MAUSAM, **70**, 4 (October 2019), 853-876

Weather in India

POST MONSOON SEASON (October - December 2018)†

1. Introduction

Post monsoon season-2018 was cyclogenetically a unique season, when four intense low pressure systems formed during period 1st October - 31st December. Out of these, three were Very Severe Cyclonic Storms (VSCSs) and the remaining one, a Severe Cyclonic Storms (SCS). No other Depression or Deep Depression formed in the season. Secondly, in a rarest of rare occurrence, two VSCS, one each in Bay of Bengal (Titli 7-13 October) and Arabian Sea (Luban 6-14 October) developed, simultaneously. This rare event occurred after 41 years. Also, Luban was the third cyclonic storm to cross Arabia and African coasts in 2018, against 8 such cyclones during the entire satellite era (1961-2018).

The southwest monsoon withdrew from the entire country on 21st October and the northeast monsoon (NEM) rains commenced over the south peninsula on 1st November against normal date of 20th October and ceased on 2nd January.

Rainfall over the core region of south peninsula during the season was below normal (66% of LPA value), which was the 6th lowest season since 1901. Northeast monsoon in the core region was, *normal** in Kerala, *deficient* in Tamil Nadu, South interior Karnataka and Coastal Andhra Pradesh and *large deficient* over Rayalaseema.

The maximum temperatures were *normal* or *above normal* over major parts of the country during the season. The Minimum Temperatures were in general *normal* or *below normal* on most days.

Severe cold wave / cold wave conditions manifested over parts of Central and Northwest India towards the third week of December. They spread over northwest as well as central India and parts of peninsular India at the end of season.

Dense Fog prevailed over some parts of northern plains and at isolated pockets over south Peninsula especially over Tamil Nadu from last week of November and were more widespread during the month of December.

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

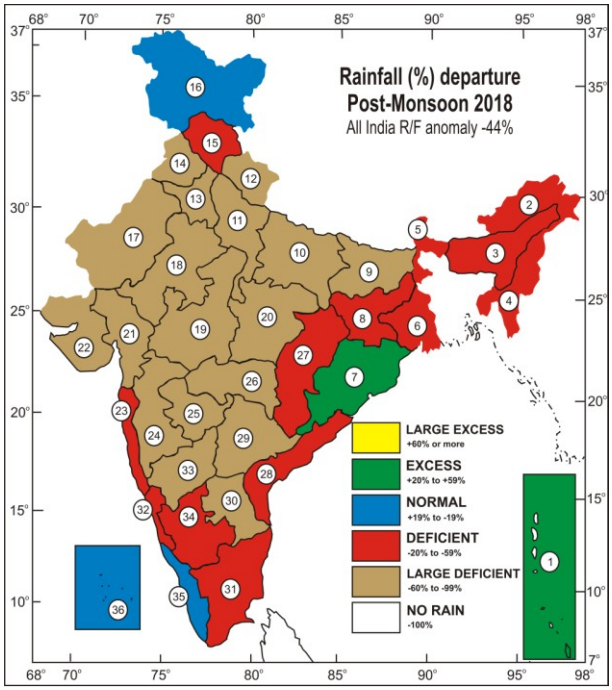

Fig. 1. Sub-divisionwise seasonal rainfall departure from normal (%) for post monsoon season (October to December 2018). Sub-divisions are indicated by number on the map & bold letters in legend. The rainfall anomaly values for these 36 sub-divisions are indicated below :

1 23	**7** 23	**13** -66	**19** -96	**25** -81	**31** -23
2 -50	**8** -43	**14** -74	**20** -86	**26** -88	**32** -31
3 -54	**9** -72	**15** -48	**21** -99	**27** -54	**33** -65
4 -52	**10** -99	**16** -2	**22** -97	**28** -54	**34** -42
5 -50	**11** -86	**17** -95	**23** -51	**29** -65	**35** -3
6 -41	**12** -72	**18** -92	**24** -60	**30** -62	**36** -14

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 (56% of LPA) over the four broad geographical regions was *below normal*, with East and Northeast India having the largest

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

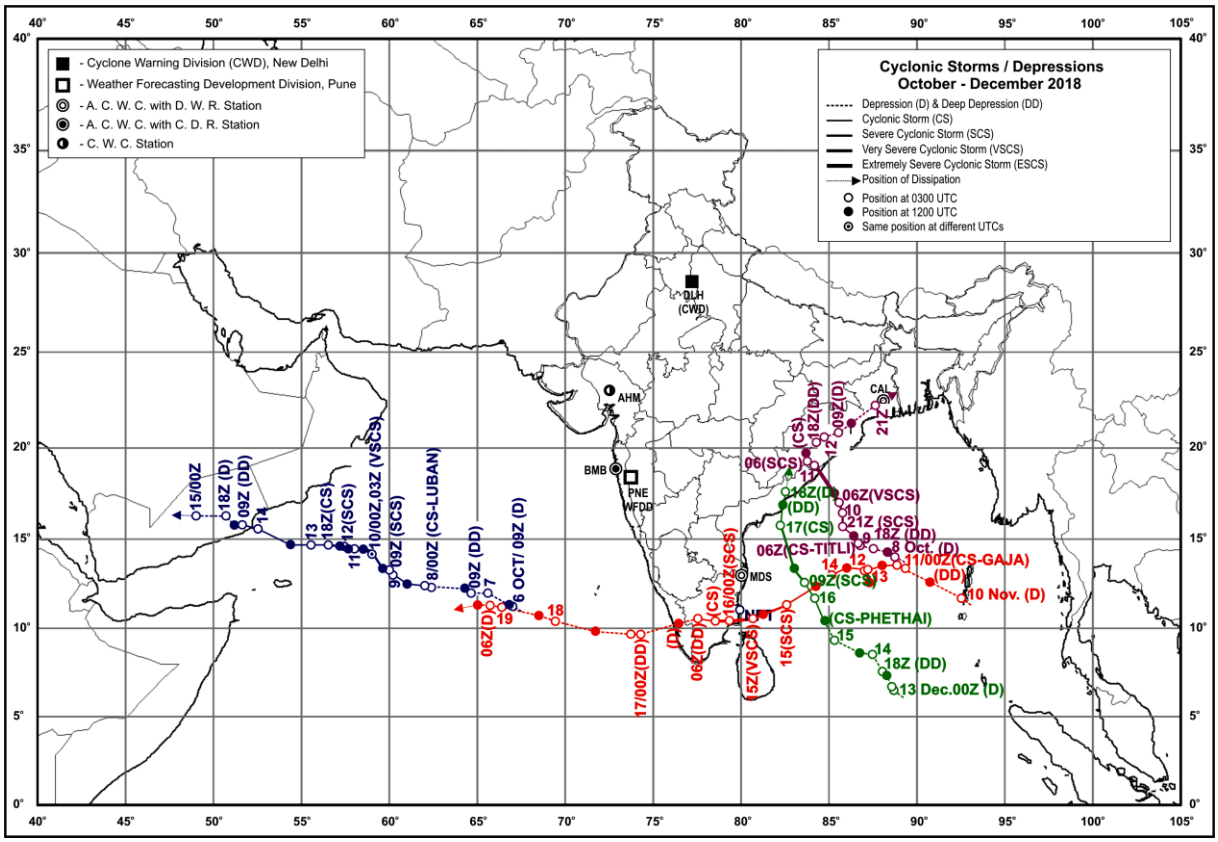

Fig. 2. Cyclones and depressions during post-monsoon season 2018

disparity at 48% followed by Central India at 50%. Northwest India at 44% deficit had only one subdivision with *normal* rainfall, (Jammu and Kashmir precipitation 98% of LPA). South Peninsula received precipitation 63% of LPA *i.e.*, deficit by 37% of LPA. In this region, NE Monsoon being the chief rainy season remained deficient in all the three months affecting adversely the rabi crops yield. In the post monsoon season, out of 36 meteorological subdivisions, 18 subdivisions were *large deficient*, 13 *deficient*, 3 *normal* and remaining 2 subdivisions (Andaman & Nicobar Islands and Odisha) received *excess* rainfall.

The monthly rainfall for the country was *normal* during December (88% of its LPA) and *deficient* in October and November with 44% and 71% of its LPA, respectively.

Perturbations in the mid-latitude westerlies moved across the northern parts of the country and gave rain/snow in the higher reaches of Himalayas during most parts of the season; which did not result in much precipitation over the northwestern parts of the country except a few days in November. Global parameters like ENSO and IOD were neutral and MJO was favorable in phase 2-4 with amplitude >1 only on 26 days during the season.

3. Monthly features

3.1. *October*

3.1.1. *Withdrawal of southwest monsoon*

With the changeover of the lower tropospheric circulation pattern from cyclonic to anticyclonic, reduction of humidity in the lower tropospheric levels and dry weather prevailing over many parts of west and northwest India, southwest monsoon started its withdrawal from 29th September onwards. Initially it withdrew from some parts of Rajasthan, Kutch and north Arabian Sea, from remaining parts of Rajasthan, entire Jammu & Kashmir, Punjab, Haryana, Chandigarh and Delhi, Himachal Pradesh, Uttarakhand, west Uttar Pradesh, some parts of east Uttar Pradesh, west and east Madhya Pradesh and some more parts of Gujarat State and north Arabian Sea by 1st October. Further withdrawal was rapid and by 6th October the monsoon had withdrawn from all India other than Southern Peninsular region. The southwest monsoon withdrew from entire country on 21st October, with the setting in of the northeasterly and easterly winds in lower tropospheric levels over the Indian region.

TABLE 1

Sub-divisionwise rainfall (mm) for each month and season as a whole (October-December, 2018)

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	298.9	296.7	1%	239.6	253.7	-6%	318.4	145.5	119%	856.9	695.9	23%
2.	Arunachal Pradesh	57.6	183.0	-69%	60.6	45.8	32%	14.8	38.4	-61%	133.1	267.2	-50%
3.	Assam & Meghalaya	46.8	154.8	-70%	16.9	28.4	-40%	25.4	11.8	115%	89.2	195.0	-54%
4.	Naga., Mani., Mizo. and Tri.	88.7	179.8	-51%	5.8	50.7	-89%	21.8	12.5	74%	116.2	243.0	-52%
5.	Sub-Himalayan West Bengal & Sikkim	72.3	154.2	-53%	11.2	20.3	-45%	9.9	10.8	-8%	93.4	185.3	-50%
6.	Gangetic West Bengal	67.2	129.3	-48%	2.8	23.3	-88%	24.2	7.5	223%	94.3	160.1	-41%
7.	Orissa	120.3	111.6	8%	0.9	27.7	-97%	56.4	4.8	1074%	177.6	144.1	23%
8.	Jharkhand	23.1	75.2	-69%	0.4	9.9	-96%	29.6	6.5	355%	52.3	91.6	-43%
9.	Bihar	17.5	64.8	-73%	0.0	6.9	-99%	4.5	5.8	-23%	22.0	77.5	-72%
10.	East Uttar Pradesh	0.3	49.2	-99%	0.0	4.5	-99%	0.0	6.7	-99%	0.4	60.4	-99%
11.	West Uttar Pradesh	6.6	42.1	-84%	0.8	4.7	-84%	0.3	7.6	-96%	7.6	54.4	-86%
12.	Uttarakhand	3.3	58.6	-94%	20.2	9.7	108%	1.6	21.3	-92%	25.1	89.6	-72%
13.	Haryana, Chandigarh & Delhi	3.0	17.6	-83%	1.8	4.9	-63%	5.1	6.9	-26%	9.9	29.4	-66%
14.	Punjab	4.2	22.0	-81%	2.7	5.7	-52%	3.6	13.3	-73%	10.6	41.0	-74%
15.	Himachal Pradesh	11.6	42.5	-73%	37.3	20.3	84%	7.5	45.4	-83%	56.4	108.2	-48%
16.	Jammu & Kashmir	22.0	38.9	-43%	77.6	33.0	135%	29.2	59.9	-51%	128.7	131.8	-2%
17.	West Rajasthan	0.4	5.4	-93%	0.1	2.5	-97%	0.0	1.6	-98%	0.5	9.5	-95%
18.	East Rajasthan	1.2	16.9	-93%	0.2	7.4	-97%	0.7	3.3	-77%	2.2	27.6	-92%
19.	West Madhya Pradesh	1.4	34.4	-96%	0.5	11.0	-95%	0.2	7.7	-98%	2.1	53.1	-96%
20.	East Madhya Pradesh	1.5	37.5	-96%	0.2	9.9	-98%	6.2	10.4	-40%	7.9	57.8	-86%
21.	Gujarat Region	0.5	23.4	-98%	0.0	9.4	-100%	0.0	1.7	-100%	0.5	34.5	-99%
22.	Saurashtra & Kutch	0.9	18.1	-95%	0.0	10.7	-100%	0.0	0.7	-100%	0.9	29.5	-97%
23.	Konkan & Goa	50.3	120.8	-58%	14.9	22.7	-34%	0.3	5.6	-94%	73.6	149.1	-51%
24.	Madhya Maharashtra	20.1	79.0	-75%	19.6	22.7	-14%	0.4	6.1	-94%	42.7	107.8	-60%
25.	Marathawada	9.2	72.3	-87%	8.9	21.2	-58%	0.0	8.1	-99%	19.7	101.6	-81%
26.	Vidarbha	0.0	59.6	-99%	1.8	13.2	-86%	8.1	9.0	-10%	10.0	81.8	-88%
27.	Chhattisgarh	4.1	63.3	-94%	0.0	9.2	-99%	31.6	5.5	474%	35.6	78.0	-54%
28.	Coastal Andhra Pradesh	48.4	193.2	-75%	41.8	106.6	-61%	59.2	27.6	114%	149.3	327.4	-54%
29.	Telangana	17.1	91.3	-81%	1.4	21.4	-93%	23.2	5.9	292%	41.7	118.6	-65%
30.	Rayalaseema	44.8	129.4	-65%	34.4	66.1	-48%	4.6	23.7	-81%	83.8	219.2	-62%
31.	Tamil Nadu	157.7	180.2	-12%	156.8	170.0	-8%	21.6	88.0	-76%	336.0	438.2	-23%
32.	Coastal Karnataka	150.2	189.5	-21%	20.3	59.6	-66%	9.9	13.7	-28%	180.3	262.8	-31%
33.	North Interior Karnataka	39.9	112.0	-64%	7.0	27.3	-74%	3.4	6.0	-43%	50.3	145.3	-65%
34.	South Interior Karnataka	97.6	147.7	-34%	18.9	49.2	-62%	4.7	12.7	-63%	121.2	209.6	-42%
35.	Kerala	305.4	292.3	4%	131.4	150.9	-13%	27.2	37.5	-27%	464.0	480.7	-3%
36.	Lakshadweep	152.9	157.1	-3%	96.7	117.7	-18%	38.3	58.8	-35%	287.9	333.6	-14%

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**)	*Cyclonic storm*					
1.	Very Severe Cyclonic Storm 'TITLI'	8-13	Eastcentral Bay of Bengal	Northeast	Odisha	It weakened into adepression on 12 and into alow pressure on 13, the associated cyclonic circulation extended upto 0.9 km a.s.l. and became less marked on 14. Details are given in the article on Storms & Depressions over the north Indian Ocean- 2018
2.	Very Severe Cyclonic Storm 'LUBAN'	6-14	Southeast and adjoining eastcentral Arabian Sea	East northeast	Yemen	It weakened into a well-marked low pressure area on 15. Became unimportant for Indian Region
(**B**)	*Well marked Low Pressure area/Low Pressure area*					
1.	Low Pressure	20-22	Gulf of Thailand and neighbourhood	Northwest	Southern parts of Myanmar and neighbourhood	Under the influence of the cyclonic circulation over Gulf of Thailand & neighbourhood the Low pressure formed on 20 and became unimportant for the region on 23
(**C**)	*Western Disturbances /Eastward moving systems*					
(*i*)	*Upper air cyclonic circulation*					
1.	Between 3.1 & 5.8 kms a.s.l.	1-3	Northwest Afghanistan & neighbourhood	Northeast	Jammu & Kashmir and neighbourhood	Trough aloft roughly along Long. 66° E to the north of Lat. 28° N on 3. Moved away northeastwards
2.	Upto 5.8 kms a.s.l.	4-6	Northeast Afghanistan & neighbourhood	Do	Northeastern parts of Jammu & Kashmir and neighbourhood	Moved away east-northeastwards
3.	Upper air	7-11	Do	Do	Jammu & Kashmir and adjoining north Pakistan	A trough aloft on 11. Moved away eastwards
4.	At 3.1 km a.s.l.	15-19	North Pakistan and neighbourhood	Do	Northeast Jammu & Kashmir and neighbourhood	Initially it lay as a trough in the upper tropospheric westerlies and ran roughly along Long. 66° E to the north of Lat. 30° N on 14. A trough aloft at 3.1 km a.s.l. with its axis at 5.8 kms a.s.l. roughly along Long. 66° E to the north of 28° N from 15-18. Moved away east-northeastwards
5.	Do	22	Northeast Afghanistan & adjoining Pakistan	Stationary	*In situ*	It was seen as a trough with its axis at 5.8 kms a.s.l. roughly along 75° E to the north of 32° N on 23. It became less marked on 24
6.	Do	24-26	West Afghanistan & neighbourhood	Northeast	Eastern parts of Jammu & Kashmir and neighbourhood	Moved away Northeastwards
7.	Between 3.1 & 5.8 kms a.s.l.	29-31	Northeast Afghanistan & neighbourhood	Do	Do	Moved away Northeastwards
8.	At 3.1 km a.s.l.	30 Oct-4 Nov	Western parts of Iran and neighbourhood	Do	Jammu and neighbourhood	A trough aloft with its axis at 5.8 km above m.s.l. roughly along Long. 54° E to the north of Lat. 28° N on 30, it moved away east-northeastwards on 5 November. The cycir became less marked on 4 November

TABLE 2 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(*ii*)	*As a trough*					
1.	At 5.8 km a.s.l.	12	Along Long. 65.0° E to the north of Lat. 27.0° N	East	Eastern parts	Moved away eastwards
2.	Do	18-20	Along Long. 65° E to the north of Lat. 32° N	East northeast wards	Roughly along Long. 69° E to the north of Lat. 32° N	It was seen as a cyclonic circulation over Punjab and adjoining central Pakistan at 3.1 km a.s.l. on 21. Became less marked on 22
3.	At 7.6 km a.s.l.	29-31	Along Long. 82° E to the north of Lat. 20° N	Northeast	Roughly along Long. 86° E to the north of Lat. 26° N	Became less marked on 1 November
(*iii*)	*As an Induced cyclonic circulation*					
1.	Upto 0.9 km a.s.l.	5-11	Northwest Rajasthan and neighbourhood	Oscillatory	Haryana and neighbourhood	Became less marked on 12
2.	Upto1.5 km a.s.l.	12	Pakistan and adjoining	Stationary	*In situ*	Became less marked on 13
3.	Do	14-18	Central Pakistan	Northeast	South Haryana and neighbourhood	Became less marked on 19
(D)	*Other upper air cyclonic circulations*					
1.	Upto 0.9 km a.s.l.	2-6	Southwest Bay of Bengal and adjoining SriLanka off Tamil Nadu coast	Stationary	*In situ*	Initially it lay as a trough in easterlies extending upto 1.5 km a.s.l. over southeast Bay of Bengal &neighbourhood on 1 October. It became less marked on 6
2.	Upto 2.1 km a.s.l.	4-7	Northern parts of Bangladesh and adjoining West Bengal	East	Central parts of Assam and neighbourhood	Initially it lay as a trough from east Bihar to central parts of Bangladesh and extended between 1.5 & 2.1 km a.s.l. across Sub-Himalayan West Bengal on 1 October. It became less marked on 8
3.	Upto 0.9 kms a.s.l.	4	South Kerala and adjoining interior Tamil Nadu	Stationary	*In situ*	Became less marked on 5
4.	Between 3.6 and 4.5 kms a.s.l.	12	Tamil Nadu and adjoining southwest Bay of Bengal between 3.6 to 4.5 kms a.s.l.	North	East central Arabian Sea off Karnataka coast	Became less marked on 13
5.	Between 1.5 and 4.5 km a.s.l	13-14	Lakshadweep area and adjoining southeast Arabian Sea	Stationary	*In situ*	Became less marked on 15
6.	Upto1.5 km a.s.l.	13-16	Coastal Karnataka and adjoining Goa	North	South Madhya Maharashtra and neighbourhood	Became less marked on 17
7.	Upto 1.5 kms a.s.l.	14-17	Central Assam	East	East Assam and neighbourhood	Became less marked on 18
8.	Between 1.5 and 3.1 km a.s.l.	14-15	South Tamil Nadu and neighbourhood	Stationary	*In situ*	A Trough ran from the cyclonic circulation to north interior Karnataka at 1.5 km a.s.l. on 15. Became less marked on 16
9.	Upto1.5 km a.s.l.	14	Southwest Rajasthan and adjoining Gujarat	Do	Do	Became less marked on 15
10.	Upto 5.8 km a.s.l.	15-22	Gulf of Siam	West	Sri Lanka & neighbourhood	It was seen as an east west trough roughly along Lat. 8.0° N and extended upto 3.1 kms a.m.s.l. on 23 and became less marked on 24
11.	Between 3.1 and 4.5 km a.s.l.	15	Coastal Karnataka & adjoining Arabian Sea	Stationary	*In situ*	Became less marked on 16

TABLE 2 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
12.	Upto 3.1 km a.s.l.	17-20	Kerala and neighbourhood	East	East central and adjoining west central Arabian Sea	Moved away on 21
13.	At 1.5 km a.s.l.	18-20	East Bangladesh & neighbourhood	Stationary	*In situ*	Became less marked on 21
14.	Do	18	South Coastal Andhra Pradesh and neighbourhood	Do	Do	Became less marked on 19
15.	At 0.9 km a.s.l.	19-20	Coastal Karnataka & neighbourhood	South	North Kerala and adjoining Coastal Karnataka	Became les marked on 21
16.	At 5.8 km a.s.l.	21	East Rajasthan and neighbourhood	Stationary	Southwest Madhya Pradesh & neighbourhood	Became less marked on 22
17.	At 0.9 km a.s.l.	21	Southwest Bay of Bengal off Sri Lanka Tamilnadu coasts to Lakshadweep	Do	*In situ*	Became less marked on 22
18.	At 1.5 km a.s.l.	21	From Lakshadweep-Maldives area	Do	Do	Became less marked on 22
19.	Do	22-23	Southwest Rajasthan & adjoining Pakistan	East	South Rajasthan & neighbourhood	Became less marked on 24
20.	Do	23-27	Central Pakistan & neighbourhood	Do	East Rajasthan & neighbourhood	Became less marked on 28
21.	Upto 3.1 km a.s.l.	24-26	Gulf of Siam	West	South Andaman Sea & neighbourhood	Became less marked on 27
22.	Upto1.5 km a.s.l.	25	Gulf of Mannar & neighbourhood	Stationary	*In situ*	Became less marked on 26
23.	Upto 4.5 km a.s.l.	25-27	Sub-Himalayan West Bengal & Sikkim and neighbourhood	East	Bangladesh	Became less marked on 28
24.	Upto 2.1 km a.s.l.	25	South Assam & neighbourhood	Stationary	*In situ*	Became less marked on 26
25.	Do	27-31	Southwest Bay of Bengal off Sri Lanka coast	North	Embedded in the trough of low from Southwest Bay of Bengal to West Central Bay of Bengal off south Andhra Pradesh	Lay embedded in the trough of low over southwest Bay of Bengal to North Bay of Bengal extending upto 1.5 km above m.s.l. on 30. Became less marked on 1 November
26.	Upto 5.8 km a.s.l.	28-30	Westcentral Bay of Bengal & neighbourhood	Do	Westcentral and adjoining areas of northwest Bay of Bengal and north Andhra Pradesh and south Odisha coasts between 3.1 km & 5.8 km above m.s.l. on 30	Lay embedded in the trough of low over southwest Bay of Bengal to North Bay of Bengal on 2 and became less marked on 31
27.	At 1.5 km a.s.l.	27-29	East Uttar Pradesh & neighbourhood	South	North Chhattisgarh & neighbourhood	Became less marked on 30
28.	Between 2.1 and 3.1 km a.s.l.	28	northern parts of West Bengal & neighbourhood	Stationary	*In situ*	Became less marked on 29

TABLE 2 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
29.	Upto 0.9 km a.s.l.	29	Maldives-Lakshadweep area	Stationary	*In situ*	Became less marked on 30
30.	Between 3.1 and 4.5 km a.s.l.	30-31	Eastcentral and adjoining areas of southeast Arabian Sea & Karnataka	East	South Interior Karnataka & neighbourhood	Became less marked on 1 November
(E)	*Other troughs/Wind discontinuity*					
1.	A trough at 1.5 kms a.s.l. ran from	1-4	From Comorin area to north Kerala	Oscillatory	South Kerala and adjoining interior Tamil Nadu to north Konkan across Karnataka	Became less marked on 5
2.	Upto 3.1 km a.s.l.	12-14	From the Deep Depression over Odisha to Kerala across Coastal Andhra Pradesh and Tamilnadu	East	From Odisha to south Tamilnadu across Coastal Andhra Pradesh	Became less marked on 15
3.	Do	14	From the Central Assam cyclonic circulation to north Bay across east Bangla Desh and Tripura	Do	From the East Assam cyclonic circulation to north Bay of Bengal	Became less marked on 15
4.	At 5.8 kms a.s.l.	20-21	From South East Arabian Sea off Kerala coast to North Interior Karnataka	Oscillatory	From Maldives area to South Interior Karnataka at 5.8 kms a.s.l.	Became less marked on 22
5.	Between 2.1 and 3.6 km a.s.l.	20	Along Long. 93° E to the north of Lat. 26° N	Stationary	*In situ*	Became less marked on 21
6.	Upto 0.9 km a.s.l.	23	From South Interior Karnataka to north Madhya Maharashtra	Do	Do	Became less marked on 24
7.	Upto 2.1 km a.s.l.	23	From Sikkim to Manipur	Do	Do	Became less marked on 24
8.	At 0.9 km a.s.l.	24	From Telangana to southeast Vidarbha	Do	Do	Became less marked on 25
9.	At 3.1 km a.s.l.	24	Long. 90° E to the north of 25° N at 3.1 kms a.m.s.l. on 24	Do	Do	Became less marked on 25
10.	At 0.9 km a.s.l.	25	From the cyclonic circulation over Gulf of Mannar & neighbourhood to south Madhya Maharashtra across interior Tamilnadu & Karnataka	Do	Do	Became less marked on 26
11.	At 5.8 km a.s.l.	26	From Maldives area to Lakshadweep area	Do	Do	Moved away westward
12.	Upto 2.1 km a.s.l.	27	From circulation over southwest Bay of Bengal off Sri Lanka coast to eastcentral Bay of Bengal	Do	Do	Became less marked on 28

3.1.2. *Commencement of northeast monsoon rains*

With the establishment of the northeasterly winds in the lower tropospheric levels along the east coast, the northeast monsoon rains commenced over Tamil Nadu and Puducherry, Kerala, adjoining areas of Andhra Pradesh and Karnataka from 1st November, eleven days later than the normal date of 20th October. The simultaneous occurrence of the two VSCS delayed the setting in of easterlies and swept moisture away from the NEM region delaying the commencement of NEM.

3.1.3. *Storms and Depressions*

The formation of the two VSCS 'Titli' and 'Luban' on two sides of the Indian mainland in a 'rarest of rare' occurrence was the highlight of the month. The occurrence of such two VSCSs last occurred in November 1977, *viz*., (i) Bay of Bengal Super Cyclonic Storm (14-20 November, 1977), which crossed Andhra Pradesh coast near Chirala on 19th November and (ii) Bay of Bengal VSCS (9-23 November 1977), which crossed Tamil Nadu coast close to south of Nagapattinam on 12th November and then emerged into Arabian Sea, made a looping track, intensified into a SCS, weakened thereafter and crossed Karnataka coast to the north of Mangalore on 29th November as a depression. Prior to 1977 it was during 1971 that two SCS formed over Arabian Sea (27 October to 1 November) and Bay of Bengal (26-31 October). The Bay of Bengal cyclone made landfall close to Paradip in Odisha while the Arabian Sea system moved west and made landfall near Somalia.

Associated with the movement of the VSCS 'Titli' widespread rainfall recorded with heavy to very heavy rainfall at many places over coastal Odisha, Gangetic West Bengal and adjoining north Bay of Bengal upto Assam with extremely heavy falls at isolated places over coastal Odisha *viz.*, G Udayagiri-35cms, Kantapada-32 cms, Raikia and Banki-28 cms each, Mohana-24 cms on 11th.

3.1.4. *Other synoptic features and associated weather*

Table 2 gives a summary of the synoptic features for the month of October 2018. The sub-divisional percentage departures of rainfall from normal and significant amounts of rainfall are given in Tables 1 and 5, respectively.

In the first fortnight precipitation caused by western disturbances was limited mostly to northern parts of the country especially Jammu & Kashmir and in the third week extending to Punjab and Himachal Pradesh.

In the month of October out of 36 meteorological subdivisions, 5 received *normal* rainfall, 7 *deficient* and 24 *large deficient* rainfall (Fig. 2). No subdivision recorded *Excess* or *Large Excess* rainfall. Out of the 5 *normal* sub divisions 4 were from Peninsula and one from Central India (Odisha), this is attributed mainly to the rainfall because of VSCS Titli.

3.1.5. *Temperature*

The maximum temperatures remained *normal* or *above normal* throughout except days when the temperatures dropped to *appreciably below normal* in some and *markedly below normal* in few subdivisions (Odisha, Bihar and Jharkhand) in correspondence with the landfall and movement of VSCS Titli. Over central India and Peninsula the day temperatures were markedly *above normal* or *appreciably above normal* on many days. *Deficient* rainfall (-56% of LPA) nearing *large deficient* during the month kept the maximum temperatures above normal in general.

The minimum temperatures in this month were normal or below normal over the country. Over most subdivisions from Northwest India, East and Northeast India the night temperatures were *appreciably below normal* on 5 to 8 days after 10thand over Jammu and Kashmir divisions they were *appreciably below normal* on most days.

No *heat wave/cold wave* condition occurred during the month. The month's and the season's highest maximum temperature was 42.2 °C recorded at Bhuj (Saurashtra & Kutch) on 6th and 7th October and the lowest minimum temperature of the month was 9.2 °C recorded at Mandla (East Madhya Pradesh) on 29th October, in the plains of the country.

3.1.6. *Damages associated with Disastrous weather events*

VSCS Titli was the most destructive cyclonic storm to strike Indian coast during 2018. As per situation report prepared by Odisha's Special Relief Commissioner's Office, VSCS Titli affected 16 out of the 30 districts in Odisha. More than 5.7 million people across 7,402 villages were affected, 18 people lost their lives. The State saw immense infrastructural damage, which highlights the long-term economic loss that accompanies natural disasters. The storm damaged more than 20,000 houses. It also destructed several bridges, culverts, embankments and roads in the State, around 0.75 million livestock died and crops on 0.58 million-acre land were destroyed. The fishing industry also lost 300 boats, 473 nets, 607 fish ponds, 69 fish seed farms and 14.66-hectare fish farms. Andhra Pradesh also faced considerable losses because of the cyclone, where 9 people died, while 1 was injured. The devastation was restricted to the two districts of Srikakulam and

TABLE 3

Details of the weather systems during November 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**)	*Cyclonic storm*					
1.	Severe Cyclonic storm 'GAJA'	10-19	Southeast Bay of Bengal near Lat. 11.7° N/ Long. 92.5° E	West	Southeast Arabian Sea	It crossed Tamilnadu & Puducherry coast between near Lat. 10.5° N and Long. 79.8° E on 16 November. Thereafter, it moved nearly westwards and weakened rapidly into an SCS. Details are given in the article on Storms & Depressions over the north Indian Ocean-2018.
(**B**)	*Well marked Low Pressure area/Low Pressure area*					
1.	Well marked Low pressure area	5-7	Southwest Bay of Bengal off Sri Lanka and adjoining equatorial Indian Ocean	Northwest	Southwest Bay of Bengal and adjoining southeast Tamil Nadu and Comorin area	Became less marked in the morning of 8, however, the associated cyclonic circulation over the same region extended upto 3.1 kms above m.s.l. on 8-9, under the influence of the cyclonic circulation over Comorin area and adjoining Sri Lanka and equatorial Indian Ocean, a low pressure area formed over the Comorin area and neighbourhood on 9 evening. It lay as a trough of low at mean sea level from Maldives Comorin area to Lakshadweep area with an embedded cyclonic circulation extending upto 1.5 kms above m.s.l. on 10 became less marked on 11. However, the cyclonic circulation extending upto 1.5 kms above m.s.l. over Lakshadweep area lay over southeast Arabian Sea & adjoining Lakshadweep area on 11, became less marked on 12
(**C**)	*Western disturbances /eastward moving systems*					
(*i*)	*Upper air cyclonic circulation*					
1.	Between 3.6 and 4.5 km a.s.l.	8-9	Between 3.6 and 4.5 kms above m.s.l. over north Pakistan and neighbourhood	East	Northern parts of Jammu & Kashmir and neighbourhood	Moved away East north eastwards
2.	At 3.1 km a.s.l.	10 -14	Northeast Afghanistan & neighbourhood	Do	Jammu & Kashmir and neighbourhood	Became less marked on 15
3.	Do	17-20	North Pakistan and neighbourhood	East northeast	Jammu & Kashmir	Moved away north eastwards
4.	Do	23-26	Northeast Afghanistan and neighbourhood	Do	Jammu Kashmir and neighbourhood	Moved away East north eastwards
(*ii*)	*Trough in westerlies*					
1.	At 3.1 km a.s.l.	20-21	Along Long. 67° E to the north of 33° N	East-northeast	Along Long. 75.0° E to the north of Lat. 32.0° N	Moved away east northeastwards
2.	At 5.8 km a.s.l.	21-22	Long. 55° E to the north of 26° N	Do	Roughly along Long. 75° E	Moved away east northeastwards
3.	Do	26-28	Along Long. 52° E to the north of Lat. 25° N (axis at 5.8 kms a.s.l.)	Do	Northeast Afghanistan and neighbourhood	It lay as a cyclonic circulation extending upto 3.1 kms above m.s.l. over northeast Afghanistan and neighbourhood with the trough aloft. Moved away east northeastwards

TABLE 3 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(*iii*)	*As an Induced cyclonic circulation*					
1.	Upto 0.9 km a.s.l.	2-4	Punjab & neighbourhood	East	Haryana & adjoining West Uttar Pradesh	Became less marked on 5. *The WD system is shown in the Table of October [C(i)8]
2.	Do	13-15	West Rajasthan and neighbourhood	Northeast	Haryana and neighbourhood	Became less marked on 16
3.	Do	22	West Rajasthan and neighbourhood	Stationary	*In situ*	Became less marked on 23
4.	At 1.5 km a.s.l.	27	Central Pakistan & neighbourhood	Do	Do	Became less marked on 28
(**D**)	*Other upper air cyclonic circulations*					
1.	Between 3.1 and 4.5 km a.s.l.	1-2	Southeast Arabian Sea & adjoining Coastal Karnataka	North	Eastcentral Arabian Sea and adjoining southeast Arabian Sea & Coastal Karnataka	Became less marked on 3
2.	Between 1.5 & 2.1 km a.s.l.	1-4	South Tamilnadu & neighbourhood	West	Maldives & adjoining Lakshadweep area	Became less marked on 5
3.	At 0.9 km a.s.l.	4	Southeast Rajasthan & neighbourhood at 0.9 km	Stationary	*In situ*	Became less marked on 5
4.	Upto 0.9 km a.s.l.	4-8	East Assam & neighbourhood	South	South Assam & neighbourhood	A trough lay aloft roughly along Long. 93° E to the north of Lat. 24° N at 2.1 km above m.s.l. it became less marked on 5. The cyclonic circulation became less marked on 9
5.	Upto 1.5 km a.s.l.	5-7	North Madhya Maharashtra and neighborhood	East	South Chhattisgarh & neighbourhood	Became less marked on 8
6.	Upto 0.9 km a.s.l.	6	North interior Karnataka & adjoining Telangana	Stationary	*In situ*	Became less marked on 7
7.	At 5.8 km a.s.l.	6	Eastcentral Arabian Sea and adjoining Coastal Karnataka	Do	Do	Became less marked on 7
8.	Between 3.1 & 4.5 km a.s.l.	8-13	West Assam and neighbourhood	West	Northeast Bangla Desh and neighbourhood	Became less marked on 14
9.	Upto 0.9 km a.s.l.	9	Lakshadweep and neighbourhood	Stationary	*In situ*	Became less marked on 10
10.	At 0.9 km a.s.l.	13	South interior Karnataka and neighbourhood	Do	Do	Became less marked on 14
11.	At 3.1 km a.s.l.	14	North Kerala coast and neighbourhood	Do	Do	Became less marked on 15
12.	Upto 0.9 km a.s.l.	16	Assam & neighbourhood	Do	Do	Became less marked on 17
13.	Do	18-19	North Bangladesh and neighbourhood	Do	Do	Became less marked on 20
14.	At 0.9 km a.s.l.	19-20	Southwest Rajasthan and neighbourhood	Northeast	East Rajasthan and neighbourhood	Became less marked on 21

TABLE 3 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
15.	At 1.5 km a.s.l.	20	Sub-Himalayan West Bengal & neighbourhood	Stationary	*In situ*	Became less marked on 21
16.	Upto 0.9 km a.s.l.	20-25	Gulf of Siam and neighbourhood	Southwest	Equatorial Indian Ocean and adjoining Sumatra	Became less marked on 26
17.	Upto 5.8 km a.s.l.	26-29	Gulf of Siam and neighbourhood	Do	Equatorial Indian Ocean and adjoining Sumatra	Became less marked on 30
18.	At 1.5 km a.s.l.	28-30	Maldives-Comorin areas	West	Equatorial Indian Ocean and adjoining southeast Arabian Sea	Became less marked on 1 December
19.	Between 1.5 & 3.6 km a.s.l.	29-30	East central Arabian Sea off south Maharashtra - Goa coasts	East	Konkan and adjoining Madhya Maharashtra	Became less marked on 1 December
20.	Between 3.1 & 3.6 km a.s.l.	30 Nov-2 Dec	Westcentral Bay of Bengal off Andhra Pradesh coast	Southwest	South coastal Andhra Pradesh and adjoining west central Bay of Bengal	Became less marked on 3 December
(E)	*Trough in easterlies*					
1.	At 0.9 km a.s.l.	19-21	From North interior Karnataka to Vidarbha across Marathwada	Oscillatory	From Eastcentral Arabian Sea off south Maharashtra coast to north Madhya Maharashtra	Became less marked on 22
2.	At 5.8 km a.s.l.	23-24	From Comorin area to interior Tamil Nadu	West	From southeast Arabian Sea off Lakshadweep area to north interior Karnataka across coastal Karnataka	Became less marked on 25
3.	At mean sea level	30 Nov-8 Dec	Equatorial Indian Ocean and adjoining south Andaman Sea	Do	Maldives Lakshadweep area	Became less marked on 9 December
(F)	*Other troughs / Wind discontinuity*					
1.	Upto 0.9 km a.s.l.	2	Along Long. 90° E to the north of Lat. 22° N	Stationary	*In situ*	Became less marked on 3
2.	Do	6-7	From East Bihar to Gangetic West Bengal	Do	Do	Became less marked on 8
3.	Between 1.5 and 2.1 km a.s.l.	17	Roughly along Long. 88° E to the north of Lat. 26° N	Do	Do	Became less marked on 18
4.	At 1.5 km a.s.l.	18	Roughly from north Bihar to south Assam across northern parts of West Bengal and Bangladesh	Do	Do	Became less marked on 19

TABLE 3 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
5.	Between 2.1 and 3.6 km a.s.l.	20	Along Long. 93° E to the north of Lat. 25° N	Stationary	*In situ*	Became less marked on 21
6.	Between 1.5 and 3.1 kms above m.s.l.	22	From the cyclonic circulation over interior Tamilnadu & neighbourhood to Maldives area across interior Tamilnadu and Kerala	North South	Long. 90.0° E to north of Lat. 25.0° N	Became less marked on 23
7.	At mean sea level	29-30	From equatorial Indian Ocean & adjoining southwest Bay of Bengal off south Sri - Lanka coast ran from Comorin area to southwest Bay of Bengal off south Tamil Nadu coast on 29	East	Equatorial Indian Ocean and adjoining southeast Arabian Sea	Became less marked on 1 December

Vizianagaram in the State. The total affected population was almost 12.5 lakh spread across 872 villages and 40,000 houses worth more than Rs. 400 crore were destroyed by the cyclone. The loss due to crop damages is pegged at a massive Rs. 800 crore. The horticultural sector also incurred significant losses of Rs. 1,000 crore due to the cyclone. Cashew and coconut plantations, which were considered long-term sources of livelihood for the farmers, had been severely damaged in Srikakulam district (Cashew trees in 44,500 acres and coconut trees in 34,600 acres).

3.2. *November*

3.2.1. *Storms and Depressions*

Very Severe Cyclonic Storm (VSCS) Gaja, which formed in this month was the first ever looping track cyclone over the Bay of Bengal after 1996. The system had one of the longest track length equal to 3418 km and life period (D to D) of the system was 219 hours (9 days and 3 hours) against long period average (LPA) (1990-2013) of 98 hours for SCS category over Bay of Bengal during post monsoon season. Under the influence of the system, rainfall occurred at most places with heavy falls at a few places and very heavy falls at isolated places over Tamil Nadu, moderate rainfall over Kerala, south coastal Andhra Pradesh, Rayalaseema and south interior Karnataka on 16^{th} and 17^{th}.

3.2.2. *Weather and associated synoptic features*

A summary of the synoptic systems for the month of November 2018 is given in Table 3. 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.

The systems in the westerlies gave rain/snow in the northern subdivisions of Northwest Region *viz.*, Jammu and Kashmir, Uttarakhand and Himachal Pradesh which received nearly double the precipitation of *normal* for the month. Out of the six remaining subdivisions five were *large deficient* and one *deficient* (Punjab).

In the second fortnight, the landfall of cyclonic storm, 'Gaja', its westward movement over the peninsula and various troughs and cyclonic circulations resulted in precipitation in many sub divisions of South India resulting in the North East monsoon being *active* for a few days over the southern parts of the peninsula and vigorous on 16^{th} in Tamil Nadu and Puducherry. There was some activity due to the western disturbances and their induced systems enhancing precipitation in North India upto the third week of this month, while the weather remained totally dry in the last week except for some subdivisions of south peninsula particularly in Rayalaseema, Tamil Nadu and Kerala.

3.2.3. *Temperature*

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

The minimum temperatures over most subdivisions were normal or below normal in the month except first week when they were above normal or appreciably above normal on a few days. The night temperatures over Central India and Peninsular India remained *above normal* or *appreciably above normal* for few days in the

TABLE 4

Details of the weather systems during December 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**)	*Severe Cyclonic Storm*					
1.	Severe Cyclonic Storm, 'PHETHAI'	13-17	Southwest Bay of Bengal	North north westwards	Northwest Bay of Bengal & adjoining coastal Odisha	Low pressure area over northwest Bay of Bengal and adjoining coastal Odisha, associated cyclonic circulation extended upto 1.5 kms above m.s.l. over northwest Bay of Bengal and adjoining coastal areas of west Bengal and north Odisha on 18 evening and became less marked on 19. Details are given in the article on Storms & Depressions over the north Indian Ocean-2018
(**B**)	*Western disturbances/Eastward moving systems*					
(*i*)	*Upper air cyclonic circulation*					
1.	At 3.1 kms above m.s.l.	8-12	Afghanistan and neighbourhood	East	North Pakistan and adjoining Jammu & Kashmir	Initially it lay as a trough along Long. 62° E to the north of Lat. 32° N on 6 and 7. A trough aloft with its axis at 5.8 kms above m.s.l. ran roughly along Long. 66° E to the north of Lat. 28° N from10th and became less marked on 15. The cycir became less marked on 13
2.	Mid & upper tropospheric westerlies (its axis at 3.1 kms a.s.l.)	13-14	Roughly along Long. 65° E to the north of Lat. 30° N	Northeast	Roughly along Long. 66° E to the north of Lat. 28° N	Became less marked on 15
3.	At 3.1 kms above m.s.l.	23-24	Northeast Afghanistan and adjoining Pakistan	Do	Northeast Afghanistan and adjoining Pakistan	Initially it lay as a trough in mid and upper tropospheric westerlies with its axis at 3.1 kms above m.s.l. and ran roughly along Long. 54° E to the north of Lat. 34° N on 22. The cycir lay with a trough aloft running roughly along Long. 62° E to the north of Lat. 32° N at 5.8 kms above m.s.l. on 23. Moved away east northeastwards
4.	Between 3.1 & 3.6 km a.s.l.	26	North Pakistan & neighbourhood	Do	Jammu and Kashmir and adjoining north Pakistan	Initially WD as a trough in mid and upper troposheric westerlies with its axis at 3.1 kms above m.s.l. and ran roughly along Long. 60° E to the north of Lat. 32° N on 25. Cycir became less marked on 27. However, WD as a trough moved away east-northeastwards
5.	At 3.1 kms above m.s.l.	29-31	Northeast Pakistan and neighbourhood	East northeast wards	Jammu & Kashmir and neighbourhood	Moved away east - northeastwards
6.	At 3.1 kms a.s.l.	31 Dec-2 Jan 2019	Northeast Afghanistan and neighbourhood	East northeast	Eastern parts of Jammu & Kashmir and neighbourhood	Moved away east - northeastwards
(*ii*)	*As a trough/ Trough in westerlies*					
1.	At 3.1 km a.s.l.	1	Roughly along Long. 88° E to the north of Lat. 22° N	Northeast	Roughly along Long. 88° E to the north of Lat. 22° N	Moved away east-north eastwards

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.	Mid tropospheric levels	3-7	Along Long. 55° E to the north of Lat. 34° N (axis at 5.8 kms a.s.l.)	East	Along Long. 82° E to the north of Lat. 34° N	The WD moved away north eastwards
3.	At 3.1 km a.s.l.	17-19	Roughly along Long. 65° E to north of Lat. 30° N	East north eastwards	Jammu & Kashmir and neighbourhood	The Feeble WD moved away east north eastwards
4.	Do	18	Roughly along Long. 90° E to the north of Lat. 25° N	Stationary	*In situ*	Became less marked on 19
5.	Mid & lower tropospheric levels with its axis at 3.1 kms above m.s.l.	19-20	Roughly along Long. 62° E to the north of Lat. 32° N	East north eastwards	Roughly along Long. 70° E to the north of Lat. 34° N on 20	The Feeble WD moved away east north eastwards
6.	Between 3.1 & 3.6 kms above m.s.l.	26-27	Roughly along Long. 93° E to the north of Lat. 25° N	Stationary	*In situ*	Moved away eastwards
(*iii*)	*As an induced cyclonic circulation*					
1.	Upto 1.5 km a.s.l.	10-12	Central Pakistan & adjoining west Rajasthan	East	East Rajasthan	Became less marked on 13
2.	Do	23	Central Pakistan & adjoining Punjab and west Rajasthan	Stationary	*In situ*	Became less marked on 24
(**C**)	*Other upper air cyclonic circulations*					
1.	At 3.1 kms above m.s.l.	1-3	Coastal Karnataka and neighbourhood	East	South interior Karnataka and neighbourhood	Became less marked on 4
2.	Between 3.1 and 3.6 km a.s.l	3	Lakshadweep area and adjoining southeast Arabian Sea	Stationary	*In situ*	Became less marked on 4
3.	At 3.1 kms above m.s.l.	4	Eastcentral Arabian Sea and adjoining coastal Karnataka	Do	Do	Became less marked on 5
4.	Between 3.1 and 3.6 km a.s.l.	4	East Assam and neighbourhood	Do	Do	Became less marked on 6
5.	Upto 3.1 km a.s.l.	5-8	Equatorial Indian Ocean and adjoining southwest Bay of Bengal	Do	Do	Became less marked on 9
6.	At 3.1 kms a.s.l.	5	Konkan and adjoining Madhya Maharashtra	Do	Do	Became less marked on 6
7.	Upto 0.9 kms a.s.l.	6	North Konkan and neighbourhood	Do	Do	Became less marked on 7
8.	At 3.1 km a.s.l.	7-8	Sub-Himalayan West Bengal & adjoining west Assam	West	Sub Himalayan West Bengal and neighbourhood	Became less marked on 9
9.	Upto 1.5 km a.s.l.	8	Mizoram & neighbourhood	Stationary	*In situ*	Became less marked on 9
10.	At 1.5 km a.s.l.	8	West Uttar Pradesh and neighbourhood	Do	Do	Became less marked on 9
11.	At 3.1 kms a.s.l.	9-17	East Bangladesh and neighbourhood	Oscillatory	Bangladesh and neighbourhood	Became less marked on 18

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
12.	Upto 0.9 kms a.s.l.	10	North Madhya Maharashtra and neighbourhood	Stationary	*In situ*	Became less marked on 11
13.	Do	11-12	North Chhattisgarh & neighbourhood	Do	Do	Became less marked on 13
14.	At 0.9 km a.s.l.	12-13	North interior Karnataka and neighbourhood	Do	Do	Became less marked on 14
15.	At 3.1 km a.s.l.	14	South Madhya Maharashtra and neighbourhood	Do	Do	Became less marked on 15
16.	Do	15-16	East central Arabian Sea off South Maharashtra and North Karnataka coast	North	East central Arabian Sea off north Maharashtra	Became less marked on 17
17.	At 1.5 km a.s.l.	16-17	Central parts of Uttar Pradesh and neighbourhood	West	East Uttar Pradesh and neighbourhood	Became less marked on 18
18.	Between 3.1 and 3.6 kms a.s.l.	18	Jammu & Kashmir and neighbourhood	East	Eastern parts of Jammu & Kashmir and neighbourhood	Initially it lay WD as a trough Roughly along Long. 65° E to north of Lat. 30° N on 17. Became less marked on 20
19.	Do	18	South Chhattisgarh & neighbourhood	Stationary	*In situ*	Became less marked on 19
20.	Upto 1.5 km a.s.l.	19-22	Southeast Arabian Sea and adjoining Comorin area	Northeast	Eastcentral Arabian Sea and north coastal Maharashtra	Became less marked on 23
21.	At 1.5 km a.s.l.	20-21	East Bangladesh	North	South Assam and neighbourhood	Became less marked on 22
22.	At 4.5 km a.s.l.	20	East Arabian Sea & adjoining coastal Karnataka	Stationary	*In situ*	Became less marked on 21
23.	At 1.5 km a.s.l.	22	East Uttar Pradesh and neighbourhood	Do	Do	Became less marked on 23
24.	At 3.1 km a.s.l.	22-24	Central Assam and neighbourhood	Do	Do	Became less marked on 25
25.	At 0.9 km a.s.l.	25	South interior Karnataka to south Madhya Maharashtra across north interior Karnataka	Do	Do	Merged with the trough in easterlies from Maldives area to Madhya Maharashtra
26.	Upto 0.9 km a.s.l.	27-28	Comorin area & neighbourhood	Do	Do	Became less marked on 29
27.	Between 1.5 & 2.1 kms above m.s.l.	28-29	Eastcentral Arabian Sea off Maharashtra coast	Do	Do	Became less marked on 30
28.	Extending upto 0.9 km above m.s.l.	28	South coastal Odisha and adjoining north coastal Andhra Pradesh	Do	Do	Became less marked on 29
29.	Upto 3.6 kms above m.s.l.	29	Coastal Karnataka and neighbourhood	Do	Do	Became less marked on 30
30.	Upto 0.9 km above m.s.l.	30	Central Pakistan and adjoining northwest Rajasthan & Punjab	Do	Do	Became less marked on 31

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(D)	*Trough in easterlies*					
1.	At 0.9 km a.s.l.	7-9	South interior Karnataka to Madhya Maharashtra across north interior Karnataka	-	North interior Karnataka to north Madhya Maharashtra	Became less marked on 10
2.	Upto 0.9 km a.s.l.	13	North interior Karnataka to south Chhattisgarh across Telangan and Vidarbha	Stationary	*In situ*	Became less marked on 14
3.	At 0.9 km a.s.l.	25	South Interior Karnataka to Madhya Maharashtra across North Interior Karnataka	Do	Do	Merged with the trough in easterlies from Maldives area to Madhya Maharashtra on 26
4.	Do	26	From Maldives area to Madhya Maharashtra across north Kerala and Interior Karnataka	Do	Do	Became less marked on 27
5.	Upto 0.9 km a.s.l.	30	Southeast Arabian Sea to eastcentral Arabian Sea off west coast	West	Southeast Arabian Sea off Kerala - Karnataka	Became less marked on 1 January, 2019
(E)	*Other trough*					
1.	At mean sea level	1	Maldives area and neighbourhood	Stationary	*In situ*	Became less marked on 2
2.	Do	4	Southeast Arabian Sea and adjoining equatorial Indian	Do	Do	Became less marked on 5
3.	At 3.1 km a.s.l.	4	From cyclonic circulation over eastcentral Arabian Sea to Marathwada across north interior Karnataka	Do	Do	Became less marked on 5
4.	Do	5	From east Bihar to northern parts of Gangetic West Bengal	Do	Do	Became less marked on 7
5.	Upto 0.9 km a.s.l.	11	From cyclonic circulation over north Chhattisgarh & neighbourhood to south Interior Karnataka across Vidarbha, Marathwada and north Interior Karnataka	Do	Do	Became less marked on 12
6.	At 3.1 km a.s.l.	15	From west Arunachal Pradesh to North Bangladesh	Do	Do	Became less marked on 16
7.	At 0.9 km a.s.l.	18	From cycir over northwest Bay of Bengal and adjoining coastal Odisha to Rayalaseema	Do	Do	Became less marked on 19

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
8.	At 5.8 km a.s.l.	19	From Odisha to eastcentral Arabian Sea across Andhra Pradesh and Interior Karnataka	Stationary	*In situ*	Became less marked on 20
9.	At mean sea level	18-27	Lay over southeast Bay of Bengal and adjoining south Andaman Sea and Equatorial Indian Ocean	West	Central parts of south Arabian Sea and adjoining equatorial Indian Ocean	Became less marked on 28
10.	Do	24-26	South Andaman Sea and adjoining south east Bay of Bengal and equatorial Indian Ocean	Do	Southeast Bay of Bengal and adjoining south Andaman Sea and adjoining equatorial Indian Ocean	Became less marked on 27
11.	At 0.9 km a.s.l.	27	Southeast Madhya Pradesh to south Interior Karnataka across Vidarbha, Marathwada & north Interior Karnataka	Stationary	*In situ*	Became less marked on 28

third week, while over Northwest India the temperatures saw a rise in the last week of the month.

3.2.4. *Damages associated with Disastrous weather events*

Severe Cyclonic storm 'Gaja' which crossed the coast between Nagapattinam and nearby Vedaranyam claimed 46 lives. As per media reports, Tamil Nadu suffered crop loss of around 88,102 hectares of agriculture lands, 86702 electric poles, 841 transformers, 201 electricity substations and 4844 fishing boats. There was extensive damage to coconut and banana plantations, rice and other standing crops. More than 80 per cent of the palms in the region were uprooted, affecting the livelihood of the small and marginal farmers. Nagapattinam, Thanjavur, Tiruvarur, Pudukottai were the worst affected places in Tamil Nadu. Carcasses of a large number of animals and birds, suspected to be from Kodiyakarai Wildlife Sanctuary, washed ashore. The storm also caused heavy damage to the 16th century shrine Basilica at Velankanni in Nagapattinam district.

Heavy rains and related incidents killed 4 people in Tamil Nadu in the second phase of the month in relation to the active monsoon conditions.

3.3. *December*

3.3.1. *Storms and Depressions*

The SCS "Phethai", seventh cyclone over north Indian Ocean formed during 2018. Earlier such occurrence of 7 cyclones in a year was witnessed in 1985. It formed as a Low Pressure area over Equatorial Indian Ocean and adjoining central parts of south Bay of Bengal on 9th December. Gradually it intensified into CS "Phethai" in the evening of 15th and concentrated into a Severe Cyclonic Storm (SCS) in the afternoon of 16th. It weakened into CS before landfall over Andhra Pradesh Coast near 16.55° N and 82.25° E on 17th.

Under the influence of this system *vigorous* monsoon conditions were observed over Coastal Andhra Pradesh on 17th and 18th.

3.3.2. *Weather and associated synoptic features*

Table 4 gives a summary of the synoptic systems during the month of December 2018. 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.

The major rain contributing system this month was the SCS "Phethai". The sub-divisions influenced by this system recorded large excess rainfall, many times that of LPA.

The cyclonic circulation over Bangladesh and neighborhood from 13-18 enhanced rainfall activity in the East and Northeast India and was further aided by passage of western disturbances. The rainfall activity remained subdued in Northwest India as the western disturbances were short-lived/ feeble and had more northerly tracks. Out

TABLE 5

Some representative amounts of rainfall in cm for October, November and December 2018 (5 cm and above)

Date	Some representative amounts of rainfall in cm for October, November and December 2018 (5 cm and above)
1 Oct	Neora 18, Murti 16, Nagarkata 14, Myladumparaagri 9, Buxaduar 8, Periyakulam, Chintalapudi and Sankalan 7 each, Singla Bazar, Thodupuzha and Subramanya 6 each, Bagrakote, Chengmari / Diana, Mangan, CIAL Kochi, Hasimara, Santhamaguluru and Garubathan 5 each
2 Oct	Kannur 12, Mangan and Alipurduar CWC 8 each, Coonoor 7, Paramakudi, Beki Mathungari, Krishnarajpet, N. Lakhimpur, Bhalukpong, Valpoi, Tadong, Eraniel, Gangtok and Vilathikulam 6 each, Sattur, Surangudi, Aswapuram, Thalasserry, Tirumangalam, Watrap and Lanja 5 each
3 Oct	Tuljapur 9, Manamelkudi, Chalakudi and Thuckalay 7 each, Nilanga 6, Ausa, Kodavasal, Tiruvarur, Panbari, Kuzhithurai, Thodupuzha and Osmanabad 5 each
4 Oct	Alappuzha and Chalakudi 12 each, K.M. Koil and Pullambadi 11 each, Tiruchendur 10, Angadipuram, Vedaranniyam, Sirkali, Mavelikara and Parumbikulam 9 each, Rameswaram, Umarga and Perinthalamanna 8 each, Pamban, Kumarakom, Cuddalore, Thrithala, Tirukattupalli, Jayamkondam, Chittur, Sethiathope, Puducherry, Karkala, Thirumanur, Mani, Kayamkulam, Mayiladuthurai and Kodungallur 7 each, Madukkur, JavaliMedha, Mannargudi, Cheyyar, Alathur, Piravam, Nannilam, Karaikal and Palakkad 6 each, Mangaon, Anaikaranchatram (Kollid)), Sholavandan, Tiruppur, Adirampattinam, Poladpur, Parangipettai, Grand Anaicut, Pandavaiyar Head, Shriwardhan, Tiruchengode, ThuvakudiImti, Puttur HMS, Needamangalam, Chidambaram, Punalur, Thiruvidaimaruthur, Nagapattnam, Ottapalam and Mylam AWS 5 each
5 Oct	Ennore AWS 13, Chengalpattu 12, Kurudamannil 11, Cholavaram 9, Kozha, Bantwal, Konni, Taliparamba, Marakkanam, Vanur and Ponneri 8 each, Mudubidre, Palani, Punalur, Tindivanam, Palayamkottai, Nagercoil, Kozhikode, Madavaram AWS and Anaikaranchatram (Kollid)) 7 each, Chengam, Radhapuram, Kelambakkam, Maduranthagam, Gingee, Jayamkondam, Sathanur Dam, Mani, Tada, Red Hills, Puzhal ARG, Chennai AP, Poonamalle ARG and Uthangarai 6 each, AluvaPwd, Pechiparai, Uthiramerur, Piravam, Chennai city, Tiruvannamalai, Munnar KSEB, Thiruthuraipoondi, Kancheepuram, Sriperumbudur, Sullurpeta, Arani, Mahabalipuram, Kodavasal, Karkala, Purandar Sasvad, Shencottah, Tiruvarur, Dgp Office, Chembarabakkam and Karaikal 5 each
6 Oct	Karaikal 12, Vilupuram 9, Coonoor and Kollur 8 each, Neyveli AWS, Mylam AWS and Mayiladuthurai 7 each, Gersoppa, Mettupalayam, Linganamakki HMS, Panruti, Needamangalam, Kancheepuram and Vanur 6 each, Cuddalore, Nagapattnam, Vedaranniyam, Vellanikkara, Thiruthuraipoondi, Kothagiri, Ketti, Bantwal, Penucondapuram and Honavar 5 each
7 Oct	Sankarankoil and Ambasamudram 8 each, Tiruppur, Thenkasi and Yagati 7 each, Kothagiri, Shencottah, AminiDivi, Pudukottai, Sathyamangalam, Tirupuvanam and Rameswaram 6 each, Panchanahalli, R.S.Mangalam, Ramanathapuram, Coonoor, Agathi, Pattukottai, Long Islands, Maya Bandar, Jayamkondam, Hut Bay, Ayikudi, Bhavanisagar, Maniyachi, Kanyakumari and Hosadurga 5 each
8 Oct	Tirupuvanam 15, Manamadurai and Port Blair 13 each, Long Islands and Chittampatti 12 each, Kodungallur, Lunglei and Rameswaram 9 each, Paramakudi 8, Watrap and Tiruppur 7 each, Mettupatti, Peermade To, Periyakulam and Ernakulam South 6 each, Thiruvananthapuram, Illayangudi, Vadipatti and R.S. Mangalam 5 each
9 Oct	Subramanya 16, Mahe 15, Tiruppur and Mangaluru 11 each, Vadipatti, Panambur and Thalasserry 9 each, AluvaPwd and Ponda 8 each, Avinasi, Hosdurg, Salem, Mettupalayam, Palakkad, Dharapuram, Kurudamannil, Bodinaickanur and Kannur 7 each, Sholavandan, H D Kote, Gobichettipalayam, Tiruchengode, Hunsur and Neyveli AWS 6 each, Vadakkancherry, Ketti, Aryankavu, Perinthalamanna, Vellanikkara, PonnampetPwd, Varkala, Uthagamandalam, CIAL Kochi, Enamakkal, Chinnakalar, Konni, Sargur, Aravakurichi, Mudukulatur, Vandavasi, Kollam Rly, Angadipuram and Dharamapuri 5 each
10 Oct	Kumta and Kuppady 8 each, Chinnakalar and Shimoga 7 each, Basudevpur AWS and Bhagamandala 6 each, Kalasa, Long Islands, Krishnarajasagara and Mannarkad 5 each
11 Oct	Ichchapuram 24, Tekkali and Mahendragarh 23 each, R. Udaigiri and Mohana 22 each, Purushottampur 21, Palasa 20, Rajghat 17, Nuagada ARG 16, Aska 15, Bhograi, Digha, Digapahandi ARG and Balikuda ARG 14 each, Chhatrapur, Mandasa, Ranpur, Raghunathpur ARG and Sorada 13 each, Kendrapara, Nilgiri, Sompeta, NH5 Gobindpur, Balasore and Kantapada ARG 12 each, Kaptipada ARG, Soro, Chandikhol ARG, Marsaghai ARG, Paradip and Binjharpur ARG 11 each, Pathapatnam, Contai, Alipingal, Jagatsinghpur AWS, Basudevpur AWS, Gop, Korei ARG and Gopalpur 10 each, Bhanjnagar, Tikabali, Sagar, Jaipur, Kujanga ARG, Madhabarida, Odagaon ARG, Kalingapatnam, Betanati ARG, Remuna ARG, Belaguntha ARG, Tirtol ARG, Pattamundai, Bhadrak AWS and Niali ARG 9 each, Raikia ARG, Kakatpur, Jagadhari, Nimpara, G Udayagiri AWS, Puri, Nischintakoili ARG, Astaranga ARG, Pipili, Jaleswar and Tangi 8 each, Contai, Banpur, Jagannath Prasad ARG, Krishnaprasad, Narsinghpur, Balimundali, Banki ARG, Derabis ARG, Akhuapada, Salepur ARG, Bari ARG, Balipatna ARG, Jajpur, Kalinga, Bhubaneshwar AP, Jenapur, Nayagarh and Garadapur ARG 7 each, Bolagarh ARG, Daitari, Cuttack, Dhamnagar ARG, Mundali, Athgarh and Mahanga ARG 6 each, Daspalla, Gudari, Rajkanika, Mustafabad, Pathankot, Naraj, Bonth, Naraingarh, Khandapara, Baripada, Udala, Nandigram, Rajpura, Anandpur, Nagercoil, Malakpur, Ranastalam, Brahmagiri AWS, Tigiria ARG and Altuma CWC 5 each

TABLE 5 (*Contd*.)

Date	Some representative amounts of rainfall in cm for October, November and December 2018 (5 cm and above)
12 Oct	G Udayagiri AWS 35, Kantapada ARG, Daringibadi and Kalinga 32 each, Raikia ARG and Banki ARG 28 each, Mohana 24, Sorada and Phiringia ARG 23 each, Ranpur 22, Baliguda 21, Harabhanga, K Nuagaon ARG, Phulbani, Monghyr and Daspalla 20 each, Puri, Satyabadi ARG, Tigiria ARG, Jagatsinghpur AWS and Niali ARG 19 each, Bolagarh ARG 18, Jaipur, Aska, Banpur and Gania ARG 17 each, Tikarpara, Khagadia, Athgarh and Nimpara 16 each, Odagaon ARG, Narsinghpur, Bhanjnagar, Barmul, R.Udaigiri, Nayagarh, Jajpur and Balipatna ARG 15 each, Tangi, Kotagarh, Krishnaprasad, Pathapatnam, Garadapur ARG, Cuttack and Pakuria 14 each, Salepur ARG, Amrapara, Alipingal and Mahanga ARG 13 each, Parjang ARG, Madhabarida, Talcher, Jagannath Prasad ARG, Gop, Ambadola, Kashinagar, Kendrapara and Pipili 12 each, Gudari, Balimundali, Mundali, Veeraghattam, Korei ARG, Marsaghai ARG, Samakhunta AWS, Ichchapuram, Kurupam, Hindol and Madanpur Rampur 11 each, Binjharpur ARG, Lanjigarh, Nilgiri, Dhenkanal, Bari ARG, Sukinda, Khandapara, Kotraguda, Tirtol ARG, Danagadi ARG, Gunupur, Tekkali, Derabis ARG and Bhubaneshwar AP 10 each, Nuagada ARG, Ghatsila, Brahmagiri AWS, Banarpal ARG, Jenapur, Naraj, Bonth, Balajipeta, Rajkishorenagar, Alappuzha, Angul, Baripada, Tihidi ARG and Maheshpur 9 each, Mandasa, Muniguda ARG, Namsai, Dhamnagar ARG, Chandanpur, Komarada, Sompeta, Akhuapada, Jiaganj, Palakonda, Rajkanika, Berhampur, Kantamal, Bhadrak AWS, Bhuban ARG, Raghunathpur ARG, Astaranga ARG, Barhiya and Sabour 8 each, Chendipada, Purushottampur, AltumaCwc, Balikuda ARG, Chandikhol ARG, Harichandanpur ARG, Khairamal, Athmalik, Boudhgarh, Narla ARG, Rayagada, Palasa, Baltara, Bangiriposi, Soro, Sonepur, Bhavani P., Bhagalpur, Rajmahal, Nawana, Pattamundai, Saintala ARG, Chandbali, JiyyammaValasa, Murarai, Ghatagaon, Kamakhyanagar, Anandpur and BasudevpurAWS 7 each, Gogri, Tarva ARG, Sagardighi, Kankadahad ARG, Godda, Rengali, Belgaon, Mahendragarh, Kaptipada ARG, Kakatpur, Thakurmunda, Nakur and Chanchal 6 each, Katihar, Bijnor, Parbatta, Bolangir, Jamsolaghat, Kesinga ARG, Udala, Birmaharajpur ARG, Colgaon, Jangipur, Thakurdwara, SirmariB.Pur, Sabroom, Betanati ARG, Kaniha ARG, Telkoi, Baghmara AWS, Williamnagar, Nalhati, Garugubilli and Dhampur 5 each
13 Oct	Betanati ARG 16, Digha 15, Kaptipada ARG, Rajghat, Contai and Bhograi 13 each, Danagadi ARG, Dhamnagar ARG, Balimundali, Bonth and Tihidi ARG 11 each, Jaleswar, Remuna ARG and Kalaikunda 10 each, Thakurmunda and Karanjia 9 each, Jajpur, Samakhunta AWS, Bangiriposi, Karimganj, Serchip (Hydro), Mahanga ARG, Anandpur, B P Ghat, Bari ARG, Balasore, NH5 Gobindpur and Chandanpur 8 each, Baripada, Nilgiri, Udala, Sukinda, Ghatagaon and Jamsolaghat 7 each, Canning Town, Swam -Patna, Basudevpur AWS, Nawana, Astaranga ARG, Salepur ARG and Raghunathpur ARG 6 each, Soro, Bashirhat, Annapurnaghat, Durgachak, Daitari, Harichandanpur ARG, D.P.Ghat, Binjharpur ARG, Nischintakoili ARG, Paradip, Kendrapara, Jenapur, Korei ARG, Jagatsinghpur AWS, Joshipur, Passighat, Sabroom, Gop and Balikuda ARG 5 each
14 Oct	Bestavaripeta 11, Thodupuzha and Pechiparai 10 each, Cherrapunji 9, Konni and Cherrapunji (Rkm) 8 each, Kurudamannil, Udayagiri and Paren 7 each, Mani 6, Thiruvananthapuram and Chodavaram 5 each
15 Oct	Bayyaram 10, Mahbubabad, Maheswaram, T Narasipur and Garla 9 each, Manuguru and Kollegal 8 each, Pathapatnam, Sathanur Dam and Markapur 7 each, Alappuzha, Ernakulam South, Valparai and Machilipatnam 6 each, Denkanikottai, Barur, Paramathivelur, Bhagamandala, Vaniaymbadi, Srivilliputhur, Pochampalli, Sivaganga, Malur, Polur, Bantwal, Ottapalam, Krishnarajpet, Anekal, Dornakal, Nilambur, Vellore and Pappireddipatti 5 each
16 Oct	Amalapuram 8, Chodavaram 7, Yelamanchili 6, Kuknoor, Vizianagaram, Haveri APmc and Mannarkad 5 each
17 Oct	Ponnani 16, Piravam 13, Kohir 11, Kuppady, Dharmasthala, Vadakara, Kurudamannil and Konni 10 each, Mandya, Hirekerur, Haveri PTO, Mudubidre and Manki 9 each, Cherthala, Mettupalayam, Ernakulam South, Kottayam, Ottapalam, Gulbarga and Mancompu 8 each, Jayamkondam, Kunnamkulam, Haripad and Kumarakom 7 each, Kochi AP, Vengurla, Sira, Amarapuram, Vythiri, Haveri APmc, Perumpavur, Thimmajipeta, Vaikom, Mahalingapur, Solapur, Mundgod, Bhadravathi, CIAL Kochi, Kannur, Kudulu, Perinthalamanna, Yedrami, Malvan, Nilambur, Kollamkode and Kanekal 6 each, Arantangi, B Durga, Tarikere, Eraniel, Sravanabelagola, Tondi, Valpoi, Nippani, Karipur, Ballari AWS, AluvaPwd, Nargund ARG, Molakalmuru, Nagercoil, Angadipuram, Sangareddy, Honavar, Thiruvananthapuram AP, Agathi, Channagiri, Myladumparaagri, Mulki, Kozhikode, Mananthavady, Mannarkad, Chinnakalar, Manjeri and Pernem 5 each
18 Oct	Hagaribommanahalli 11, Davanagere 9, Kampli 8, Gooty, Chennai AP, Minicoy, Sandur and Virinjipuram AWS 7 each, Pavagada, Tiptur, Long Islands, Koppal PTO, Santhebennur, Davanagere PTO, Settur, Molakalmuru, Talikote, Kanekal, Ulundurpet and Tavaragera 6 each, Pakala, Nambulipulikunta, Palamaner, Mudgal, Kadaladi, Golkonda, Bengaluru CO, Anekal, Hut Bay, Chittoor, Kudligi and K Agraharamjurala 5 each
19 Oct	Sira and Srivilliputhur 11 each, Vadakkancherry and Karipur 9 each, Ernakulam South, Hiriyur HMS, Bellur and Vaikom 7 each, Ottapalam, Bukkapatna, Kayamkulam, Thiruvananthapuram, Kozha and Kollapur 6 each, Kovilpatti, Cherthala, Vellanikkara, Lingadahalli, Subramanya, Mangan, Kurudamannil and Neyyattinkara 5 each
20 Oct	Periyakulam 16, Piravam 12, Periyanaickenpalayam 10, Mahe and Cherthala 9 each, Quilandi, Kannur, Vadakara and Alathur 8 each, Kushalnagar, Chennai AP, Perinthalamanna and Mavelikara 6 each, Thrithala, Kollamkode, Nilambur, Enamakkal, Sankarankoil and Kochi AP 5 each
21 Oct	Virudhunagar 12, Peraiyur and Nanguneri 9 each, Aranmanaipudur and Periyakulam 7 each, Bhagamandala 6, Manimutharu U U, Mylaudy, Quilandi, Thodupuzha, Srivilliputhur, Peermade TO, Nagercoil, Ambasamudram and Rameswaram 5 each
22 Oct	Chidambaram and Vanur 9 each, Anaikaranchatram (Kollid)) 8, Pechiparai, Sathyamangalam and Marakkanam 7 each, Tiruchendur, Car Nicobar and Thenkasi 6 each, Kurudamannil, Sirkali, R.S.Mangalam and Satankulam 5 each
23 Oct	CIAL Kochi 7, Aryankavu, Manimutharu U U and Aluva PWD 6 each, Nanguneri 5
24 Oct	Domakonda and Punalur 7 each, Asifabad 6, Pechiparai, Narayankhed, Narayankhed (ARG) and Gandhari 5 each

TABLE 5 (*Contd*.)

Date	Some representative amounts of rainfall in cm for October, November and December 2018 (5 cm and above)
25 Oct	Tiruchendur 8, Thoothukudi, Vedaranniyam, Thoothukudi Port AWS and Ottapadiram 6 each, Noothankal 5
26 Oct	Rameswaram 7, Pamban 5
27 Oct	Nil
28 Oct	Kamalpur 10, Gharmura 8, Dharmanagar/Panisagar 7, Lengpui and Kailashahar 6 each, Silchar 5
29 Oct	Nil
30 Oct	Nil
31 Oct	Ennore AWS, DGP Office, Mahabalipuram and Ponneri 5 each
1 Nov	Puzhal ARG 11, Kelambakkam 10, Punalur, Periyanaickenpalayam, Perundurai and Cuddalore 9 each, Myladumparaagri 8, Madavaram AWS and Avinasi 7 each, Peraiyur, Konni, Ennore AWS, Red Hills and Taramani ARG 6 each, Vedaranniyam, Satyabama Uty ARG, Sivakasi, Mahabalipuram and Thodupuzha 5 each
2 Nov	Vedaranniyam 15, Nagapattnam 14, Thiruthuraipoondi 13, Mayiladuthurai 9, Tiruvarur 8, Karaikal, Nannilam, Rameswaram, Nagari and Parangipettai 7 each, Pamban, Kandukur and Madukkur 6 each, Sirkali, Pattukottai, Tissa, Kaveli, Pollachi, Pakala, Chidambaram, Anaikaranchatram (Kollid)) and Kodavasal 5 each
3 Nov	Manimutharu U U 29, Satankulam 22, Papanasam 16, Tiruchendur 11, Neyyattinkara 10, K.M. Koil 9, Thiruvananthapuram AP 8, Thiruthuraipoondi, Maniyachi, Srivaikuntam and Nannilam 7 each, Jayamkondam, Valangaiman, Thoothukudi, Nedumangad, Karaikal, Shalimar AGRO, Kaikalur, Aduthurai AWS, Cheranmahadevi, Srinagar AGRO AWS, Thiruvananthapuram, Nanguneri, Thoothukudi Port AWS and Harran AWS 6 each, Sirkali, Parangipettai, Kumbakonam, Thuckalay, Thiruvidaimaruthur, Vedaranniyam, Rambagh AWS, Srinagar, Needamangalam, Colachel, Pahalgam, Srinagar IAF, Pandavaiyar Head, Nagapattnam, Tiruvarur and Ottapadiram 5 each
4 Nov	Papanasam 15, Anantnag, Quazigund, Pahalgam and Srinagar IAF 7 each, Banihal, Manimutharu U U, Coonoor and Kukernag 6 each, Tirumangalam, Kannur, Madurai AP and Joshimath 5 each
5 Nov	Akole 15, Vadgaon Maval 6, Pen, Chiplun and Tuting 5 each
6 Nov	Mahabaleshwar and Tuting 5 each
7 Nov	Nil
8 Nov	Nagapattinam 8, Satankulam 7, Rameswaram 6, Vedaranniyam and Srivaikuntam 5 each
9 Nov	Sirkali 7, Hut Bay, Port Blair and Nannilam 5 each
10 Nov	Long Islands 14, Maya Bandar 10, Port Blair 9, Mavelikara and Hut Bay 5 each
11 Nov	Maya Bandar 7, Long Islands 6
12 Nov	Long Islands 10, Port Blair 5
13 Nov	Nil
14 Nov	Nil
15 Nov	Gohar 5
16 Nov	Thiruthuraipoondi and Muthupet 17 each, Adirampattinam 16, Peravurani, Pattukottai and Neyveli AWS 14 each, Virudachalam 12, Chengalpattu 11, Cuddalore 9, Madukkur, Arantangi and Vandavasi 8 each, Srimushnam, Nagercoil, Uthiramerur, Valinokkam ARG, Orthanad, Needamangalam, Sethiathope, Thuckalay, Puducherry and Tozhudur 7 each, Nagapattnam, Parangipettai, Kodaikanal, Valangaiman, Jayamkondam and Kancheepuram 6 each, Chidambaram, Karaikal, Varkala, Alangudi, Sendurai, Kanyakumari, Eraniel, Ariyalur, Rameswaram, Kodavasal, Kelambakkam, Pamban, Mayiladuthurai, Thoothukudi, Thanjavur and Tiruvaiyaru 5 each
17 Nov	Kozha 28, Piravam 19, Sivaganga 17, Thodupuzha 15, Kodaikanal 14, Cherthala and Munnar KSEB 12 each, Kumarakom 11, Idukki and Thammampatty 10 each, Vaikom, Nilakottai, Illuppur, Periyakulam, Bodinaickanur and Myladumparaagri 9 each, Kottayam and Tirupathur 8 each, Kandukur, Peermade TO, Aswaraopeta, Chinnakalar, Vadipatti and Gudivada 7 each, Andipatti, Aswaraopet AP, Kamatchipuram, Dindigul, Chatrapatti (Odanchatra) and Gudalur 6 each, Aranmanaipudur, Ernakulam South, Sholavandan, Karaikudi, Tuting, Valparai, Perumpavur, Vinjamur, Natham, Mettupatti and Valparai Taluk Office 5 each
18 Nov	Srungavarapukota 8, Narsampet 6
19 Nov	Pavagada and Nilanga 7 each, Perumpavur, B Durga, Mettupalayam, Dabholim (Goa) and Hubballi 6 each, Davanagere, Kurudamannil, Marmugoa, Konni and Vellanikkara 5 each
20 Nov	Shencottah 8, Vaikom 7, Manimutharu U U 6, Chengannur, Kayamkulam Agri, Piravam, Pamban, Mohol, Dahiwadi Man, Papanasam, Tiruchendur, Thiruvananthapuram AP, Rameswaram and Indi 5 each

TABLE 5 (*Contd*.)

Date	Some representative amounts of rainfall in cm for October, November and December 2018 (5 cm and above)
21 Nov	Ottapalam 9, Karaikal and Trangambadi (Or Tranqueb) 7 each, Thodupuzha 6, Vedaranniyam, JavaliMedha, Vaikom, Chidambaram, Dahiwadi Man, Parangipettai, Valangaiman, Adirampattinam, Chennai AP, Kumbakonam, Kochi AP and Chembarabakkam 5 each
22 Nov	Gudur 17, Sullurpeta 15, Cholavaram and Madavaram AWS 12 each, Vanur, Tirupathi AP, Tada and Red Hills 11 each, Ponneri 10, Rapur, Chennai city, DGP Office, Marakkanam, Tindivanam, Chennai AP, Panruti and Anna Uty ARG 9 each, Thamaraipakkam, Venkatagiri and Neyveli AWS 8 each, Taramani ARG, Nagari, Pallipattu, Atmakur and Chengalpattu 7 each, Mahabalipuram, Tiruttani, Maduranthagam, Vilupuram, Puducherry, Gingee, Samayapuram, Cheyyur, Anna University and Poondi 6 each, Nellore, Kelambakkam, Vandavasi, Chittoor, Palasamudram, Pakala, Tozhudur and Tiruvallur 5 each
23 Nov	Chengalpattu 18, Maduranthagam 14, Mahabalipuram 10, Uthiramerur, Vandavasi and Sullurpeta 9 each, Tada, Marakkanam, Parangipettai, Vanur, Gingee and Tindivanam 8 each, Sriperumbudur, Kancheepuram and Arani 7 each, Avinasi, Tirupathi AP, Polur, Vaikom, Cuddalore, Cholavaram and Red Hills 6 each, Kalavai AWS, Neyveli AWS, Tiruvannamalai, Ayikudi, Tambaram, Sirkali, Cheyyar, Thamaraipakkam, Sankarapuram, Manimutharu U U, Puducherry, Anaikaranchatram (Kollid)), KVK Kattukuppam ARG, Perumpavur and Vellore 5 each
24 Nov	Rameswaram 23, Valangaiman 19, Tiruvarur and Nagapattnam 17 each, Pamban, Needamangalam and Kumbakonam 15 each, Kodavasal 14, Pandavaiyar Head 12, Mannargudi and Karaikal 11 each, Ariyalur, Trangambadi (Or Tranqueb), Madukkur and Nannilam 10 each, Chettikulam, Thiruvidaimaruthur, Perambalur and Tozhudur 9 each, Chinnakalar and Tiruvaiyaru 8 each, Pattukottai, Valparai Taluk Office, Adirampattinam, Jayamkondam, Thiruthuraipoondi and Sendurai 7 each, Mayiladuthurai, Manjeri, Thirumanur, Srimushnam, Papanasam, Lalgudi, Perinthalamanna, Pullambadi and Perungalur 6 each, Mangaluru, Samayapuram, Venbavur, Perumpavur, Parangipettai, Ulundurpet, Aduthurai AWS, Kottayam, Nilambur, Puttur HMS, Angadipuram, Sethiathope, Vaikom, Sattur, Thanjavur, Anaikaranchatram (Kollid)), Sirkali, Harur, Venkatagiri and Orthanad 5 each
25 Nov	Kottayam 8, Bhoothapandy, Mannargudi and Chengannur 5 each
26 Nov	Amini Divi 24, Manjeri 6
27 Nov	Nil
28 Nov	Nil
29 Nov	Thiruthuraipoondi 10, Anaikaranchatram (Kollid)) 7, Chidambaram AWS and Sirkali 6 each, Chidambaram, Parangipettai, Sethiathope and Mayiladuthurai 5 each
30 Nov	Kumbakonam 8, Rameswaram 7, Thiruvidaimaruthur and Aduthurai AWS 6 each, Tirukattupalli, Trangambadi (Or Tranqueb), Grand Anaicut, Kodavasal, Pamban, Puducherry and Coonoor 5 each
1 Dec	Nil
2 Dec	Nil
3 Dec	Nil
4 Dec	Ponneri 13, Ennore AWS 10, Cholavaram 8, Kelambakkam 7, Red Hills, Karaikal and Chennai AP 5 each
5 Dec	Cholavaram 8, Gudur 6, Car Nicobar IAF and Thamaraipakkam 5 each
6 Dec	Kavali 11, Nellore and Marakkanam 8 each, Virudachalam 7, Banavasi, Sullurpeta and Shikaripur 5 each
7 Dec	Irikkur 5
8 Dec	Long Islands 16
9 Dec	Hut Bay 5
10 Dec	Hut Bay 11
11 Dec	Nil
12 Dec	Long Islands 5
13 Dec	Kaithal 7, Dahegaon 5
14 Dec	Hakimpet 9, Shamirpet, Cherthala, Kamalapur, Hyderabad and Gulbarga 5 each
15 Dec	Car Nicobar 9, Car Nicobar IAF 7
16 Dec	Nil
17 Dec	Vijaywada AP 24, Gudivada 10, Nuzvid, Aswaraopeta, Avanigada, Sathupalle, Vijaywada and Aswaraopet AP 9 each, Mulakalapalle, Chandrugonda, Enkuru and Eluru 8 each, Kothagudem, Julurpad, Manuguru, Palawancha, Kaikalur, Chintalapudi, Repalle, Burgampadu, Amalapuram and Tenali 7 each, Kukunoor, Velairpad, Tiruvuru, Pinapaka, Thollada, Mangalagiri, Vararamachandrapur, Tekulapalle, Madanpur Rampur and Kothagudam 6 each, Kunavaram, Machilipatnam, Aswapuram, Sinapali ARG, Polavaram, Venkatapuram, Tadepalligudem, Boden ARG, Bheemavaram, Dornakal, Yellandu, Konijerla, Bapatla and Koyyalagudem 5 each

TABLE 5 (*Contd*.)

Date	Some representative amounts of rainfall in cm for October, November and December 2018 (5 cm and above)
18 Dec	Araku Valley and Salur 13 each, Amalapuram and Bheemunipatnam 12 each, Visakhapatnam, Bondapalle, Mentada and Ranastalam 11 each, Gajapathinagaram, Kalingapatnam, Gurundia ARG, Padampur and Kirmira ARG 10 each, Cheepurupalle, Bolangir, Merakamudidam, Lahunipara, Therlam, Nellimarla, Tensa, Bobbili, Garividi, Nuagada ARG, Bamra ARG, Banaigarh AWS, Jamankira, Rajgangpur and Jamshedpur AP 9 each, Deogaon, Burla ARG, Kuchinda, Hirakud, Jhumpura, Joda ARG, Ambabhona, G Udayagiri AWS, Reamal, Pottangi, Vizianagaram, Lakhanpur ARG, Binika, Bargarh, Chodavaram, Panposh, Barpalli ARG, Jharsuguda AP, Batli ARG, Paikmal and Champua 8 each, Laikera, Pusapatirega, Seethanagaram, Sambalpur, Gaisilet ARG, Kakinada, Chakradharpur, Ullunda ARG, Paralakhemundi, Gantyada, Chaibasa, Chintapalle, Dunguripalli, Deogarh, Parvathipuram, Balajipeta, Keongjhargarh, Rairakhol, Tuni, Paderu, Sonepur, Garugubilli, Srungavarapukota, Hemgiri, Bijepur, Atabira ARG and Lanjigarh 7 each, Tikarpara, Birmaharajpur ARG, Naktideul, Jharbandh ARG, Nawapara, Sohela, Vepada, Veeraghattam, Kantamal, Balod, Ichchapuram, Harabhanga, Narsipatnam, Denkada, Jujumura ARG, Torpa, Kurupam, Tiring, Visakhapatnam AP, Bargaon, Saintala ARG, Tarva ARG, Bilaspur, Muniguda ARG, Ranchi AP, Koraput, Turekela, Pathapatnam, Khaprakhol ARG, Anakapalle AP, Sarangarh, Madanpur Rampur and Rayagada 6 each, Khairamal, Ranpur, Anakapalle, Titlagarh, Angul, Janjgir, Gopalpur, Yelamanchili, Ambadola, Tekkali, Barkote, Bhanjnagar, Dhamtari, Daspalla, Banarpal ARG, Raikia ARG, Rairangpur, Peddapuram AP, Joshipur, R.Udaigiri, Dondilohara, Chandahandi ARG, Champa, Pathalgaon, Mandar, Mana AP, Thollada, Jamshedpur, Hindol, Sorada, Raipur, Jashpurnagar, Kashinagar, Car Nicobar IAF, Aska, Peddapuram, Nayagarh, Odagaon ARG, Kharidwar, JiyyammaValasa, Kolabira ARG, Kunavaram, Similiguda AWS, Gunupur, Madhira, Dharmagarh ARG, Digapahandi ARG, Jaipatna, Pallahara, Jaridih, Madhabarida, Tenali, Deobhog, Phulberia, Mangalagiri, Belaguntha ARG, Kesinga ARG and Barmul 5 each
19 Dec	Tawang AWS 6, Paren Nsdma AWS, Car Nicobar and Ong Pangkong Nsdma AWS 5 each
20 Dec	Long Islands 8
21 Dec	Maya Bandar 6
22 Dec	Nil
23 Dec	Nil
24 Dec	Nil
25 Dec	Perumpavur 7
26 Dec	Nil
27 Dec	Nil
28 Dec	Nil
29 Dec	Vaikom and Kozhikode 5 each
30 Dec	Manimutharu U U 7
31 Dec	Nil

of the 9 subdivisions in this region 7 were *large deficient* and 2 remained *deficient*.

An anomalous anticyclone over southern parts of Peninsula in the lower levels hindered rainfall activity resulting in three core regions of this monsoon having large deficiency, Rayalaseema at -81%, Tamil Nadu & Puducherry -76% and South Interior Karnataka at -63% of LPA.

3.3.3. *Temperature*

Cold wave conditions manifested from mid December from West Rajasthan and prevailed for a few days at isolated places over sub-divisions of North and Central India. In the last week of the month the cold wave spread to major parts of Northwest India and some parts of Central India and isolated incidences over Peninsular India. Along with spatial extension there was also intensification of the cold waves at the end of the season and these regions also experienced severe cold wave conditions for 1-2 days during this period. Frequency of cold wave conditions was highest over Rajasthan, Saurashtra & Kutch and West Uttar Pradesh divisions.

Cold day conditions prevailed at isolated places for 2 days over Madhya Pradesh in the second half of the month. The lowest minimum temperature recorded was -1.0 °C at Hissar (Haryana) and Bhilwara (west Rajasthan) on 26 and 29 December, respectively.

Minimum temperatures were *normal to below normal* over most parts of India except over parts of peninsular

India in the first fortnight of the month and some sub divisions of East and northeast India in the third week of the month. In the second fortnight minimum temperatures dropped to appreciably below normal and in the last week some divisions recorded markedly below normal temperatures.

3.3.4. *Damages associated with the Disastrous weather events*

As per media reports, Severe Cyclonic Storm 'Phethai' claimed nine lives and forced evacuation of 20,000 people in Andhra Pradesh and 11,600 people in Odisha. Over 10.3 lakh hectares of agricultural crops, 10,000 hectares of horticultural crops and 12,000 mobile towers were damaged in Andhra Pradesh, East and West Godavari were the worst hit. Winds that gusted up to 85-90 kmph uprooted electric poles and trees in East Godavari, disrupting power supply.

The other weather related disasters that occurred were due to dense fog, which lead to very low visibility in North India, which claimed 16 lives and left 33 injured in different road accidents.

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%
No Rain	- –100%

(*ii*) *Intensity (during the past 24 hours period ending at 0300 UTC)*

Heavy rainfall	- 6.5-11.5 cm
Very heavy rainfall	- 11.6-20.4 cm
Extremely heavy rainfall	- 20.5 cm or more
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 less 10 °C 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 more than 6.4 °C.
Markedly below normal	-	When departure from *normal* is –5 °C or less
Appreciably below normal	-	When departure from *normal* is between –3.1 °C to –5.0 °C
Below normal	-	Departure from *normal* is –1.6 °C to –3.0 °C
Normal	-	Departure from *normal* is –1.5 °C to +1.5 °C