 kms a.s.l	5	East Madhya Pradesh & neighbourhood	Do	Do	Merged with monsoon trough on 6
4.	Between 3.1 & 3.6 kms a.s.l.	5	North Haryana & neighbourhood	Do	Do	It became Less marked on 6
5.	Do	7 -8	Saurashtra & neighbourhood	Do	Do	Merged with the shear zone running roughly along Lat. 22° N on 9
6.	Upto 1.5 kms a.s.l.	7-9	Central Pakistan & neighbourhood	Do	Do	It became Less marked on 10
7.	Do	8	East Assam	Do	Do	It became Less marked on 9

TABLE 8 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
8.	Upto 1.5 kms a.s.l.	10-11	Northeast Assam & adjoining Arunachal Pradesh	Stationary	*In situ*	It became less marked on 12
9.	Between 3.1 & 5.8 kms a.s.l.	11-12	Coastal West Bengal & neighbourhood	Northwest	Jharkhand and neighbourhood	Merged with Monsoon Trough on 13
10.	Between 1.5 kms & 2.1 kms	11-14	Northeast Arabian Sea & neighbourhood	Stationary	Kutch and neighbourhood	Became less marked on 15
11.	At 0.9 km a.s.l.	11-12	South Haryana & neighbourhood	Quasi-Stationary	Haryana & neighbourhood	Became less marked on 13
12.	Between 3.1 & 5.8 km a.s.l.	11-12	Coastal West Bengal & neighbourhood	Stationary	Jharkhand and neighbourhood	Merged with the Monsoon trough on 13
13.	At 0.9 kms a.s.l.	11-12	South Haryana & neighbourhood	Qausi-Stationary	Haryana and neighbourhood	Became less marked on 13
14.	Between 4.5 kms & 5.8 kms a.s.l.	12-13	Tamil Nadu	West	North Kerala coast and neighbourhood	Became less marked on 14
15.	At 7.6 km a.s.l.	14-15	North Tamil Nadu	Stationary	*In situ*	Became less marked on 16
16.	Between 4.5 kms & 5.8 kms	15	South Gujarat & neighbourhood	Do	Do	Became less marked on 16
17.	Upto 5.8 kms a.s.l.	16	Malay peninsula & neighbourhood	Do	Do	Became less marked on 17
18.	Between 3.1 kms & 4.5 kms	16-19	West central & adjoining northwest Bay of Bengal off north Andhra Pradesh-south Odisha coasts	West	Rayalaseema & neighbourhood	Merged with the east-west shear zone roughly along latitude 18° N on 20
19.	Upto 2.1 kms a.s.l.	19	Madhya Maharashtra & adjoining Marathwada	Stationary	*In situ*	Merged with the low pressure area over eastcentral Arabian Sea and off north Maharashtra coast on 20
20.	At 2.1 kms a.s.l.	19	Central Pakistan & adjoining west Rajasthan	Do	Do	It became less marked on 20
21.	At 0.9 kms a.s.l.	19-24	East Assam & neighbourhood	West	Nagaland & adjoining east Assam	It became less marked on 25
23.	Do	21 (1200 IST)	Southeast Rajasthan & neighbourhood	Stationary	*In situ*	Became less marked on 22
24.	Upto 7.6 kms a.s.l.	21	Westcentral Bay of Bengal off north Andhra Pradesh coast	Do	Do	Became less marked on 22
25.	Upto 0.9 kms a.s.l.	21	Northeast Bay of Bengal & adjoining Myanmar coast	Do	Do	Became less marked on 22
26.	Upto 5.8 kms a.s.l.	22-24	Haryana & neighbourhood	West	East Rajasthan & adjoining West Madhya Pradesh	Became less marked on 25
27.	Upto 0.9 kms a.s.l.	22	Southeast Madhya Pradesh	Stationary	*In situ*	Became less marked on 23
28.	Upto 1.5 kms a.s.l.	23-25	South Rajasthan & neighbourhood	East	Kutch & adjoining areas of southwest Rajasthan and south Pakistan	Became less marked on 26
29.	Upto 0.9 kms a.s.l.	25	North Konkan & adjoining Madhya Maharashtra	Stationary	*In situ*	Merged with the cyclonic circulation over south Maharashtra coast & adjoining areas of Goa-Karnataka & eastcentral Arabian Sea on 26

TABLE 8 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
30.	At 1.5 km a.s.l.	26	Northern parts of Punjab & neighbourhood	Stationary	*In situ*	Became less marked on 27
31.	Upto 2.1 km a.s.l.	26-27	East Assam & neighbourhood	West	East Assam & adjoining Nagaland	Became less marked on 28
32.	Between 1.5 & 3.1 km a.s.l.	27 Sep - 3 Oct	Southwest Uttar Pradesh & neighbourhood	East	Merged with the trough running from northwest Rajasthan to Gangetic West Bengal on 4th October	A trough aloft at 4.5 km above m.s.l. ran roughly along Long. 85.0° E to the north of Lat. 23.0° N on 30th and became less marked on 1 October
33.	Upto 0.9 km a.s.l.	27	South Pakistan & adjoining west Rajasthan	Stationary	*In situ*	Became less marked on 28
34.	Upto 1.5 km a.s.l.	27	Equatorial Indian Ocean and adjoining south Bay of Bengal	Do	Do	Became less marked on 29
35.	Upto 2.1 km a.s.l.	27	Northeast Bay of Bengal & neighbourhood	Do	Do	Merged with trough from south Uttar Pradesh & adjoining north Madhya Pradesh to northeast Bay of Bengal across Jharkhand and Gangetic West Bengal on 28
36.	Upto 0.9 km a.s.l.	28	Comorin area & adjoining south Tamil Nadu	West	Southeast Arabian Sea and adjoining Maldives-Lakshadweep area	Became less marked on 3 October
37.	Do	28	Central Pakistan & adjoining northwest Rajasthan	Stationary	*In situ*	Became less marked on 29
38.	At 5.8 km a.s.l.	29	Punjab & neighbourhood	Do	Do	Became less marked on 1 October
	(**E**) *East-west shear zone*					
1.	Between 3.1 & 5.8 km a.s.l.	2-10	Along Lat. 18° N	Stationary	Along Lat. 23° N	Became less marked on 11
2.	between 1.5 km & 5.8 km a.s.l.	18-20	Along Lat. 14° N across south peninsula	North	Along Lat. 18° N across central parts of peninsular India	It became less marked on 21
	(**F**) *North-south trough/other trough*					
1.	Between 3.1 kms & 5.8 kms a.s.l.	11-13	South Gujarat to coastal West Bengal	North	Kutch to Sub-Himalayan West Bengal	Became less marked on 14
2.	Upto 3.1 km a.s.l.	17-18	Westcentral Bay of Bengal to northwest Madhya Pradesh	Oscillatory	Westcentral and adjoining southwest Bay of Bengal to south Madhya Pradesh and adjoining Vidarbha	Moved away northeastwards on 19
3.	At 5.8 km a.s.l.	17	Along Long. 86° E to the north of Lat. 27° N	Stationary	*In situ*	Moved away northeastwards on 18
4.	At 0.9 km a.s.l.	16	Along Long. 92° E to the north of Lat. 25° N	Do	Do	Became less marked on 17
5.	Upto 0.9 km a.s.l.	24	South Andhra Pradesh & neighbourhood to southwest Madhya Pradesh	South	Interior Karnataka & adjoining areas of Rayalaseema and Telangana to southwest Madhya Pradesh	Became less marked on 25
6.	Upto 3.1 km a.s.l.	28	South Uttar Pradesh & adjoining north Madhya Pradesh to northeast Bay of Bengal across Jharkhand and Gangetic West Bengal	East	Long. 85.0° E to the north of Lat. 23.0° N	Became less marked on 1st October

TABLE 8 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(G)	*Trough in westerlies*					
1.	At 5.8 km a.s.l.	18	Eastern parts of Jammu & Kashmir to southwest Uttar Pradesh	Stationary	*In situ*	Became less marked on 19
2.	At 4.5 km a.s.l.	24	Along Long. 90° E to the north of 25° N	Do	Do	Moved away eastwards on 25
(H)	*Trough in easterlies*					
1.	Between 1.5 & 3.1 km a.s.l.	21-22	North Punjab to the centre of depression over eastcentral and adjoining northeast Arabian Sea off Gujarat coast	South	North Punjab to the centre of Depression	Became less marked on 23
2.	Upto 5.8 km a.s.l.	25	Interior Karnataka & adjoining areas of Rayalaseema and Telangana to Jharkhand	North	South Maharashtra coast & adjoining areas of Goa- Karnataka & eastcentral Arabian Sea to Bihar	Became less marked on 27
(I)	*East west trough*					
1.	Between 0.9 & 3.1 kms a.s.l.	14-15	Northwest Madhya Pradesh to Jharkhand	North	Southwest Rajasthan to northeast Bihar	Became less marked on 16
2.	At mean sea level	18	Saurashtra to eastcentral Bay of Bengal across Interior Maharashtra, Telangana, Coastal Andhra Pradesh and westcentral Bay of Bengal	Stationary	*In situ*	Became less marked on 19

and neighbourhood on 14 August. It lay as a well marked low pressure area over northwest Madhya Pradesh and adjoining south Uttar Pradesh. It moved north westwards and weakened on 19 August. Second system in August formed under the influence of a cyclonic circulation over West Bengal and adjoining Bangladesh extending upto 7.6 km above mean sea level, over central parts of Gangetic West Bengal and adjoining Jharkhand on 18th. It became less marked over northeast Madhya Pradesh and adjoining south Uttar Pradesh in the evening of 22 August. In the last week of August, a low pressure area formed under the influence of the cyclonic circulation over northwest Bay of Bengal off Odisha - West Bengal coasts, with associated cyclonic circulation extending upto 7.6 km above m.s.l. tilting westwards with height on 24 August. It lay as a feeble low pressure area over north Chhattisgarh and adjoining east Madhya Pradesh on 25 August. It merged with the monsoon trough on 26 August. Last low pressure area of August formed under the influence of a cyclonic circulation over north Bay of Bengal and neighbourhood on 29 August over northwest Bay of Bengal and adjoining areas of Gangetic West Bengal and north Odisha. It became less marked on 30 August.

In September a low pressure area formed under the influence of cyclonic circulation over Northwest Bay of Bengal and adjoining areas of west central Bay of Bengal and south Odisha-north Andhra Pradesh coasts on 2 September. It moved north-westwards and became less marked on 17 September.

Very Severe Cyclonic Storm 'HIKAA' formed over northwest and adjoining westcentral Arabian Sea (22-25 September, 2019). It formed out of a low pressure area over east central Arabian Sea off north Maharashtra coaston 20 September morning. It concentrated into a Depression (D) over eastcentral and adjoining northeast Arabian Sea off Gujarat coast in the morning of 22nd September. It intensified into a deep depression (DD) over northeast and adjoining eastcentral Arabian Sea off Gujarat coast in the same evening. It moved nearly westwards and intensified into cyclonic storm "HIKAA" in the early morning of 23rd over northeast and adjoining eastcentral Arabian Sea. It then moved west-southwest-wards and intensified, into a severe cyclonic storm (SCS) in the same afternoon over northeast and adjoining northwest and central Arabian Sea. Moving nearly

westwards, it further intensified into a VSCS in the early morning of 24th September over northwest and adjoining westcentral Arabian Sea. It then moved west-southwest-wards and crossed Oman coast near latitude 19.7° N and longitude 57.7° E, close to north of Duqm in the same evening as a VSCS. It weakened into a cyclonic storm over Oman in the early hours of 25th, into a DD over Oman in the morning and a depression around noon over Oman.

The month of August also witnessed the formation of a Deep Depression over Northwest Bay of Bengal off north Odisha - West Bengal coastsduring 6-9 August. It formed as a Low Pressure Area over North Bay of Bengal and adjoining coastal areas of Bangladesh and West Bengal on 5 August. It lay as a well markedlow pressure area over the same region on 6th early morning. It concentrated into a depression over Northwest Bay of Bengal off north Odisha - West Bengal coast on 6th morning. Moving initially west-northwestwards and then north-westwards it intensified into a Deep Depression in the early morning of 7 August and lay over the same region. Moving north westwards, it crossed north Odisha-West Bengal coasts close to north of Balasore (Odisha) between 0800 & 0900 UTC of the same day and lay over north Odisha and neighbourhood in the evening of 7th. It continued to move westnorthwestwards and weakened into a Depression and lay centred in the early morning of 8th, over northeast Chhattisgarh and neighbourhood. The Depression continued to move westnorth westwards and weakened into a well marked low pressure area over southeast Rajasthan and neighbourhood in the evening of 9th. It continued to move further northeastwards and weakened as low pressure area over northwest Arabian Sea and neighbourhood on 12th evening.

A Depression formed over Gulf of Kutch and neighbourhood (29 - 30 September). This depression was first seen as a low pressure area over northeast Arabian Sea and adjoining areas of Saurashtra and Kutch on 29 September. It became well marked over Gulf of Kutch and neighbourhood on the same day. It concentrated into a Depression on 29 September evening. It moved further north eastwards and lay over Saurashtra and adjoining Gujarat region around noon of 30 September. Moving east-north eastwards it lay centred at 0000 UTC of 1October, over southeast Rajasthan and neighbourhood. It thenweakened into a well marked low pressure areaover the same regionon 1 October. It weakened into a low pressure area over northern parts of east Madhya Pradesh and neighbourhood on 2 October.

The off-shore trough along different parts of the west coast persisted from 7 June-9 September except during 9-11 June, 15-19 June, 23 June-2 July, 5-8 July and 26 July-2 August, 15 August, 17 August-1 September.

The Somali Low Level Jet (LLJ) remained stronger than normal for nearly the entire two months of August and September. This seems to have significant contribution to the prolonged wet spell leading to flood situation over Maharashtra, Kerala and Karnataka during the period.

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 the Arabian Sea was stronger than normal in the 1st week of June, in the 2nd week it was just below normal and for the 3rd and 4th week it was near normal, during June 2019. It was near normal in 2nd, 3rd and 4th week and weaker than normal in 1st week of July 2019. Weaker than normal in 1st and 4th week, near normal in 3rd week and stronger than normal in the 2nd week of August 2019. Stronger than normal in 1st and 3rd week while it was normal in 2nd and 4th week during September 2019.

The surface winds over the Arabian Sea to the north of 5° N were Stronger than normal in 2nd and 3rd week and in the 4th week it was normal, while in the 1st week it was weaker than normal during June 2019. It was normal during all the weeks of July 2019. Close to normal in 1st and 3rd week, stronger than normal in 2nd week but weaker than normal in the 4th week of August 2019. They were stronger than normal during September 2019.

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 weaker than normal in the 1st week, normal in the 2nd and 3rd week during June 2019. It was close to normal in 1st and 2nd week and was stronger than normal in 3rd and 4th week July 2019. It was stronger than normal in August 2019 & in September 2019.

The surface winds over the Bay of Bengal to the north of 5º N were close to normal in 1st, 2nd and 3rd week and stronger than normal in the 4th week of June 2019. Close to normal in 1st, 2nd and 4th week and stronger than normal in the 3rd week of July 2019. Stronger than normal in 1st, 2nd and 4th week and close to normal in the 3rd week of August, 2019. Stronger than normal during September 2019.

Position of equatorial trough was close to normal position in the first and third week. In the second week it was south of its normal position by 2-3° and in the fourth week, it was to south of its normal by 2-3° to the E of 65° E and was close to normal to W of 65° E, in the

month of June 2019. In the first and second week of July, it was close to the normal, from 60-100° E, it was to the north of its normal position by 2-3°. In the third and fourth week, to the west of 70° E and to east of 70° E, it was to the north of its normal by 2-3°. It was south of its normal by 8-10° in July 2019. In the first week of August it was to the north of its normal position by 1- 4°. In second week, it was to the south of its normal position, but to the east of 90° E, it was to the north of its normal by 2-3°. In the 3rd week it was to the south of its normal to west of 65° E varying between 0-20° but to east of 65° E it was to the north of its normal by 0-3°. In the fourth week, it was close to the normal to W of 90° and to east of 90° E, it was to the north by 0-3° in August 2019. In the first and second week of September, it was close to the normal. In the third week, it was close to the normal, but to the east of 65° E it was to the north of normal by 3° and in the 4th week it was to the south of its normal W of 65° E varying between 3-15° but to east of 65° E it was to the north of its normal by 2° in September 2019.

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

(*i*) In the West Pacific Ocean/South China Sea

There were, in all, 19 low pressure systems (reaching the intensity of Tropical depression and above) in the north-west Pacific Ocean/South China Sea during June-Sept., 2019.

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 were 5 in June, 4 in July, 2 in August and 4 in September at 500 hPa and 5 in June and August each, 3 in July and 4 in September at 300 hPa.

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

The troughs in upper air westerlies which moved across the South Indian Ocean from west to east penetrated to the north of Lat. 30° S, in the Southern Hemisphere, during June to September 2019 are 8 in June, 7 in July, 8 in August and 7 in September at 500 hPa and 10 in June, 9 in July, 7 in August and 8 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-Sept., 2019.

4.5.2. *Mascarene High*

The Mascarene High with its mean position at 30.4° S/62.3° E was weaker than normal by -0.5 hPa during the monsoon period June to September 2019. It was above normal by 0.4 and 1.0 in June and July respectively and below normal by -2.7 and -0.5 hPa during the months of August and September 2019 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 second week of June. It was mostly seen in its near normal position all through the season with varying intensity. It started gradually filling up from first week of September and became less marked in the first week of October.The lowest and the second lowest values of the Heat Low were:

Jun : 996 hPa (on 11) and 994 hPa (on 30)

Jul : 982 hPa (on 7 and 10) and 992 hPa (8), 995 (23), 998 (26-28)

Aug : 994 hPa (on 1, 2, 6, 7 and 11) and 996 hPa (on 5, 8, 10 and 13)

Sep : 998 hPa (on 6, 7 and 12), 1000 hPa (9-11)

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 all through the month of June. With the southwest monsoon covering the entire country, it got established as the monsoon trough south of its normal position on 19th July. The trough remained in the near normal position for most of the days till mid August. It remained to the south of normal position till 15th September. The monsoon trough got disorganized and disappeared from the pressure and wind field from 18th September.

5.3. *Tibetan anticyclone/high*

This year, the Tibetan anticyclone was seen to either south to southeast of its normal position upto mid-June. Then it was seen to the east/south east of normal and got established in its near normal position on 4 July. Almost all through the month of July it remained either to the north, east or west of normal position and in August it remained to the northeast or east of normal. In September, it remained to the east or southeast on most days in the

first three weeks. It then shifted southeastwards thus becoming unimportant in the third week of October.

5.4. *Tropical Easterly Jet (TEJ)*

The TEJ got established over the southern tip of Peninsular India by 1 June with Minicoy reporting easterlies of 64 kts at 98 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 110 kts at 129 hPa was reported at Aminidivi on 11 July.

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

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

The STWJ started shifting northwards from the last week of June. Srinagar reported 84 knots wind (at 190 hPa) at 0000 UTC of 28 June. Subsequently, the core of STWJ shifted to the north of the Himalayas. However, it was not observed over Indian latitude from 10 July. 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 70 knots westerly wind reported over Srinagar at 184 hPa on 3 October 0000 UTC.

6. Disastrous weather events and damage during Monsoon months

Several record-breaking extreme rainfall and resultant flood events caused human casualty and property damage in states including Maharashtra, Karnataka, Kerala, West Bengal, Odisha, Uttar Pradesh and Madhya Pradesh during later part of July to September.

During the season heavy rain and flood related incidents reportedly claimed at least 1900 lives from different parts of the country. The highest number of deaths nearly 382, were reported from Maharashtra and 227 from West Bengal, 149 persons were reported dead in Bihar during the season (39 in July and 110 In September), 112 from Uttar Pradesh (of which 14 in the month of July, 19 in the month of August and 79 in month of September), 88 From Kerala in August, 27 from Gujarat, 31 in Karnataka, 27 in Himachal Pradesh.

The data provided in this section are consolidated from the flood situation report information available in the media reports.

6.1. *June*

Severe heat waves killed at least 90 people in Bihar. In Jammu, Kashmir and Ladakh, a stormin Bandipora district claimed 2 lives. 26 people were killed and 57 injured after severe dust storms swept over many parts of Uttar Pradesh on 6 June. At least 38 people were killed and 11 injured after thunderstorm and lightning struck different parts in eastern state of Bihar

6.2. *July*

Torrential monsoon rainfall in north east India caused flooding in several states, affecting over 4 million people, leaving thousands displaced and dozens dead. Total 91 persons died due to heavy rain during the month. From Maharashtra state, 23 from Mumbai suburban on second, 13 from Ratnagiri on third. In Uttar Pradesh 14 from Fatehpur, Mahoba, Pilibhit, Kanpur dehat, Sonbhadra, Hardoi, Kushinagar, Pratapgad, Sitapur, Kannoj, Barabanki and Jaunpur districts on 12. 2 from Solan district of Himachal Pradesh on fourteenth, 39 from parts of Bihar on 16 and 20 July. Total 5 persons reportedly claimed dead from Maharashtra due to lightning. Total 45 persons reportedly died due to thunderstorm during the month from Jharkhand.

6.3. *August*

Rain related incidents reportedly claimed more than 261 lives from different parts from the country during the month. The most severely affected state was Kerala from where at least 88 deaths were reported during the period 8-19 August. Wayanad, Malappuram, Kozhikode, Kannur, Palakkad, Thrissur and Ernakulam districts of Kerala were the worst affected. Deaths due to heavy rain and floods were also reported from other parts of the country, where it took a toll of 56 person in Maharashtra, 27 persons in Gujarat and Himachal Pradesh, 19 persons in Uttar Pradesh, 31 in Karnataka.

6.4. *September*

At least 26 people diedand 5 people were missing after heavy rain and flash floods in the district of Pune, on 25 September, 2019. At least 45,000 people were evacuated to safer areas after flooding in Madhya Pradesh. Flooding affected the districts of Neemuch, Agarmalwa, Khargone, Barwani, Shajapur, Jhabua, Burhanpur, Ujjain, Ratlam, Dewas and Mandsour. Over 20 people have died in floods or storms in the state. The floods in Madhya Pradesh increased levels of rivers in Rajasthan, over 4,500 people have evacuated after flooding in the Rajasthan. The worst affected areas include the districts of Kota, Baran, Jhalawar and Dholpur. On 29 September extremely heavy

rains occured in East Uttar Pradesh in the districts of Lucknow, Kanpur, Rae-Bareilly (Raebareli), Jaunpur in the Gomti river basin, flooding Sei river at Rae-Bareilly and Gomti river at Jaunpur. Total 93 persons reportedly claimed dead due to heavy rain and floods in Uttar Pradesh during the month. In Bihar, heavy rains and floods have claimed 29 lives. Incessant heavy rain led to flooding of rivers BurhiGandak, Bagmati, Ganga, Kosi and Sone in Bihar.

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Appendix

Definitions of the terms given in '*Italics*'

Rainfall

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

Monthly/seasonal rainfall distribution on regional scale

Large Excess	- percentage departure from normal rainfall is +60% or more
Excess	- percentage departure from normal rainfall is +20% to +59%
Normal	- percentage departure from normal rainfall is from +19 % to –19 %
Deficient	- percentage departure from normal rainfall is from –20 % to –59%
Large Deficient	- percentage departure from normal rainfall is from –60 % 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