MAUSAM, **71**, 4 (October 2020), 757-778

Weather in India

POST MONSOON SEASON (October - December 2019)†

1. Introduction

Post monsoon season 2019 was cyclogenetically an active season in the Arabian Sea which witnessed the formation of 5 intense low-pressure systems of the total 6 in the North Indian Ocean (NIO) comprising of the Bay of Bengal and the Arabian Sea. The 5 systems formed in the Arabian Sea, included two Deep Depressions, one Cyclonic Storm, one Extremely Severe Cyclonic Storm and one Super Cyclonic storm. The year as a whole also witnessed development of more intense cyclones over the Arabian Sea corresponding with strongly positive Indian Ocean Dipole. However, the cyclone activity over the Bay of Bengal during 2019 had been slightly subdued, as only 3 cyclones formed against the normal of 4 per year.

In a first since 1965, two cyclones occurred, simultaneously in the Arabian Sea, with the formation of Cyclone 'MAHA' (30th October - 7th November), even as Super Cyclonic Storm 'Kyarr' (24th October - 2nd November) prevailed over the region. Likewise, Extremely Severe Cyclonic Storm 'MAHA' co-existed with Very Severe Cyclonic Storm (VSCS) 'BULBUL' over the Bay of Bengal during 5-7 November. Similarly, co-existence of Cyclonic Storm 'Pawan' over southwest Arabian Sea and a deep depression over southeast Arabian Sea in the first week of December, is the second such event after super cyclonic storm 'Kyarr' and extremely severe cyclonic storm 'MAHA'. Cyclone 'Kyarr' was the second super cyclone formed over the Arabian Sea after Cyclone 'Gonu' in 2007 during the period of 1965-2019.

The super cyclonic storm 'Kyarr', Extremely Severe Cyclonic Storm 'MAHA' and the cyclonic storm 'Pawan' did not cause any major damage to any of the States of India. The VSCS 'Bulbul' which formed over the Bay of Bengal, crossed West Bengal coast close to Sunderban Forest. Even after landfall its intensity remained maintained for 4 more hours after crossing and subsequently it maintained the cyclonic storm intensity for subsequent 9 hours over the land owing to its proximity with Sea water resulting in widespread damage in the coastal districts of West Bengal and Odisha. Weather related disasters that occurred over the country during this season were due to heavy rainfall, lightning, cold wave, dense fog and low visibility.

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

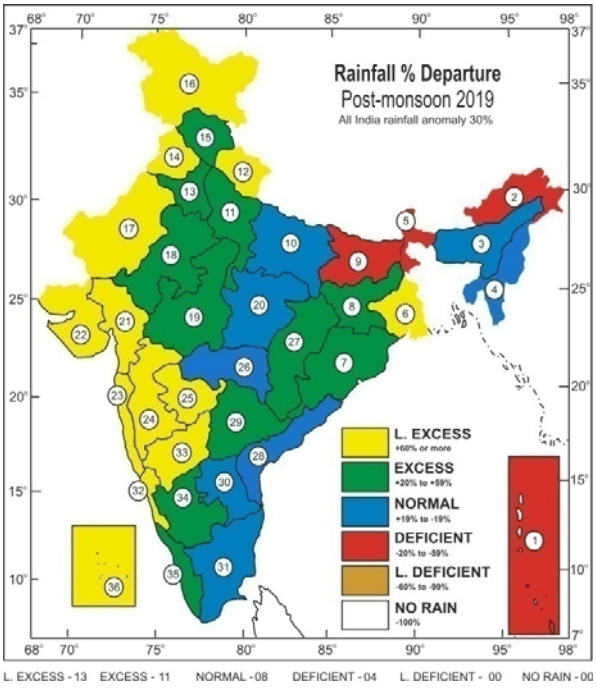

Fig. 1. Sub-divisionwise seasonal rainfall departure from normal (%) for post monsoon season (October to December 2019). Sub-divisions are indicated by number on the map & bold letters in legend. The rainfall anomaly values for these 36 sub-divisions are indicated below :

1	-57	**7**	44	**13**	40	**19**	35	**25**	157	**31**	1
2	-43	**8**	58	**14**	141	**20**	4	**26**	-14	**32**	127
3	4	**9**	-42	**15**	32	**21**	181	**27**	39	**33**	77
4	-12	**10**	0	**16**	89	**22**	134	**28**	-11	**34**	50
5	-34	**11**	59	**17**	315	**23**	103	**29**	40	**35**	27
6	64	**12**	89	**18**	49	**24**	122	**30**	1	**36**	164

The southwest monsoon withdrew from the entire country on 16th October (normal date 15th October) and the northeast monsoon (NEM) rains commenced over the south peninsula on the same day against normal date of 20th October and ceased on 10th January, 2020.

Rainfall over the core northeast monsoon region during the season was above normal (114% of LPA value). Northeast monsoon in the five Meteorological sub-divisions was, *normal** in Tamil Nadu, Puducherry & Karaikal, Rayalaseema and Coastal Andhra Pradesh & Yanam while *excess* in Kerala - Mahe andsouth interior Karnataka, hence the seasonal rainfall was *excess*.

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TABLE 1

Sub-divisionwise rainfall (mm) for each month and season as a whole (October-December, 2019)

S. No.	Meteorological Sub-divisions	October			November			December			Season		
		Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)
1.	A. & N. Islands	136.6	282.4	-52%	131.9	239.0	-45%	24.5	154.4	-84%	293.0	675.8	-57%
2.	Arunachal Pradesh	116.7	184.9	-37%	13.9	45.5	-70%	17.0	37.0	-54%	151.3	267.4	-43%
3.	Assam & Meghalaya	188.5	157.6	20%	13.7	28.0	-51%	2.5	10.9	-77%	204.8	196.5	4%
4.	Naga., Mani., Mizo. and Tri.	149.9	165.5	-9%	39.3	43.7	-10%	5.0	11.8	-58%	194.2	221.0	-12%
5.	Sub-Himalayan West Bengal & Sikkim	107.3	151.5	-29%	4.5	17.9	-75%	6.6	10.0	-34%	118.3	179.4	-34%
6.	Gangetic West Bengal	183.8	127.6	44%	62.7	21.4	193%	10.1	7.4	37%	256.6	156.4	64%
7.	Orissa	176.1	100.2	76%	10.7	24.5	-56%	1.8	6.6	-73%	188.6	131.3	44%
8.	Jharkhand	129.8	74.7	74%	0.0	9.0	-99%	13.2	6.6	100%	143.0	90.3	58%
9.	Bihar	25.5	61.6	-59%	0.0	6.0	-100%	16.6	5.4	208%	42.2	73.0	-42%
10.	East Uttar Pradesh	25.1	37.3	-33%	1.2	4.1	-70%	20.6	6.3	227%	47.7	47.7	0%
11.	West Uttar Pradesh	9.3	22.2	-58%	9.8	3.8	158%	33.1	6.7	394%	52.1	32.7	59%
12.	Uttarakhand	32.0	35.3	-9%	24.0	7.2	234%	58.2	18.0	223%	114.2	60.5	89%
13.	Haryana, Chandigarh & Delhi	5.3	9.9	-47%	12.9	3.8	240%	10.1	6.5	55%	28.3	20.2	40%
14.	Punjab	9.1	8.9	2%	25.8	5.2	397%	28.3	12.2	132%	63.3	26.3	141%
15.	Himachal Pradesh	21.8	27.5	-21%	49.0	20.3	141%	50.2	43.8	15%	120.9	91.6	32%
16.	Jammu & Kashmir	30.7	36.0	-15%	158.9	33.4	376%	65.0	65.0	0%	254.6	134.4	89%
17.	West Rajasthan	17.1	6.9	147%	27.1	2.7	905%	3.9	2.0	97%	48.1	11.6	315%
18.	East Rajasthan	28.9	14.0	107%	5.9	8.0	-26%	3.7	3.8	-2%	38.5	25.8	49%
19.	West Madhya Pradesh	55.6	29.7	87%	8.4	13.0	-35%	4.5	8.2	-45%	68.5	50.9	35%
20.	East Madhya Pradesh	37.7	34.2	10%	0.6	12.0	-95%	21.7	11.2	93%	59.9	57.4	4%
21.	Gujarat Region	68.1	17.9	280%	14.5	10.1	44%	1.2	1.8	-35%	83.8	29.8	181%
22.	Saurashtra & Kutch & Diu	39.4	15.8	149%	23.0	10.6	117%	1.8	1.1	62%	64.2	27.5	134%
23.	Konkan & Goa	257.1	110.5	133%	26.2	23.7	11%	0.2	5.4	-96%	283.6	139.6	103%
24.	Madhya Maharashtra	202.3	73.3	176%	25.0	23.5	6%	1.4	6.3	-78%	228.6	103.1	122%
25.	Marathawada	227.5	71.7	217%	28.2	20.5	37%	1.8	7.8	-78%	257.4	100.0	157%
26.	Vidarbha	55.6	57.6	-3%	11.3	14.8	-24%	2.9	9.1	-68%	69.8	81.5	-14%
27.	Chhattisgarh	100.3	59.4	69%	0.7	10.2	-93%	5.2	7.1	-26%	106.2	76.7	39%
28.	Coastal Andhra Pradesh	252.6	191.3	32%	20.2	117.3	-83%	28.0	29.5	-5%	300.7	338.1	-11%
29.	Telangana	160.3	92.7	73%	9.4	24.2	-61%	3.0	6.8	-56%	172.6	123.7	40%
30.	Rayalaseema	168.9	129.8	30%	20.8	70.2	-70%	35.6	23.3	53%	225.4	223.3	1%
31.	Tamil Nadu, Pudcherry & Karaikal	224.6	177.2	27%	124.9	178.5	-30%	103.7	91.7	13%	453.3	447.4	1%
32.	Coastal Karnataka	519.6	186.0	179%	50.2	59.7	-16%	12.2	11.1	9%	581.9	256.8	127%
33.	North Interior Karnataka	221.0	105.9	109%	21.5	26.0	-17%	2.4	6.2	-61%	245.0	138.1	77%
34.	South Interior Karnataka	259.2	141.6	83%	30.8	50.6	-39%	16.7	11.9	40%	306.7	204.1	50%
35.	Kerala & Mahe	471.4	303.4	55%	119.2	153.4	-22%	36.3	34.8	4%	626.8	491.6	27%
36.	Lakshadweep	503.4	142.3	254%	40.0	125.3	-68%	306.7	54.2	466%	850.0	321.8	164%

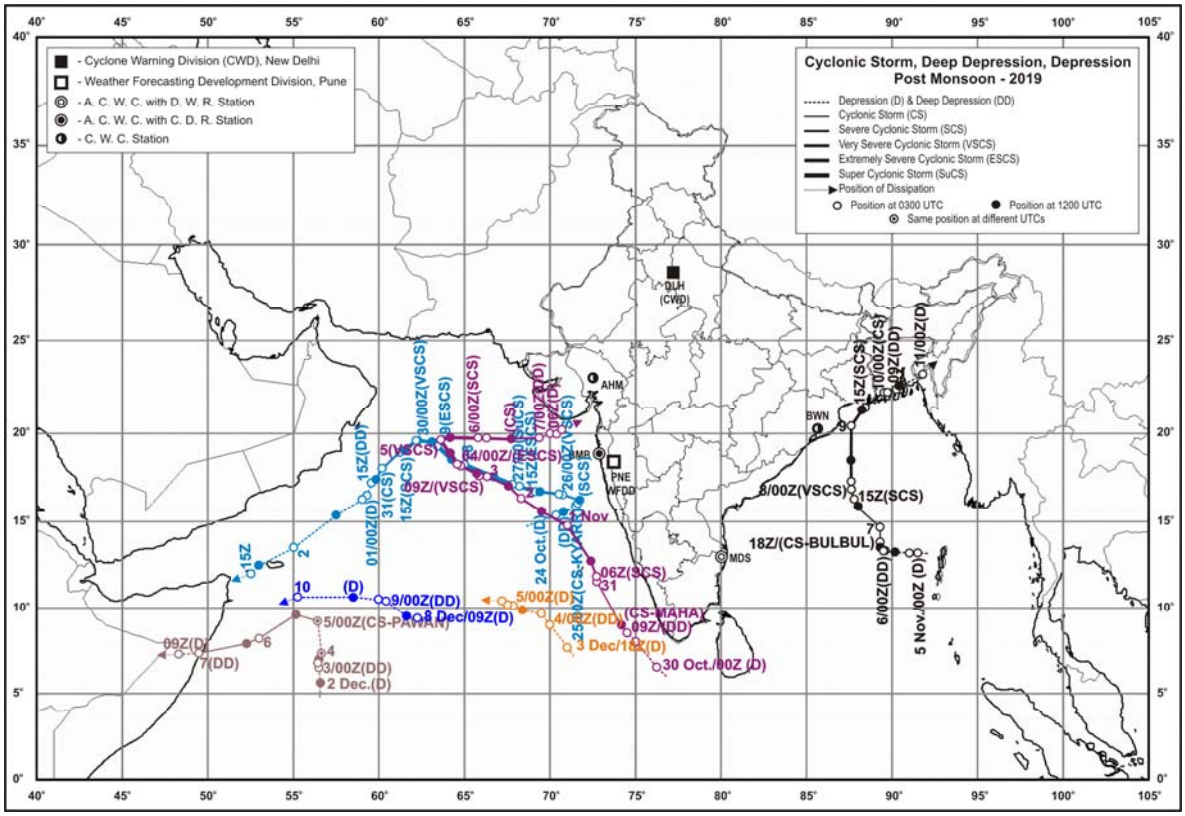

Fig. 2. Cyclones and depressions during post-monsoon season 2019

The maximum temperatures were generally *normal* or *below normal* over major parts of the country during the season. The minimum temperatures were generally *normal* or *above normal* on most days during the season except last week of December when the night temperatures were *appreciably below normal* or *markedly below normal* in central India, east India and northwest India.

Severe cold wave / cold wave conditions manifested over parts of central and northwest India towards the last week of December.

Dense fog was observed during morning hours from second fortnight of November and very dense fog from last week of November to the end of the season, while dense to very dense fog occurred during most days of December over northwest India. Moderate fog on most days prevailed over northwest India and a few days over east, northeast India and south Peninsula.

2. Seasonal rainfall (October - December)

The meteorological sub-division wise rainfall percentage departures from normal are given in Fig. 1 and Table 1.

During the season, rainfall over the country at 130% of LPA was *excess*, while the homogeneous regions of central India (164% of LPA) and northwest India (178% of LPA) were *large excess*. Seasonal rainfall in the other regions, southern Peninsula (116% of LPA) and east and northeast India (-95%) remained *normal*.

The low pressure systems that formed in quick succession modified the NEM circulation features and transported moisture away from the NEM region leading to large deficiency in NEM rainfall during first three weeks of November. Good rainfall activity during second half of October, last week of November and first week of December were associated with passage of easterly wave troughs over the NEM region.

The monthly rainfall for the country was *excess* during October (145% of its LPA) and *normal* in November and Decemberwith 104% and 111% of its LPA, respectively.

Formation of the first three cyclones in quick succession - first, the Super Cyclonic Storm *KYARR* over the Arabian Sea (AS) during 24th October - 2nd November, followed by the ESCS *MAHA* over AS during 30th October - 7th November followed by the VSCS BULBUL over Bay of

TABLE 2

Details of the weather systems during October 2018

S. No.	System	Duration	Place of initial Location	Direction of movement	Place of final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**)	*Storms/Deep Depression/Depression*					
1.	Super Cyclonic Storm 'KYARR'	17 Oct - 2 Nov	Southeast Arabian Sea & adjoining Lakshadweep area	Southwest	Westcentral and adjoining southwest Arabian Sea	It weakened into awell-marked low pressure area onover westcentral and adjoining southwest Arabian Sea off north Somalia coast on 2nd November (2330 UTC). Details are given in the article on 'Storms & Depressions over the north Indian Ocean-2019'
2.	Extremely severe cyclonic storm 'MAHA'	28 Oct - 7 Nov	Southwest Bay of Bengal off south Sri Lanka coast	East northeast	Yemen	It weakened into a well-markedlow pressure area over northeast Arabian Sea and adjoining south Gujarat at 1200 UTC of 7th November which became less marked on 8th morning. Details are given in the article on 'Storms & Depressions over the north Indian Ocean-2019'
(**B**)	*Well marked Low Pressure area / Low Pressure area*					
1.	Well marked low pressure area	22 (1200 UTC) - 24	WestcentralBay of Bengal & adjoining southwest Bay of Bengal	Northwest	North coastal Andhra Pradesh & adjoining area of south Odisha and westcentral Bay of Bengal	Under the influence of the cyclonic circulation over southwest Bay of Bengal off Tamil Nadu coast, the Low pressure formed on 22nd morning with the associated cyclonic circulation extended upto 5.8 kms a.s.l. & intensified subsequently. It weakened into low pressure area on 24th evening which became less marked on 25th. However, associated cyclonic circulation became less marked on 2nd November
(**C**)	*Western Disturbances / Eastward moving Systems*					
(*i*)	*Upper air cyclonic circulation*					
1.	Upto 1.5 kms a.s.l.	1-2	Iran & neighbourhood	East	Iran and adjoining Afghanistan	Then it lay as trough aloft roughly along Long. 64°E to the north of Lat. 30°N on 3rd then again it lay as a cyclonic circulation at 3.1 km a.s.l. over north Pakistan & adjoining Jammu-Kashmir & Ladakh on 4th which Moved away east-northeastwards
2.	Between 3.1 & 3.6 kms a.s.l.	2-3	Western parts of Jammu-Kashmir & Ladakhand neighbourhood	Do	Eastern parts of Jammu & Kashmir and neighbourhood	Moved away northeastwards
3.	At 5.8 kms a.s.l.	11-12	Afghanistan & neighbourhood	Northeast	North Pakistan & adjoining Jammu & Kashmir	Moved awayeast- northeastwards
4.	At 5.8 km a.s.l.	16-20	Central parts of Iran	Do	Jammu & Kashmir and neighbourhood	With a trough aloft with its axis at 7.6 kms a.s.l. running roughly along Long. 64°E to the north of Lat. 26°N which moved away east-northeastwards

TABLE 2 (*Contd*.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(*ii*)	*As a trough*					
1.	At 5.8 km a.s.l.	4-6	Along Long. 63°E to the north of Lat. 25°N	East	Along Long. 66°E to the north of Lat. 20°N	Then it lay as a cyclonic circulation at 3.1 kms a.s.l. over north Pakistan & neighbourhood with the trough in mid & upper tropospheric westerlies with its axis at 5.8 kms a.s.l. ran roughly along Long. 71°E to the north of Lat. 25°N on 7th & it persisted on 8th which moved away east-northeastwards on 9th Morning. However, trough aloft moved away east-northeastwards
2.	Do	22	Along Long. 63°E to the north of Lat. 30°N	Do	Roughly along Long. 72°E to the north of Lat. 33°N	It moved away east-northeastwards on 25
3.	Lower level	22	Along Long. 92°E to the north of Lat. 23°N	Stationary	*In situ*	Became less marked on 23
4.	Between 3.1 & 3.6 kms a.s.l.	30 -31	Along Long. 65°E to the north of Lat. 32°N	East	Along Long.70°E to the north of Lat. 32°N	Then it lay as a cyclonic circulation over Jammu & Kashmir at 3.1 km a.s.l. on 1st November which moved away east-northeastwards on 3rd November
5.	Mid Totropospheric levels	31 Oct - 2 Nov	Along Long. 55°E to the north of Lat. 30°N	Do	Along Long. 64°E to the north of Lat. 23°N	Then, it lay as a cyclonic circulation over Afghanistan and neighbourhood at 3.1 kms a.s.l. with a trough aloft roughly along Long. 70°E to the north of Lat. 30°N on 3rd November. Then, again it lay as a trough in mid tropospheric levels with its axis at 5.8 kms a.s.l. roughly along Long. 73°E to the north of Lat. 32°N on 4th November which moved away northeastwards on 5th November
(*iii*)	*As an Induced cyclonic circulation*					
1.	Upto 1.5 km a.s.l.	18-19	West Rajasthan and adjoining Pakistan	East	Central parts of Rajasthan	Initially it lay as a cyclonic circulation over central Pakistan and adjoining west Rajasthan on 17th. It became less marked on 20
(**D**)	Other upper air cyclonic circulations					
1.	Upto 0.9 km a.s.l.	1	Interior Karnataka & adjoining Telangana	Stationary	*In situ*	It became less marked on 2
2.	Do	2-3	Haryana and adjoining areas of Punjab & northwest Rajasthan	East	Haryana and neighbourhood	It became less marked on 4
3.	Between 1.5 & 2.1 kms a.s.l.	2-3	Southwest Rajasthan and neighbourhood	Stationary	*In situ*	Became less marked on 4
4.	Between 3.6 & 4.5 kms a.s.l.	3	Central parts of south Uttar Pradesh and neighbourhood	Do	Do	Became less marked on 4
5.	Upto 0.9 km a.s.l.	3	Northwest Bay of Bengal and adjoining areas of west Bengal & north coastal Odisha	Do	Do	It merged with the trough ran from northwest Rajasthan to Gangetic west Bengal on 4

TABLE 2 (*Contd*.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
6.	Upto 0.9 km a.s.l.	3	South Tamil Nadu and neighbourhood	Stationary	*In situ*	Became less marked on 4
7.	Between 3.6 & 4.5 kms a.s.l.	4	Northwest Rajasthan and neighbourhood	Do	Do	Became less marked on 5
8.	Between 0.9 and 2.1 km a.s.l.	4	North Kerala and neighbourhood	Do	Do	Became less marked on 5
9.	Upto 0.9 km a.s.l.	4	Northeast Assam and neighbourhood	Do	Do	Became less marked on 5
10.	At 3.1 kms a.s.l.	5-6	Northwest Uttar Pradesh and neighbourhood	Do	Do	Became less marked on 7
11.	At 1.5 km a.s.l.	5-7	Jharkhand & adjoining north Odisha	South	Interior Odisha and neighbourhood	It merged with the cyclonic circulation over south coastal Odisha & neighbourhood on 8
12.	Between 3.1 & 5.8 km a.s.l.	7-10	Odisha and neighbourhood	East	Coastal Andhra Pradesh and neighbourhood	Became less marked on 11
13.	Between 1.5 & 4.5 km a.s.l.	7	Southwest Bay of Bengal off south Sri Lanka coast	Stationary	*In situ*	Became less marked on 8
14.	At 3.1 km a.s.l.	9-11	Haryana and neighbourhood	East	Northwest Uttar Pradesh and neighbourhood	Became less marked on 12
15.	At 1.5 km a.s.l.	9-12	Eastcentral Arabian Sea off Karnataka coast	North	Maharashtra coast and neighbourhood	Became les marked on 13
16.	Upto 0.9 km a.s.l.	9	East Assam and neighbourhood	Stationary	*In situ*	Became less marked on 10
17.	Do	7-8	Northern parts of west Bengal and neighbourhood	East	Bangladesh and adjoining Gangetic west Bengal	Initially it lay as a trough ran from Sub Himalayan west Bengal to cyclonic circulation over interior Odisha on 6^{th}. It became less marked on 9
18.	Upto 2.1 km a.s.l.	10-11	North Bay of Bengal and adjoining Gangetic west Bengal-Odisha coasts	North	South Bangladesh and neighbourhood	Became less marked on 12
19.	At 0.9 km a.s.l.	10	Comorin area and neighbourhood	Stationary	*In situ*	Became less marked on 11
20.	Upto 0.9 km a.s.l.	12	Central Pakistan & adjoining west Rajasthan	Do	Do	Became less marked on 13
21.	Between 3.1 & 3.6 km a.s.l.	12-13	Punjab & neighbourhood	East	Northwest Uttar Pradesh & neighbourhood	Became less marked on 14
22.	At 2.1 km a.s.l.	13-14	South Assam and neighbourhood	Stationary	*In situ*	Became less marked on 15
23.	At 0.9 km a.s.l.	13	North coastal Andhra Pradesh & neighbourhood	Do	Do	Became less marked on 14
24.	Upto 1.5 km a.s.l.	13	Sri Lanka and neighbourhood	Do	*In situ*	Became less marked on 14
25.	Between 3.1 & 3.6 km a.s.l.	14	Bihar & neighbourhood	Do	Do	Became less marked on 15
26.	Upto 1.5 km a.s.l.	14	Lakshadweep area and neighbourhood	Do	Do	Became less marked on 15
27.	Upto 0.9 km a.s.l.	16	Eastcentral Arabian Sea off south Karnataka coast	Do	Do	Became less marked on 17

TABLE 2 (*Contd*.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
28.	Between 2.1 & 3.1 km a.s.l.	18	Eastcentral Madhya Pradesh & neighbourhood	Stationary	*In situ*	Became less marked on19
29.	Upto 3.1 km a.s.l.	19-20	Northwest Uttar Pradesh and neighbourhood	East	East Uttar Pradesh and neighbourhood	Became less marked on 21
30.	Upto 1.5 km a.s.l.	20-21	Comorin area and neighbourhood	North	South Tamil Nadu & adjoining north Sri Lanka and Comorin area	Became less marked on 22
31.	Upto 1.5 km a.s.l.	20	East Assam and neighbourhood	Stationary	*In situ*	Became less marked on 21
32.	Do	23-24	Central Assam and neighbourhood	Do	Do	It merged with the trough from cyclonic circulation over interior Odisha&neighbourhood to central Assam on 25
33.	At 3.1 km a.s.l.	28-29	Jammu & Kashmir and neighbourhood	Do	Do	It moved away east-northeastwards on 30
34.	Between 1.5 & 2.1 kms a.s.l.	29 Oct - 1 Nov	Central Pakistan and adjoining west Rajasthan	Do	Do	Became less marked on 2 November
(**E**)	Other troughs / Wind Discontinuity					
1.	Between 3.1 & 3.6 kms a.s.l.	1	From Southwest Uttar Pradesh to north Gujarat region	Stationary	*In situ*	Became less marked on 2
2.	At 0.9 km a.s.l.	5-11	From Comorin area to South Chhattisgarh across interior Tamil Nadu, Rayala seema & Telangana	Oscillatory	From Lakshadweep area to Coastal Andhra Pradesh across interior Karnataka & Rayalaseema	Became less marked on 12
3.	Do	6-7	From Comorin area to Eastcentral Arabian Sea off Goa coast across south Tamil Nadu & north Kerala	East	From south Kerala to Madhya Maharashtra across interior Karnataka	Became less marked on 8
4.	At 1.5 km a.s.l.	8	South Tamil Nadu to North coastal Karnataka across south Interior Karnataka	Stationary	*In situ*	Became less marked on 9
5.	M.S.L. & extended upto 1.5 kms a.s.l.	15-16	From south Sri Lanka coast to eastcentral Arabian Sea off north Kerala coast	Oscillatory	North Sri Lanka coast to cyclonic circulation over eastcentral Arabian Sea off south Karnataka coast	Became less marked on 17
6.	Between 3.1 & 5.8 km a.s.l.	17	From cyclonic circulation associated with low pressure area over southeast Arabian Sea & adjoining Lakshadweep area to Telangana across Kerala, south interior Karnataka & Rayalaseema	Stationary	*In situ*	Became less marked on 18

TABLE 2 (*Contd*.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
7.	At M.S.L. & extended upto 0.9 km a.s.l.	19-21	Southwest Bay of Bengal off Sri Lanka coast	Stationary	From Cyclonic circulation over south Tamil Nadu & adjoining north Sri Lanka and Comorin area to north coastal Andhra Pradesh across southwest Bay of Bengal	Became less marked on 22
8.	Upto 2.1 km a.s.l.	20-21	From low pressure area over eastcentral Arabian Sea to Vidarbha across north interior Karnataka & Telangana	Do	Eastcentral Arabian Sea to south Chhattisgarh across Goa, north interior Karnataka & Telangana	Became less marked on 22
9.	Upto 1.5 km a.s.l.	24-26	From low pressure area over north coastal Andhra Pradesh & adjoining area of south Odisha and westcentral Bay of Bengal to Sub Himalayan west Bengal across Odisha, Gangetic West Bengal	Do	From north Odisha to cyclonic circulation over west Assam & neighbourhood across Gangetic West Bengal	Became less marked on 27
(**F**)	*Trough in easterlies*					
1.	Between 1.5 & 2.1 kms a.s.l.	16	From southwest Bay of Bengal off south Tamil Nadu coast to westcentral Bay of Bengal	Stationary	*In situ*	Became less marked on 17

Bengal during 5-11 November, 2019 affected the seasonal flow pattern as well as transported moisture away from the NEM region.

3. Monthly features

3.1. *October*

3.1.1. *Withdrawal of southwest monsoon*

The southwest monsoon withdrew from the entire country on 16th October (normal date 15th October) and the northeast monsoon (NEM) rain commenced over the south peninsula on the same day against normal date of 20th October and ceased on 10th January, 2020. An account of the withdrawal of southwest Monsoon 2019 is provided in the seasonal summary of southwest Monsoon published in the last issue of Mausam.

3.1.2. *Commencement of northeast monsoon rains*

In view of reversal of surface and low level winds from southwesterly to northeasterly beginning from 12th October over the south eastern parts of peninsular India, strengthening of easterly winds from 14th October and significant increase in rainfall activity over the same region, southwest monsoon with drew from the entire country and simultaneously the northeast monsoon rains commenced over Tamil Nadu and adjoining areas of Andhra Pradesh, Karnataka and Kerala on 16th October.

3.1.3. *Storms and depressions*

Super Cyclonic Storm Kyarr (24th October - 2nd November) co-existed with ESCS MAHA (30th October - 6th November), for a brief period over the Arabian Sea. Climatologically, no such simultaneous occurrence of two cyclonic storms over the Arabian Sea had been observed since 1965.

Super Cyclonic Storm, ‘Kyarr’ caused heavy to very heavy rainfall at isolated places during 24th - 26th November over Maharashtra and along the west coast of India. Extremely Severe Cyclonic Storm, ‘MAHA’ caused light to moderate rainfall with isolated heavy to very heavy and extremely heavy falls at isolated places along the west coast of India.

3.1.4. *Other synoptic features and associated weather*

Table 2 gives a summary of the synoptic features for the month of October 2019. The sub-divisional percentage departures of rainfall from normal and significant amounts of rainfall are given in Tables 1 and 5, respectively.

TABLE 3

Details of the weather systems during November 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.	Very Severe Cyclonic storm (BULBUL)	5-11 (0000 UTC) Nov	Eastcentral & adjoining southeast Bay of Bengal & north Andaman Sea	West	Southeast Bangladesh and adjoining south Tripura	Under the influence of cyclonic circulation over north Andaman Sea & adjoining Myanmar coast, a low pressure area formed over north Andaman Sea on 4th morning Then it lay as a well marked low pressure are on 0900 UTC of 4th. Details are given in the article on Storms & Depressions over the north Indian Ocean-2019
(**B**)	*Western Disturbances / Eastward moving Systems*					
(*i*)	*Upper air cyclonic circulation*					
1.	At 3.1 km a.s.l.	5-10	South Pakistan and neighbourhood	East	Northern parts of Jammu & Kashmir and neighbourhood	With a trough aloft with its axis at 5.8 km a.s.l. roughly along Long. 62° E to the north of Lat. 32° N. However, trough moved away northeastwards on 7th. Again, the trough aloft with its axis at 5.8 km a.s.l. roughly along Long 62° E to the north of Lat. 27° N on 9th which became less marked on 10th. The western disturbance moved away east-northeastwards on 11th
2.	Between 3.1 & 3.6 km a.s.l.	11	North Pakistan & neighbourhood	Stationary	*In situ*	With a trough aloft with its axis at 5.8 km a.s.l. roughly along Long. 72° E to the north of Lat. 29°N and moved away east-northeastwards on 12
3.	Upto 9.6 km a.s.l.	12-16	Afghanistan and neighbourhood	East	North Pakistan & neighbourhood	With a trough aloft with its axis at 5.8 km a.s.l. roughly along Long. 60° E to the north of Lat. 24° N. However, trough became less marked on 16th. And western disturbance moved away northeastwards on 17
4.	At 3.1 km a.s.l.	16-24	Iran and neighbourhood	East northeast	North Pakistan and adjoining Jammu & Kashmir	With a trough aloft with its axis at 5.8 km a.s.l. roughly along Long. 54° E to the north of Lat. 30°N. However, trough merged with the WD as a cyclonic circulation on 17th. Western disturbance moved away east-northeastwards on 25th
5.	At 3.1 km a.s.l.	18	North Pakistan and neighbourhood	Stationary	*In situ*	Moved away east-northeastwards on 19
6.	Between 3.1 & 3.6 km a.s.l.	26-28	Afghanistan and neighbourhood	Northeast	North Pakistan and adjoining Jammu Kashmir	Initially, it lay as a trough in md tropospheric westerlies with its axis at 5.8 km a.s.l. ran roughly along Long. 52° E to the north of Lat. 28°N on 21st. Cyclonic circulation became less marked on 29th and trough also became less marked on 30th
7.	Between 3.1 &3.6 km a.s.l.	30 Nov - 2 Dec	North Pakistan and neighbourhood	East	Jammu & Kashmir and neighbourhood	Moved away east-northeastwards on 3rd December
(*ii*)	*As an Induced cyclonic circulation*					
1.	Upto 1.5 km a.s.l.	6-8	Central Pakistan and adjoining west Rajasthan	East	Punjab and adjoining central Pakistan	Became less marked on 9
2.	Upto 1.5 km a.s.l.	12-16	Southwest Rajasthan and neighbourhood	Stationary	*In situ*	Became less marked on 17

TABLE 3 (*Contd*.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
3.	Between 1.5 & 2.1 km a.s.l.	25-29	West Rajasthan and adjoining Pakistan	Oscillatory	North Rajasthan and neighbourhood	Then, it lay as a cyclonic circulation over Haryana & neighbourhood on 30th November and became less marked on 2nd December
(**C**)	*Other upper air cyclonic circulations*					
1.	At 0.9 km a.s.l.	3	South Madhya Maharshtra and neighbourhood	Stationary	*In situ*	Became less marked on 4
2.	At 1.5 km a.s.l.	3-4	Bangladesh & neighbourhood	Do	Do	Became less marked on 5
3.	Upto 1.5 km a.s.l.	6-7	Coastal Maharashtra	South	South interior Karnataka & neighbourhood	Became less marked on 8
4.	Between 3.1 & 4.5 km a.s.l.	6-7	Sub Himalayan West Bengal & Sikkim	East	South Assam and neighbourhood	Became less marked on 8
5.	Between 1.5 & 3.1 km a.s.l.	8	Sri Lanka and neighborhood	Stationary	*In situ*	Became less marked on 9
6.	At 0.9 km a.s.l.	12	Kerala and neighbourhood	Do	Do	Became less marked on 13
7.	Between 1.5 & 3.1 km a.s.l.	13	Andaman Sea and neighbourhood	Do	Do	Became less marked on 14
8.	Upto 2.1 km a.s.l.	15	Meghalaya and neighbourhood	Do	Do	Became less marked on 16
9.	At 3.1 km a.s.l.	15	South Madhya Maharashtra and neighbourhood	Do	Do	Became less marked on 16
10.	Upto 0.9 km a.s.l.	16	North Kerala and neighbourhood	Do	Do	Became less marked on 17
11.	At 0.9 km a.s.l.	17-19	East Assam and neighbourhood	Do	Do	Became less marked on 20
12.	Upto 0.9 km a.s.l.	19	Coastal Karnataka & neighbourhood	Do	Do	Became less marked on 20
13.	At 1.5 km a.s.l.	20	Southwest Rajasthan and neighbourhood	Do	Do	Became less marked on 21
14.	Between 1.5 & 2.1 km a.s.l.	20-23	North Bangladesh and neighbourhood	East	East Bangladesh and neighbourhood	Became less marked on 24
15.	Do	21-23	Punjab & neighbourhood	Do	Haryana and neighbourhood	Became less marked on 24
16.	Between 4.5 & 5.8 km a.s.l.	24	Lakshadweep area	Stationary	*In situ*	Became less marked on 25
17.	At 1.5 km a.s.l.	26-28	East Bangladesh and neighbourhood	East	Northeast Bangladesh and neighbourhood	Became less marked on 29
(**D**)	*Trough in easterlies*					
1.	Upto 1.5 km a.s.l.	15-18	Eastcentral and adjoining southeast Bay of Bengal	Oscillatory	Equatorial Indian ocean off south Sri Lanka coast to southwest Bay of Bengal off north Tamil Nadu coast	Then, it lay as a cyclonic circulation over Comorin area and neighbourhood on 19th and it lay as a trough at 0.9 km a.s.l. from Comorin area to north Kerala on 20th and moved away westwards on 22nd
2.	At 0.9 km a.s.l.	28-29	From North Gujarat region to north Rajasthan	Do	West Madhya Pradesh to east Rajasthan	Became less marked on 30
3.	Between 0.9 & 1.5 kms a.s.l.	29	Southwest Bay of Bengal off Sri Lanka & Tamil Naidu coast	Stationary	*In situ*	Then, it lay as a cyclonic circulation over Comorin area & neighbourhood on 30th November which became less marked on 1st December

TABLE 4

Details of the weather systems during December 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.	Cyclonic Storm, 'Pawan'	2 (1200 UTC) - 7 (1200 UTC)	Southwest Arabian Sea	West-northwestward	North Somalia & adjoining Ethiopia	Initially, low pressure area formed over Equatorial Indian ocean & adjoining southwest Arabian Sea with associated cyclonic circulation extended upto 5.8 kms a.s.l. on 30th November. Then, it became a well marked low pressure area on 2nd Dec and intensified subsequently as a depression on 2nd (1200 UTC). Details are given in the article on Storms & Depressions over the north Indian Ocean-2019
(**B**)	*Deep Depression/Depression*					
1.	Deep Depression	03 (1800 UTC) - 05 (1200 UTC)	Eastcentral Arabian Sea & adjoining areas of southeast Arabian Sea & Lakshadweep area	Northwestward	Eastcentral Arabian Sea and neighbourhood	Initially, low pressure area formed over southeast Arabian Sea & adjoining Lakshadweep area with associated cyclonic circulation extended upto 5.8 kms a.s.l. on 1st December. Then, it became a well marked low pressure area on 3rd and intensified subsequently as a depression on 3rd (1800 UTC). Details are given in the article on Storms & Depressions over the north Indian Ocean-2019
2.	Deep Depression	08 (0900 UTC) – 10 (0600 UTC)	Southwest Arabian Sea	West-northwestward	Southwest Arabian Sea	Initially, a trough in easterlies in the lower tropospheric levels lay over southwest Bay of Bengal off Sri Lanka - south Tamil Nadu coasts on 2nd December Under its influence, a low pressure area formed over southeast Arabian Sea & adjoining Equatorial Indian Ocean on 7th December. Then, it became a well marked low pressure area on 8th and intensified subsequently as a depression on 8th (0900 UTC). Details are given in the article on Storms & Depressions over the north Indian Ocean-2019
(**C**)	*Low Pressure area*					
1.	Low Pressure area	22-28 (0000 UTC)	Southeast Arabian Sea and adjoining southwest Arabian Sea and equatorial Indian Ocean		Southwest Arabian Sea & adjoining westcentral Arabian Sea	It formed under the influence of cyclonic circulation over Lakshadweep area & neighbourhood. Associated cyclonic circulation extended upto mid-tropospheric levels. It became less marked on 28th
(**D**)*Western Disturbances /Eastward moving systems* (*i*) *Upper air cyclonic circulation*						
1.	Mid & upper tropospheric levels	9 - 13	Eastern parts of Iran & adjoining Afghanistan	East	North Pakistan and adjoining Jammu &Kashmir	With a trough aloft with its axis at 5.8 kms above m.s.l. ran roughly along Long. 62°E to the north of Lat. 24° N from 12th. WD became less marked on 14th. However, trough moved away northeastwards on 15th
2.	Between 3.1 & 5.8 kms a.s.l.	18	West Iran & neighbourhood	Stationary	*In situ*	Initially, it lay as a trough with its axis at 5.8 kms above m.s.l. ran roughly along Long. 50° E to the north of Lat. 30° N on 17th. Again, it lay as a trough with its axis at 5.8 kms above m. s. l. roughly along Long. 63° E to the north of Lat. 28° N on 19th which moved away northwards 20th

TABLE 4 (*Contd*.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
3.	Between 3.1 & 5.8 kms a.s.l.	20 - 22	North Pakistan and adjoining Jammu & Kashmir	Stationary	*In situ*	Moved away east northeastwards on 22nd evening
4.	At 3.1 km a.s.l.	24-26	Central Pakistan & neighbourhood	Northeast	Jammu and Kashmir and neighbourhood	A trough aloft with its axis at 5.8 kms above m.s.l. and ran roughly along Long. 65° E to the north of Lat. 28° N, which became less marked on 25th. However, WD moved away east-northeastwards on 27th
5.	At 3.1 kms above m.s.l.	30 Dec - 5 Jan	East Iran & adjoining Afghanistan	East	Eastern parts of Jammu and Kashmir	With a trough with its axis at 5.8 kms above m.s.l. ran roughly along Long. 71° E to the north of Lat. 32° N on 31st December which became less marked on 2nd Jan. Western Disturbance as a cyclonic circulation moved away northeastwards on 6th
(*ii*)	*As a Trough / Trough in westerlies*					
1.	At 3.1 km a.s.l.	2	Roughly along Long. 90°E to the north of Lat. 24°N	Stationary	*In situ*	Became less marked on 3
(*iii*)	*As an induced cyclonic circulation*					
1.	Upto1.5 km a.s.l.	11-15	North west Rajasthan & neighbourhood	East	Southwest Uttar Pradesh & neighbourhood	Then, it lay as a cyclonic circulation over northeast Uttar Pradesh on 16th which became less marked on 17
(**E**)	*Other upper air cyclonic circulations*					
1.	Between 1.5 & 3.1 km a.s.l.	3-4	East Bangladesh and neighbourhood	Stationary	*In situ*	Became less marked on 5
2.	At 1.5 km a.s.l.	4	Punjab and neighbourhood	Do	Do	Became less marked on5
3.	Between 2.1 & 3.1 km a.s.l.	7	East Bangladesh and adjoining	Do	Do	Became less marked on 8
4.	Between 1.5 & 3.1 kms a.s.l.	10	Southeast Arabian Sea & adjoining Lakshadweep area	Do	Do	Then, it lay as a trough on 11 which became unimportant for the region on 12
5.	Upto 0.9 kms a.s.l.	10-11	Bangladesh & adjoining west Assam	East	South Assam & neighbourhood	Became less marked on 12
6.	Do	11-13	Southeast Rajasthan & neighbourhood	Do	Do	Became less marked on 14
7.	Between 2.1 & 3.1 kms a.s.l.	13-15	East Uttar Pradesh & adjoining Bihar	Do	North Bihar & neighbourhood	Became less marked on 16
8.	Between 1.5 & 2.1 kms a.s.l.	14-17	East Bangladesh & neighbourhood	West	East Assam and neighbourhood	Became less marked on 18
9.	At 2.1 km a.s.l.	21-22	Punjab & neighbourhood	East	Haryana & adjoining Delhi and northwest Uttar Pradesh	Became less marked on 23
10.	At 1.5 km a.s.l.	22	South Sri Lanka and neighbourhood	Stationary	*In situ*	Became less marked on 23
11.	Do	23	South Tamil Nadu and neighbourhood	Do	Do	Became less marked on 24
12.	At 3.1 kms a.s.l.	24-26	Central Assam and neighbourhood	East	East Assam & neighbourhood	Became less marked on 27

TABLE 4 (*Contd*.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
13.	Between 1.5 & 3.6 kms a.s.l.	27-30	Bihar & adjoining east Uttar Pradesh	Do	Southeast Uttar Pradesh & neighbourhood	Became less marked on 31
14.	Upto 0.9 km a.s.l.	28	Lakshadweep & neighbourhood	Stationary	*In situ*	Then, it lay as a trough in easterlies from Maldives to Lakshadweep area on 29th which moved away westwards on 30th
15.	At 1.5 km a.s.l.	28-29	Southwest Madhya Pradesh and neighbourhood	West	Southeast Rajasthan & neighbourhood	Became less marked on 30
16.	Between 0.9 and 2.1 kms a.s.l.	31 Dec - 2 Jan	North Gujarat & neighbourhood	Oscillatory	South Gujarat region & neighbourhood	Became less marked on 3
17.	Between 1.5 & 2.1 km a.s.l.	31 Dec	Haryana & adjoining northeast Rajasthan	Stationary	*In situ*	Became less marked on 1 January
18.	Between 1.5 and 2.1 kms a.s.l.	31 Dec	North Odisha and neighbourhood	Do	Do	Became less marked on 1 January
(**F**)	*Trough in easterlies*					
1.	Upto 0.9 km a.s.l.	8-10	Southwest Bay of Bengal off Sri Lanka coast	South	Equatorial Indian ocean & adjoining Comorin area	Became less marked on 11
2.	Do	12	Southwest Bay of Bengal off Sri Lanka coast	Stationary	*In situ*	Became less marked on 13
3.	At 0.9 km a.s.l.	15	Southeast Arabian Sea off Kerala coast	Do	Maldives to north Lakshadweep	It moved away westwards on 16
4.	Upto 2.1 km a.s.l.	24-25	Comorin area to south Tamil Nadu	Do	*In situ*	Became less marked on 26
(**G**)	*Other Troughs*					
1.	At 1.5 km a.s.l.	8	Northwest Uttar Pradesh to north Gujarat	Stationary	*In situ*	Became less marked on 9
2 .	At 0.9 km a.s.l.	14	Central parts of Uttar Pradesh to Vidarbha	Do	Do	Became less marked on 15
3.	At M.S.L.	21	Equatorial Indian ocean & adjoining southwest Bay of Bengal	Do	Do	Became less marked on 22
4.	At 0.9 km a.s.l.	27-28	Tripura to north coastal Odisha	Oscillatory	Tripura to north Bay of Bengal	Became less marked on 29
5.	At 1.5 km a.s.l.	30	Northeast Rajasthan to northeast Arabian Sea across Gujarat	Stationary	*In situ*	Became less marked on 31
6.	Between 1.5 & 2.1 km a.s.l.	31 Dec	From cyclonic circulation over north Odisha & neighbourhood to Haryana and adjoining Northeast Rajasthan across Jharkhand and south Uttar Pradesh	Do	Do	Became less marked on 1 January

TABLE 5

Some representative amounts of rainfall in cm for October, November and December 2019 (7 cm and above)

Date	Some representative amounts of rainfall in cm for October, November and December 2019 (7 cm and above)
1 Oct	Williamnagar 23, Satlasana 20, Bhabhar 19, Bhiloda 18, Vijaynagar 17, Himatanagar and Haldwani 16 each, Mawsynram and Vijapur 14 each, Devel, Sarara, Idar, Amfu Majhian and Radhanpur 13 each, Kherwara 12, Kankrej, Deodar, Dharoi Colony, Sagwara and Duldula 11 each, Nithuwa, Thangadh, Aspur, Prantij, Salumber, Tikrikilla, Jhadol and Ganeshpur 10 each, Siddhpur, Nahan, Cherrapunji, Veja, Danta, Vadakara, Dharmasthala, Loharia, Dhrangadhra and Sohra (Rkm) 9 each, Borsad, Belonia, Naina Davi, Sabla, Harij, Shankheshvar, Dhansura, Patan and Becharaji 8 each, Nongstein, Dantiwada, Vadgam, Wankaner, Deesa, Dhubri Cwc, Visnagar, Galiakot, Suigam, Jagpura, Dungarpur Tehsil, Dhariabad, Anand, Vadali, Palanpur, Goalpara, Goalparacwc, Sabroom, Agar, Mandsaur - AWS, Sami, Seoni, Amarwara, Amirgadh, Kheralu and Saraswati 7 each
2 Oct	Rajula 19, Pratapgarh 15, Orchha 14, Kunda 13, Jogipet 12, Maudaha and Sohra (Rkm) 11 each, Manjhanpur 10, Sohra 9, Mauranipur, Banda Cwc, Hindupur, Chilaghat, Nimpara, Periyapatna and Gummagatta 8 each, Jhansi, Brahmasamudram, Bhanpura, Mahoba, Bagepalli, Panchanahalli, Hosur, Khajurao, Settur and Ajaigarh 7 each
3 Oct	Gyanpur 19, Allahabad PBO 10, Chandauli and Allahabad AP 9 each, Kollapur, Sohra and Mau Tehsil 8 each, Bara, Karchhana, Beberu, Kanakapura, Gudamalani, Kottayam, Mirzapur Tehsil, Kollam Rly and Attarra 7 each
4 Oct	Durgachak 10, Vadakara and Silchar 9 each, Haveri PTO and Diamond Harbour 8 each, Jammalamadugu, Kudligi, Madanapalle, Pamidi, Hanumana, Mangaluru, Buxaduar, Proddutur and Kusumanchi 7 each
5 Oct	Chauldhowaghat 14, Chittoor, Champasari and Mohol 9 each, Neora, Nilanga, Sankaridurg and Murti 8 each, Pakala, Krishnagiri and Holagunda 7 each
6 Oct	Hidkal Dam 13, Haveri PTO and Shrirampur 11 each, Shiggaon, Sanguem and Athni 10 each, Londa 9, Lohandiguda, Harsul - FMO, Ozharkheda - FMO, Harapanahalli, Dharmasthala, Karkala, Haveri APmc, Tiptur, Tanakal and Madakasira 8 each, Thodupuzha, Burgampadu, Machilipatnam, Lakkavalli, Bastanar, Chickmagalur, Bhuvanagiri, Amadagur, Canacona, Poladpur, Sangamner, Rairakhol, Karjatagri and Quepem 7 each
7 Oct	Messenjor 18, R. S. Mangalam 16, Tadpatri and Madakasira 11 each, Gummagatta, Yelburga and Itanagar 10 each, Hosapete, Mancompu and Kailashahar 9 each, Rayadurg, Naharlagun, Kunurpi and Chevella 8 each, Silchar, Bokajan, Tuli Nsdma AWS, Ambejogai / Mominabad, Perinthalamanna, Vichhiya, Thodupuzha, Shamirpet, Karanjia, Kushtagi, Mortad, Hindupur, Rolla and Parbatsar 7 each
8 Oct	Alipurduar PTO 12, Chengmari / Diana and Channapatna 11 each, Maithon 9, Mylaudy, Buxaduar, Nalbari / Pagladia, Krishnagiri, Mandira Dam, Maddur, Malavalli and Ghatagaon 8each, Mandya, Khed, Tamenglongi, Devarakonda, Nagar Kurnool, Kumargram, Konni and Khalapur 7 each
9 Oct	Hosanagar 16, Amtala and Rampurhat (Drms) 11 each, Dharmasthala and Vepada 9 each, Bokaro, Deogaon, Nelogi and Tilpara Barrage 8 each, Gheropara, Maniyachi, Basirhat PTO, Suri Cwc, Hazaribagh and Pune (Lohogaon) 7 each
10 Oct	Swam - Patna 13, Enkuru 12, Polavaram and Koyyalagudem 11 each, Digha 10, Ramannapeta 9, Marsaghai ARG, Belthangadi, Vararamachandrapur and Venkatapuram 8 each, Avanigada, Putki, Haveri PTO, Dalhousi Alha AWS, Chinnakalar, Kavathe Mahakal, Royachoti, Bhograi, Jamtara, Paralakhemundi and Kamalapuram 7 each
11 Oct	Naigaon Khairgaon 15, Jammalamadugu 11, Srungavarapukota and Navipet 10 each, Kampli, Kamalpur and Bhalukpong 9 each, Kalwakurthy, Pandharpur, Kudathini, Panhala, Jogipet, Nuagada ARG and Tuting 8each, Bellatti, Tamenglongi, Sandur, Gudur, Falakata, Atpadi, Vellanikkara and Seethanagaram 7 each
12 Oct	Punalur, Nandigama and Mirdoddi 10 each, Aswaraopeta and Thondebhavi 9 each, Atchampet and Aska 8 each, Sadasivanagar, Dimapur Nsdma AWS, Neora and Baderajpur 7 each
13 Oct	Kozha 14, Gobichettipalayam 13, Piravam and Balajipeta 7 each
14 Oct	Chalakudi 13, Hassan and Kodaikanal 8 each, Sagar, Visakhapatnam AP, Karanjia and Swam - Patna 7 each
15 Oct	Chittur 9, Srivaikuntam and Kochi AP 8 each, Thoothukudi, Tondi and Kollamkode 7 each
16 Oct	Kamalpur 13, Gudur 12, Poonamallee 11, Pamban, Hassan and Dholai 10 each, Tada, Satyavedu, Ayikudi, Thottambedu, Cholavaram and Karimganj 9 each, Atmakur and Kundapur 8each, Krishnarajpet, Poondi, Amraghat, Mudubidre, Kaveli, Silchar, Karkala and Sivakasi 7 each
17 Oct	Kadaladi 12, Kozha 11, Paramakudi and Kodaikanal 10 each, Tiruvarur and Tiruvadanai 9 each, Tondi, Chengannur, Mavelikara and Banpur 8 each, Kurudamannil, Vilathikulam, Devakottai, Mahe, Kayamkulam, Kayamkulam Agri, Perumpavur, Mahabalipuram, Tada, Chimakurthi, Tiruvannamalai, Tirupuvanam, Piravam and Vallam 7 each
18 Oct	K Bridge 12, Angadipuram 11, Chennai city 10, Nilambur, Mannarkad and Dgp Office 9 each, Chalakudi, Asansol, Peermade To, Perinthalamanna and Coonoor 8 each, Pollachi, Kozhikode, Kakinada, Karkala, Ambalavayal and Manjeri 7 each
19 Oct	Parkal 19, Amalapuram and Avanigada 18 each, Yanam 16, Narsampet 15, Devala 13, Kothaguda, Kottur and Pattambi 12 each, Nallabelly 11, Madnur, Hagaribommanahalli, Sawantwadi, Degloor - FMO and Palakkad 10 each, Munirabad, Devgarh, Khanapur, Machareddy, Vellanikkara, Mannarkad, Madha and Dich Palle 9 each, Ghanpur, Washi, Paranda, Sattenapalle, Jukkal, Indi,

TABLE 5 (*Contd*.)

Date	Some representative amounts of rainfall in cm for October, November and December 2019 (7 cm and above)
	Tokapal and Hanamkonda 8 each, Tyagarthi, Gersoppa, Kozha, Zaffergadh, Madhabarida, Yeda Palle, Piravam, Kurudamannil, B. Bagewadi, Vedasandur, Mangaluru, Vadakkancherry, Kallamb, Repalle, Gokarna, Canacona, Sadasivanagar, Ankola, Kammardi, Honavar, Perinthalamanna and Marmugoa 7 each
20 Oct	Selu 16, Kittur 15, Chalisgaon 13, Perinthalamanna 12, Parkal, Malshiras and Barshi 11 each, Visakhapatnam, Pathri and Parbhani 10 each, Venkatapuram, Wai, Madha, Khandala*, Patan, Satara, Govindaraopet, Haliyal and Kodungallur 9 each, Haveri PTO, Mogullapalle, Angadipuram, Partur, Londa, Javali Medha, Eturnagaram and Nagercoil 8each, Bhupalpalle, Tada, Aluva Pwd, Shiggaon, Ongole and Belthangadi 7 each
21 Oct	Ernakulam South 20, Vaikom 19, Alappuzha, Mancompu and Ajjampura 17 each, Kochi AP and Yedwad 16 each, Ramdurga and Kozha 15 each, Kuzhithurai 14, Mahalingapur, Jalkot, Rabkavi, Yagati and Lakkavalli 13 each, Periyanaickenpalayam, Lokapur, Punalur, Shivani, Kanjirappally, Patan and Phaltan 12 each, Konni and Harihar 11 each, Kottayam 10, Lower Kothaiyar ARG, Perinthalamanna, Belgaum, Belagavi PTO, Manki, Byadgi, Ranjal, Satara, Sargur, Aryankavu, Chalakudi, Balod, Ausa, Kumarakom, Mettupalayam, Dharwad PTO, Chengannur, Lingadahalli, Anavatti, Haveri PTO, Hirekerur, Banavasi and Lanja 9each, Kurudamannil, Chitradurga, Gundardehi, Piravam, Udupi, Kandhar, Mukhed, Jamkhandi, Yargatti, Belwadi, Hosadurga, Santhebennur, Solapur, Lohara, Sangameshwar Devrukh, Holalkere and Shimoga 8 each, Nawapara, Mudigere, Channagiri, Honnali, Kundgol, Kodungallur, Ranebennur (Hos), Rajapur, Nedumangad, Angadipuram, Valparai, Karkala, Ottapalam, Koilkuntla, Neyyattinkara, Mylaudy, Kagal, Ahmedpur, Aravakurichi, Cherthala, Rameshwaragri, Bailhongal, Thrithala, Palus, Shirala, Kadur, Thoothukudi, Kammardi, Nagari, Thiruvananthapuram, Akkalkot, Shirur Anantpal and Chennai AP 7 each
22 Oct	Pamban 18, Rameswaram 17, Chalakudi 15, Canacona 13, Ponda 12, Ottapalam, Karaikal, Bellur, Arimalam, Pudukottai and Arantangi 11 each, Nuggehalli, Holalkere, Nellore, M. M. Hills, Wadawani, Salem and Hosadurga 10 each, Hadagali, Panchanahalli, Srirangapatna, Chakur, Harapanahalli, Balehonnur, Gubbi, Mahabalipuram, Perungalur, Kanakapura, Londa and Bhor 9 each, Trangambadi (Or)Tranqueb, Honakere, Honnali, Parner, Jagalbet, Bellatti and Sudhagad Pali 8each, Kottigehara, Enamakkal, Paramathivelur, Vadakara, Bhira, Ankola, Davanagere, Bhatkal, Gadag, Ongole, Mangalooru AP, Munirabad, Panhala, Velhe, Krishnarajpet and Kunnamkulam 7 each
23 Oct	Amalapuram 16, Visakhapatnam 13, Anakapalle and Kalingapatnam 12 each, Yelamanchili and Narsapur 10 each, Parola, Hogenekal, Agathi and Visakhapatnam A. P. 9 each, Chodavaram, Sillod, Partur and Tuni 8each, Kakinada, Yagati, Kothaguda, Niphad, Yanam, Dhule and Tanuku 7 each
24 Oct	Krishnaprasad 25, Bheemunipatnam 23, Mandasa and Ranastalam 22 each, Sompeta 20, Brahmagiri AWS, Ichchapuram and Manki 18 each, Puri 17, Marmugoa, Palasa, Shirali and Kollur 16 each, Purushottampur, Denkada and Berhampur 15 each, Mentada, Nellimarla, Pipili, Satyabadi ARG, Garividi, Bondapalle, Balajipeta and Kudulu 14 each, Gop, Ranpur, Honavar, Alipingal, Aska and Gajapathinagaram 13 each, Gersoppa, Kujanga ARG, Tekkali, Khandapara and Niali ARG 12 each, Digapahandi ARG, Banpur, Bolagarh ARG, Panjim (Goa), Belaguntha ARG, Chhatrapur, Sorada, Dabholim (Goa), Karwar, Pusapatirega, Nimpara, Velairpad, Garugubilli, Pamban, R. Udaigiri, Vizianagaram and Tangi 11 each, Gunupur, Gopalpur, Canacona, Gantyada, Kota, Kakatpur, Vadakara, Bhubaneshwar A. P., Rameswaram, Tirtol ARG, Therlam, Cheepurupalle, Kumta, Kundapur, Salur, Palakonda, Gokarna, Kashinagar, Yelamanchili and Nuagada ARG 10each, Balipatna ARG, Amalapuram, Danagadi ARG, Lalgudi, Udupi, Balikuda ARG, Odagaon ARG, Nayagarh, Suri PTO, Narsinghpur, Mani, Kurupam, Dharmasthala, Bobbili, Mapusa, Vallam, Srungavarapukota, Mundali, Quilandi, Kantapada ARG, Salepur ARG, Jagannath Prasad ARG, Puttur HMS, Simula, Komarada, Karkala, Bhanjnagar, Chandikhol ARG, Veeraghattam, G. Udayagiri AWS and Marsaghai ARG 9 each, Madhabarida, Jagatsinghpur AWS, Panambur, Dhamnagar ARG, Kendrapara, Kalingapatnam, Merakamudidam, Phulberia, Paralakhemundi, Parvathipuram, Kadra, Chintapalle, Mahendragarh, Margao, Ernakulam South, Paderu, Pathapatnam, Banki ARG and Paradip 8 each, Cuttack, Tikabali, Kansabati Dam, Mandira Dam, Malvan, Jiyyamma Valasa, Chandbali, Binjharpur ARG, Cheyyur, Garadapur ARG, Kottigehara, Suri Cwc, Chengalpattu, Tuni, Bari ARG, Gania ARG, Badnapur, Yanam, Vengurla, Gudari, Seethanagaram, Ghatsila, Poondi, Samayapuram, Mangaluru, Prathipadu, Kochi AP, Astaranga ARG, Tozhudur, Cherthala, Chalakudi, Raghunathpur ARG, Vadipatti, Badami, Jamshedpur AP, Kaveripakkam, Hindol, Grand Anaicut, Mudubidre, Similiguda AWS, Ankola, Aluva Pwd, Pernem, Bankura Cwc, Banarpal ARG and Raikia ARG 7 each
25 Oct	Binjharpur ARG 24, Digha 23, Basudevpur AWS 22, Kantapada ARG 18, Remuna ARG, Mahanga ARG, Satyabadi ARG and Pipili 17 each, Rajkanika, Banki ARG, Bhadrak AWS, Nimpara, Tihidi ARG, Dhamnagar ARG and Bhograi 16 each, Bari ARG, Niali ARG, Nischintakoili ARG, Panjim (Goa), Kota and Brahmagiri AWS 15 each, Bhubaneshwar AP, Balasore, Ranpur, Rajghat, Salepur ARG and Jaleswar 14 each, Jajpur, Nilgiri, Bonth, Raghunathpur ARG, Athgarh, Mapusa, Krishnaprasad, Mudigere, Ankola, Soro and Marmugoa 13 each, Chandbali, Tangi, Derabis ARG, Pattamundai, Kundapur, Nh5 Gobindpur, Balipatna ARG, Dabholim (Goa) and Contai 12 each, Patnagarh, Cuttack, Pernem, Dhenkanal, Chandikhol ARG, Alipingal and Balikuda ARG 11 each, Marsaghai ARG, Canacona, Jaipur, Udala, Jagatsinghpur AWS, Tirtol ARG, Ramgarh, Mudhole, Akhuapada, Paralakhemundi and Ramagundam 10 each, Gop, Manjlegaon, Valpoi, Kotraguda, Luchipur, Karwar, Koner, Gopalpur, Danagadi ARG, Sukinda, Dumri, Ichchapuram, Manvat, Sompeta, Puri, Hosdurg, Naraj, Maheshpur, Daitari, Muniguda ARG, Gokarna, Angul, Tigiria ARG, Topchanchi, Astaranga ARG, Balimundali and Kannur 9 each, Baripada, Jenapur, Margao, Gangadhara, Tenughat, Pathri, Chaibasa, Quepem, Pathardi, Betanati ARG, Kaptipada ARG, Chandanpur, Malvan, Akole, Mundali, Ahmedpur and Mudholebasar 8 each, Hindol, Jamshedpur A. P., Talcher, Korei ARG, Ramgarh Bdo, Dodamarg, Kudulu, Asansol Cwc, Berhampur, Garadapur ARG, Kendrapara, Manki, Bankura Cwc, Sawantwadi, Bissem - Cuttack, Katoria, Shirali, Chhatrapur, Panposh, Siddapura, Putki, Sanguem, Kottigehara, Paradip, Chakradharpur, Bhatkal, Vengurla, Banpur, Kolebira, Hindgir, Narla ARG, Altuma Cwc, Madhabarida, Ghatagaon, Lalgarh, Dharmasagar, Pallahara, Joda ARG, Jaridih, Kujanga ARG, Banarpal ARG, Kamakhyanagar, Bangiriposi, Karkala, Diamond Harbour, Bhuban ARG, Georai, Pupunki, Suri PTO and Gomia 7 each

TABLE 5 (*Contd*.)

Date	Some representative amounts of rainfall in cm for October, November and December 2019 (7 cm and above)
26 Oct	Mawsynram 35, Sohra 29, Malvan 25, Manki 24, Sohra (Rkm) and Williamnagar 23 each, Pernem 22, Khliehriat 19, Gokarna and Devgarh 18 each, Kota 16, Ankola and Shillong 15 each, Vengurla and Karwar 14 each, Garugubilli, Taliparamba and Kadra 13 each, Seethanagaram, Kudal, Vadakara, Kollur, Kottigehara, Kannur and Pathapatnam 11 each, Haflong, Honavar, Barapani, Mudubidre and Selu 10 each, Mangalooru A. P., Kudulu, Guwahati AWS, Guwahati A. P., Kampur, Ratnagiri, Bhaghmara, Berhampur, Hosdurg, Quilandi, Veeraghattam and Mani 9each, Karimganj, Guwahati City, Jagalbet, Bhagamandala, Hosanagar, Mahe and Paralakhemundi 8each, Parbhani, Karkala, Dharamtul, Quepem, Kalasa, Dodamarg, Irikkur, Rajapur, Sawantwadi, Palam, Udupi, Jangipur, Kurupam, Margao, Siddapura, Betanati ARG, Kundapur, Khandapara, Panambur, Gantyada, Londa, Mangaluru, Puttur HMS, Mapusa, Belthangadi, Chandgad, Purna and Marmugoa 7 each
27 Oct	Silchar 19, Sawantwadi 18, Annapurnaghat 16, Lakhipur 13, Ukhrukl 12, Khliehriat, Matijuri and Senapati 11 each, Karimganj and Dharmanagar / Panisagar 9 each, Kodungallur and Kudulu 8 each, Korpana, B. P. Ghat, Cherrapunji, Hosdurg, Kiphire and Lumding 7 each
28 Oct	Rampura, Bhainsdehi and Amarapuram 9 each, Rayadurg 8, Mudgal, Gummagatta, Bhokar, Nanded, Settur, Dharmabad and Karatagi 7 each
29 Oct	Govindaraopet 9, Bhopal 8, Tiruvarur and Shujalpur 7 each
30 Oct	Tiruttani 19, R. K. Pet 15, Papanasam, Sholingur and Manimutharu u U 14 each, Ongole, Ottapadiram and Bhainsdehi 12 each, Anand, Chittoor, Tiruttani PTO and Tindivanam 11 each, Nagari, Wadhvan, Cheranmahadevi, Srivaikuntam, Mylaudy and Vilathikulam 10 each, Satyavedu, Puducherry, Ambasamudram and Marakkanam 9 each, Tambaram, Tirukattupalli, Kaveli, Hogenekal, Minicoy, Anna Uty ARG, Palasamudram, Kodaikanal, Sattur, Sankarapuram, Gingee, Maniyachi, Anna University, Satankulam, Radhapuram and Sriperumbudur 8each, Nanguneri, Pallipattu, Coonoor, Watrap, Thiruvalangadu, Mahabalipuram, Lakhtar, Palayamkottai, Thoothukudi, Chembarabakkam, Ariyalur, Cheyyur, Poonamallee, Wankaner, Sayla, Kaveripakkam, Chuda, Tozhudur, Chengalpattu, Tiruchendur, Surendranagar, Kelambakkam, Kadaladi, Virudunagar AWS, Tankara, Cholavaram, Atmakur and Tirupathi A. P. 7 each
31 Oct	Amini Divi 30, Coonoor 13, Minicoy and Mylaudy 12 each, Nagercoil, Arantangi and Ponneri 11 each, Alappuzha, Kayamkulam, Kuzhithurai, Pudukottai, Kamudhi, Dandepalle and Kayamkulam Agri 10 each, Paramakudi, Tirupuvanam, Pechiparai, Cuddalore, Neyyattinkara and Rameswaram 9 each, Pamban, Nanguneri, Mavelikara, K. Bridge, Kothagiri, Cherthala, Bhoothapandy, Nedumangad, Mancompu, Thiruvananthapuram A. P., Kumarakom, Thiruvananthapuram and Malkangiri 8each, Kollam Rly, Kadaladi, Ernakulam South, Kodaikanal, Illayangudi, Devakottai, Mudukulatur, Vaikom, Periyakulam, Uthagamandalam, Vilathikulam, Kochi A. P., Chengannur, Vedaranniyam and Tirupathur 7 each
1 Nov	Nancowry 10, Mani 8, Kannur, Taliparamba, Thalasserry, Kochi A. P. and Kumarakom 7 each
2 Nov	Nandgaon 15, Girnadam - FMO 12, Alibag 9, Chandwad 8, Sillod and Soegaon 7 each
3 Nov	Armur 19, Dharur 10, Khergam and Shencottah 8 each, Soegaon and Limbdi 7 each
4 Nov	Jalna and Kanjirappally 9 each, Port Blair 8, Konni and Dharur 7each
5 Nov	Nil
6 Nov	Nil
7 Nov	Holalur 8, Guledgud and Nargund 7 each
8 Nov	Kukernag and Sankaridurg 12 each, Batote 11, Baderwah 10, Pudukottai and Govindpura AWS 9 each, Shopian AWS, Manamelkudi, Tirupuvanam, Srinagar and Kawa AWS 8 each, Banihal, Harran AWS, Tirumangalam, Alangudi, Quazigund, Srinagar IAF and Diu 7 each
9 Nov	Paradip and Krishnarajasagara 16 each, Chandbali 15, Sendamangalam and Rajkanika 14 each, Tirtol ARG 10, Omalur and Chengam 9 each, Contai and Srirangapatna 8 each, Digha, Bhadrak AWS, Sattur, Pechiparai, Sankarapuram and Jabot 7 each
10 Nov	Canning Town 20, Contai 16, Durgachak, Kolkata AP and Digha 10 each, Kolkata, Diamond Harbour, Bhograi, Barrackpur IAF and Amfu Kakdwip 9 each, Kadaladi 8, Chittampatti and Nedumangad 7 each
11 Nov	Piravam 9, Sabroom, Chalakudi and Palakkad 8 each
12 Nov	Vellanikkara and Sivagiri 7 each
13 Nov	Nil
14 Nov	Barmer Tehsil 8
15 Nov	Tiruchendur 13, Gudur 12, Nellore 10, Sulur 8, Ramsar 7
16 Nov	Cheranmahadevi and Palayamkottai 10 each, Mettupalayam 9, Tiruchendur 8, Maniyachi 7
17 Nov	Coonoor 17, Ottapadiram7

TABLE 5 (*Contd*.)

Date	Some representative amounts of rainfall in cm for October, November and December 2019 (7 cm and above)
18 Nov	Nil
19 Nov	Nil
20 Nov	Mavelikara 9, Chengannur 7
21 Nov	Tiruchendur 7
22 Nov	Satyabama Uty ARG and Chidambaram 8 each, Kelambakkam 7
23 Nov	Cheyyur 14, Nagapattnam 8
24 Nov	Karaikal 9
25 Nov	Pamban 7
26 Nov	Cheyyur 7
27 Nov	Nil
28 Nov	Tambaram 13, Jayamkondam 10, Sriperumbudur 9, K. M. Koil and Gudur 8 each, Thottambedu, Cuddalore, Batote, Srikalahasti, Kukernag, Banihal and Sirkali 7 each
29 Nov	K. M. Koil 12, Mayiladuthurai and Anaikaranchatram (Kollid) 8 each, Jayamkondam 7
30 Nov	Mayiladuthurai 14, Pudukottai and Kodavasal 13 each, Anaikaranchatram (Kollid) and K. M. Koil 12 each, Ramanathapuram, Papanasam and Trangambadi (Or) Tranqueb 11 each, Rameswaram, Vallam and Needamangalam 10 each, Valangaiman, Vedaranniyam, Kanyakumari, Thiruvidaimaruthur and Thiruthuraipoondi 9 each, Radhapuram and Madukkur 8 each, Kadaladi, Sirkali, Satankulam and Manimutharu U 7 each
1 Dec	Satankulam 19, Cuddalore and Thoothukudi 17 each, Neyveli AWS and Manimutharu u U each 15, Vedaranniyam 14, Cheyyur, Ulundurpet, Chidambaram, Maduranthagam and Trangambadi (Or) Tranqueb 13each, Parangipettai, Tambaram, Satyabama Uty ARG, Marakkanam and Pamban 12 each, Puducherry, Pudukottai, Rameswaram, Virudachalam, Tada, Mahabalipuram, Anna University and Mannargudi 11 each, Panruti, Dgp Office, Thiruthuraipoondi, Tiruchendur, Sethiathope, Sriperumbudur, Sullurpeta and Poonamallee 10 each, Ambasamudram, Jayamkondam, Muthupet, Nagari, Venkatagiri, Needamangalam, Vanur, Nagapattnam, Chembarabakkam, Puttur, Anna Uty ARG, Tondi, Pallipattu, Tiruvallur, Madukkur and Pattukottai 9 each, Adirampattinam, Thiruvalangadu, Chengalpattu, Pandavaiyar Head, Kelambakkam, Palayamkottai, Srivaikuntam, Poondi, Manamelkudi, Kaveripakkam, Karaikal, Uthiramerur, Valinokkam ARG, Thamaraipakkam, Cholavaram and Kallakurichi ARG 8each, Mylaudy, Chembarambakkam ARG, Nannilam, Srimushnam, Thottambedu, Sirkali, Mayiladuthurai, Periya Kalapet ARG, Chennai AP, Vallam, Papanasam, Kallakkurichchi, Cheranmahadevi, Ponneri, Srikalahasti, Kodavasal, Kodur and Kolapakkam ARG 7 each
2 Dec	Minicoy 21, Mettupalayam 18, Coonoor 13, Thottambedu, Maduranthagam, Taliparamba, Cholavaram and Tada 10 each, Chembarabakkam and Mahe 9 each, Srikalahasti, Periyakulam, Red Hills, Thamaraipakkam and Puttur 8each, Ponneri, Tiruvallur, Kodur, Poondi, Sullurpeta, Tambaram, Dgp Office, Poonamallee, Musiri and Kelambakkam 7 each
3 Dec	Amini Divi 20, Agathi 17, Ramanathapuram, Ketti and K Bridge 9 each, Trangambadi (Or) Tranqueb, Anaikaranchatram (Kollid), Rameswaram and Sirkali 8 each, Coonoor, Parangipettai, K. M. Koil, Kothagiri, R. S. Mangalam, Tiruvadanai and Tondi 7 each
4 Dec	Nil
5 Dec	Nil
6 Dec	Rameswaram 8
7 Dec	Nil
8 Dec	Nil
9 Dec	Nil
10 Dec	Nil
11 Dec	Nil
12 Dec	Nil
13 Dec	Gautam Buddha Nagar 11, Katra and Jammu City 10 each, Shahjahanpur T, Pahalgam, Banihal, Batote, Baheri and Sambhal 8 each, Kothi, Kawa AWS, Meja, Deoprayag, Undhampur ARG, Baderwah and Dharmasala 7 each
14 Dec	Rafiganj, Shahjahanpur T, Moradabad, Dharmasala and Pahalgam 9 each, Cuddalore, Nighasan and Deoprayag 8 each, Quazigund, Banihal, Nangal, Baheri and Thakurdwara 7 each

TABLE 5 (*Contd*.)

Date	Some representative amounts of rainfall in cm for October, November and December 2019 (7 cm and above)
15 Dec	Mancompu 9
16 Dec	Bhaiyathan 8, Odagi 7
17 Dec	Nil
18 Dec	Nil
19 Dec	Nil
20 Dec	Nil
21 Dec	Tiruchendur 9, Mylaudy and Quazigund 8 each, Nagercoil, Kanyakumari and Radhapuram 7 each
22 Dec	Nil
23 Dec	Nil
24 Dec	Nil
25 Dec	Nagapattnam 14, Karaikal 13
26 Dec	Nil
27 Dec	Subramanya 8
28 Dec	Nil
29 Dec	Nil
30 Dec	Nil
31 Dec	Anaikaranchatram (Kollid) and Periya Kalapet ARG 9 each

A low pressure area that had formed over northeast Arabian Sea and adjoining coastal areas of Saurashtra and Kutch on 28th September. It had concentrated into a Depression over Gulf of Kutch and neighborhood and then weakened into a well marked low pressure area over southeast Rajasthan and neighborhood in the morning of 1st October. It caused heavy to very heavy rainfall with extremely heavy falls at isolated places over Gujarat State, Konkan & Goa and East Rajasthan.

Super Cyclonic Storm, 'Kyarr' caused heavy to very heavy rainfall at isolated places during 24-26 October over Maharashtra, Konkan and Marathwada along west coast of India.

Under the influence of a westward moving trough in the easterlies across southern peninsula during 15-17 October and another trough in easterlies passed over the region during 27-29 October, these systems contributed significantly towards the NEM rainfall.

In the month of October, out of 36 meteorological sub-divisions, 16 sub-divisions comprising of 49% area of the country received *large excess* rainfall, 6 sub-divisions received *excess* and *normal* each, while 8 sub-divisions received *deficient* rainfall. No sub-division recorded *large deficient* or no rainfall. The broad geographical region of central India recorded double the amount of rainfall for the month.

Out of the 10 sub-divisions from central India, 8 recorded *large excess* rainfall and 2 *normal* rainfall.

3.1.5. *Temperature*

The maximum temperatures remained *normal* or *below normal* throughout the monthand temperatures dropped to *appreciably below normal* in some areas and *markedly below normal* in most sub-divisions of central India, east and northeast Indiaand a few sub-divisions of peninsular India in the last week of the month.

The minimum temperatures in this monthwere generally normalover the country except in the second fortnight when most sub-divisions from central India, northwest India, east and northeast India were *above normal* on some days and *appreciably above normal* on few days particularly in the last few days of the month.

No *heat wave/cold wave* conditions occurred during October. The month's and the season's highest maximum temperature was 39.4 °C at Dharmapuri (Tamil Nadu)

on 28th October and the lowest minimum temperature of the month was 12.6 °C at Erinpura Road (West Rajasthan) on 23rd October, in the plains of the country.

3.1.6. *Damages associated with disastrous weather events*

The heavy rain in Bihar from September end continued to the first week of October causing major flooding and damage to life and property as per media reports, killing at least 73 people. As per media reports, lightning claimed 13 lives in Khammam in Telangana in the first week of October. Two people died in Thane (Mumbai) when a tree fell on them where they were taking shelter during a thunderstorm. Due to intense spell of rain in Pune, a van driver of PMPL died after a huge tree fell on the vehicle on 10th October. Heavy rains caused deadly floods in Karnataka, 12 people were reportedly killed, at least 5444 homes were damaged, and thousands of residents were displaced. Mudigere bridge collapsed after heavy rain in Chikkamangaluru, Karnataka. Cyclonic storm Kyarr, which headed towards Oman, left behind a trail of destruction with broken homes, uprooted trees and throwing life out of gear by knocking down electricity poles, inundating roads, in the coastal states *viz*., Maharashtra & Karnataka of India. Incessant rain and flooding have left three people dead in Nagaland. Nearly 17 villages in Dimapur were affected by floods and around 240 people were rescued by teams of the State Disaster Response Force and the Assam Rifles. Unseasonal rain in October damaged *kharif* crops on over 54 lakh hectares of the 140 lakh hectares under cultivation in Maharashtra resulting in huge losses.

3.2. *November*

3.2.1. *Storms and Depressions*

ESCS, 'MAHA' in Arabian Sea occurred simultaneously with VSCS,'BULBUL' over the Bay of Bengal during 5-7 November similar to last year when two VSCS, one each in Bay of Bengal (Titli 7-13 October) and Arabian Sea (Luban 6-14 October) had coexisted. ESCS, 'MAHA' originated as a low pressure area (LPA) over Equatorial Indian Ocean off south Sri Lanka coast in the forenoon (0600 UTC) of 28th October, well marked low pressure area over Comorin area and adjoining equatorial Indian Ocean on 29th, a depression over southeast Arabian Sea and adjoining Lakshadweep area moving north-northwestward, it further intensified into a deep depression in the early morning (0000 UTC) of 3rd December. Continuing to move north-northwestward, it intensified into a cyclonic storm on 5th December. After multiple re-curvatures, it finally crossed Somalia coast near latitude 7.4° N and longitude 49.6° E during 0200 to 0300 UTC of 7th December as a cyclonic storm.

As the Extremely Severe Cyclonic Storm MAHA moved over to eastcentral Arabian Sea, coastal areas and windward side of the western Ghats of Maharashtra received fairly widespread to widespread rainfall with heavy to very heavy falls at isolated places on 2nd November.

A low pressure area formed over north Andaman Sea on 4th November. It became a well marked low pressure area in the afternoon of the same day and concentrated into a Depression in the early morning hours of 5th November, over east-central and adjoining Southeast Bay of Bengal and north Andaman Sea. It intensified into a Deep Depression in the early morning hours of 6th November, over East-central and adjoining Southeast Bay of Bengal and further intensified into the Cyclonic Storm 'Bulbul' in the night hours of 6th November, over east-central and adjoining southeast Bay of Bengal, This system caused widespread rainfall/thunderstorm activity along with isolated heavy falls to very heavy falls over Andaman and Nicobar Islands during the week.

An active Western Disturbance and its interaction with remnant of Very Severe Cyclonic Storm 'MAHA' caused largely excess rainfall over most of the sub-divisions of northwest India in the second week. The second half of the month experienced fairly widespread to widespread rainfall/snowfall activity over northwest India under the influence of intense western disturbances and their induced systems. Similarly movement of easterly troughs caused scattered to fairly widespread rainfall / thunderstorm activity over southern Peninsular India along with intense to very intense rainfall activity at isolated places over the region.

3.2.2. *Weather and associated synoptic features*

A summary of the synoptic systems for the month of November 2019 is given in Table 3. The sub-divisionwise percentage departure of rainfall from normal and the significant amounts of rainfall during the month are given in Tables 1 and 5, respectively.

Intense western disturbances triggered rain/snow in the sub-divisions of Northwest Region *viz.*, Jammu-Kashmir & Ladakh, Punjab, Haryana, Chandigarh, Delhi, Uttarakhand, East Uttar Pradesh, west Rajasthan and Himachal Pradesh. The broad geographical region of northwest India received four times the precipitation of *normal* for the month. Out of the nine sub-divisions seven were *large excess, one deficient* (west Rajasthan) and one *large deficient* (east Uttar Pradesh). All the other

homogenous regions except Northwest India were rainfall deficient in this month. During November, Madden Julian Oscillation (MJO) was in phase 5-8, over the other half of the hemisphere and was not favourable for good NEM activity.

3.2.3. *Temperature*

Cold day and cold wave conditions were not observed in this month

The minimum temperatures over most sub-divisions were generally *normal* or *above normal* in the month. Over Central India they were *above normal* or *appreciably above normal* on many days and *markedly above normal*on few days in the first fortnight. The night temperatures over Peninsular India remained *above normal* or *appreciably above normal* for few days in the last week of the month.

The month's lowest minimum temperature over the plains of the country was 8.8 °C at Betul (West Madhya Pradesh) on 19th and 20th November.

3.2.4. *Damages associated with disastrous weather events*

Severe Cyclone, 'Bulbul' left behind a trail of destruction in West Bengal and parts of Odisha, taking more than thirty lives, damaging around 40 per cent standing crops and over six lakh hectares of cultivable land spread over five districts, affecting 2. 97 lakh people and damaging over 28,000 houses, uprooting hundreds of trees and affecting power supply in the state.

Heavy snowfall over Jammu-Kashmir & Ladakh caused massive damage to apple trees. The valley remained cut off from the rest of the country for a few days, as both surface and air traffic were suspended due to snowfall. Four soldiers and two civilian porters were killed by an avalanche on the Siachen Glacier's northern sector on 7th November. Intense to very intense rainfall activity over Tamil Nadu, Puducherry and Karaikal due to movement of an easterly wave claimed at least twenty-five lives in various rain-related incidents in the last week of the month.

3.3. *December*

3.3.1. *Storms and depressions*

Cyclonic Storm (CS), 'PAWAN' was the fifth Cyclonic Storm over the Arabian Sea during the year 2019 against the normal (1891-2018) of 1 per year. It formed over southwest Arabian Sea and adjoining equatorial Indian Ocean and co-existed with a deep depression (3-5 December) over southeast Arabian Sea. Cyclonic Storm, 'PAWAN' did not cause any adverse weather over any of the Indian states along west coast of India.

Three intense low pressure systems (2 depressions and 1 Cyclonic storm) formed over the Arabian Sea during the month which is a record for the month since 1891.

3.3.2. *Weather and associated synoptic features*

Table 4 gives a summary of the synoptic systems during the month of December 2019. The sub-division wise percentage departure of rainfall from normal and the significant amounts of rainfall during the month are given in Tables 1 and 5, respectively.

In the third week of December, movement of an intense western disturbance along with its induced cyclonic circulation caused fairly widespread to widespread rainfall / snowfall over Western Himalayan Region and scattered to fairly widespread rainfall / thunderstorm / hail storm activity over the adjoining plains of northwest India. Also, movement of an easterly wave triggered scattered to fairly widespread rainfall / thunderstorm activity over parts of peninsular India with isolated intense rainfall activity over Tamil Nadu, Puducherry & Karaikal and Kerala during the same period. Interaction between both the western disturbance and easterly wave caused isolated to scattered rainfall / thunderstorms activity over parts of Central India.

3.3.3. *Temperature*

Cold day conditions were observed from second fortnight of the month in isolated pockets over northwest India particularly Rajasthan, Uttar Pradesh, Punjab, Haryana, Chandigarh, Delhi and at isolated places over east India and Madhya Pradesh in Central India in the last week of the month. Cold day to Severe cold day conditions were observed in the last week over West Uttar Pradesh, North Rajasthan and North Madhya Pradesh.

Cold wave conditions manifested from last few days of the month. Cold wave conditions were observed on many days in Jammu-Kashmir & Ladakh, East Uttar Pradesh, Madhya Pradesh and Rajasthan and a few days over Vidarbha, Odisha, Bihar, Saurashtra and Kutch. Severe cold wave conditions prevailed over parts of north and northwest India and isolated incidences over central and east India especially in the last week of the month. The National Capital Delhi recorded longest cold spell since 1997 and second coldest December since 1901.

Delhi (Safdurjang) recorded the coldest day for the month of December on 30th December, 2019 with a maximum temperature of 9.4 °C (about 11.4 degrees below normal). The earlier record of lowest maximum

temperature for Safdurjung for the month of December had been 11.3 °C on 28th December, 1997. It has also surpassed the lowest maximum temperature ever recorded for Safdurjung of 9.8 °C on 2nd January, 2013.

The lowest minimum temperature recorded was -1.0°C at Sikar (East Rajasthan) on 28th December.

Minimum temperatures were *normal to above normal* over most parts of Indiaand *appreciably above normal* on some days over south peninsular India, East and northeast India and a few days over Northwest India.

3.3.4. *Damages associated with the disastrous weather events*

As per media reports, at least seventeen people were killed in various rain-related incidents in Tamil Nadu in the first week of December. Seventeen of the victims died after a wall collapsed following a continuous heavy downpour in Coimbatore. Around 1,305 huts and 465 tiled-roof houses were damaged, while 1000 people were evacuated to government relief centers in Tuticorin, Cuddalore and Tirunelveli districts. Rajasthan received heavy rains and hailstorms in the second week of the month, particularly the district of Nagaur bore the brunt of heavy hailstorms. The intensity with which they fell caused damage to standing crops, injuring birds, animals and other livestock. Cold wave claimed 57 lives from northern parts of the country, 28 persons reportedly dead from Uttar Pradesh, 19 from Bihar and 10 persons from Madhya Pradesh during the last week of December. 4 Jawans killed due to snow avalanche from Jammu-Kashmir & Ladakh on 4th December. Lightning killed 2 persons from Raisen and Vidisha districts of Madhya Pradesh on 12th December. Six people, including two minors, were killed when their car skidded off the road and fell into a canal in Uttar Pradesh's Greater Noida, apparently due to fog. Low visibility caused the death of atleast eight people while 17 were injured in various road accidents in North India.

Appendix

Definitions of the terms given in '*Italics*'

(A) Rainfall

(*i*) Percentage departure from normal	
Large Excess	- + 60 % or more
Excess	- +20% to +59%
Normal	- –19% to +19%
Deficient	- –20% to –59%
Large Deficient	- –60% to –99%
(*ii*) Intensity (during the past 24 hours period ending at 0300 UTC)	
Extremely heavy rainfall	- 20.5 cm and above
Very heavy rainfall	- 11.6 cm to 20.4 cm
Heavy rainfall	- 6.5 cm to 11.5 cm
Heavy snowfall	- 64.5 cm to 115.5 cm
(*iii*) Spatial distribution (percentage of the stations in a meteorological sub-division reporting a 24 hour rainfall of 0.1 mm or more)	
At most places (Widespread)	- 76% of stations gets rainfall
At many places (Fairly widespread)	- (51-75)% of stations gets rainfall
At a few places (Scattered)	- (26-50)% of stations gets rainfall
At isolated places (Isolated)	- ≤25% of stations gets rainfall

(B) Monsoon activity

(*i*) Southwest monsoon	
Vigorous	- Rainfall exceeding 4 times the normal with, at least two stations reporting rainfall more than or equal to 8 cm along the west coast and 5 cm elsewhere. Rainfall in that sub-division should be fairly widespread or widespread
Active	- Rainfall more than 1½ to 4 times the normal, with at least two stations reporting rainfall more than or equal to 5 cm along the west coast and 3 cm elsewhere. Rainfall in that sub-division should be fairly widespread or widespread
(*ii*) Northeast monsoon	
Vigorous	- Rainfall exceeding 4 times the normal with at least two stations reporting rainfall more than or equal to 5 cm in coastal Tamil Nadu and south coastal Andhra Pradesh and 3 cm elsewhere in the northeast monsoon region. Rainfall in that sub-division

	should be fairly widespread or widespread
Active	- Rainfall more than 1½ to 4 times the normal, with at least two stations reporting rainfall more than or equal to 3 cm in coastal Tamil Nadu and south coastal Andhra Pradesh and 2 cm elsewhere in the northeast monsoon region. Rainfall in that sub-division should fairly widespread or widespread

(C) Temperatures

(*i*) Maximum / Day temperature

Markedly above normal	- When departure from normal is +5 °C or more
Appreciably above normal	- When departure from normal is +3.1 °C to +5.0 °C
Above normal	- Departure from normal is +1.6 °C to +3.0 °C
Normal	- When departure from normal is +1.5 °C to –1.5 °C

(*ii*) Minimum / Night temperature

Based on the revised criteria which came into practice with effect from 2016, cold waves are declared based on the actual minimum temperatures. Cold wave is considered when the minimum temperature of a station is 10 °C or less for plains and 0 °C or less for hilly regions. Also to declare cold wave, the criteria should be met at least in 2 stations in a met sub-division for at least 2 consecutive days.

Severe cold wave conditions	- When the negative departure of minimum temperature from Normal is more than 6.4°C or when the actual minimum temperature is ≤2 °C over the plains
Cold wave conditions	- When the negative departure of minimum temperature from normal is 4.5°C to 6.4°C or when the actual minimum temperature is ≤4°C over the plains. For stations located over the coastal areas, when the minimum temperature departure is –4.5°C or more, 'Cold Wave' may be described if the actual minimum temperature is 15 °C or less
Cold day to severe cold day conditions	- When the minimum temperature is 10 °C or less for plains and 0°C or less for hilly regions. Cold day may be described if the departure of maximum temperature is –4.5°C to –6.4°C and severe cold day when it is less than 6.4°C
Markedly below normal	- When the departure from normal is –5°C to or less
Appreciably below normal	- When the departure from normal is between –3.1°C to –5.0°C
Below normal	- When the departure from normal is –1.6°C to +3.0°C
Normal	- Departure from normal is –1.5°C to+1.5°C