MAUSAM, **67**, 2 (April 2016), 383-400

Weather in India

HOT WEATHER SEASON (March-May 2016)†

1. Chief features

(*i*) The hot weather season of 2016 witnessed the formation of one Cyclonic Storm (CS) 'Roanu' over the Bay of Bengal towards the end of the season. Also, 2 induced low pressures areas formed in the westerly wind regime during March and April.

(*ii*) *Heat wave conditions** manifested from the last week of March over central and adjoining west/northwestern parts of India. As the season progressed, its severity and extent increased and by the end of April it extended over parts of south India.

(*iii*) Rainfall during March and May had been *normal* while April received *below normal* rainfall. The seasonal all India rainfall had been 99.8% of its Long Period Average.

(*iv*) Southwest Monsoon (SWM) advanced over parts of southeast Bay of Bengal and Andaman Sea & Nicobar Islands on 18th May.

(*v*) Widespread hailstorm activity with moderate to severe intensity (qualitaively categorized in terms of the extent of damage) occurred over Himachal Pradesh, Rajasthan, Madhya Maharashtra, Meghalaya, Mizoram, Bihar and Madhya Pradesh during the season causing damage to several houses and standing crops. Apart from this, extremely heavy rainfall, Thunder squalls and Dust storms were major weather events which caused destruction and casualty during the season.

2. Seasonal rainfall

The sub-division wise rainfall and its departure from *normal* for each month and season as a whole are given in Table 1. The sub-divisional rainfall departures for the season March-May 2016 are also depicted in Fig. 1.

Consecutive passage of western disturbances (WDs) and their induced systems, favourable conditions for intense convective activity generated by lower tropospheric instability and upper level velocity divergence, moisture incursion in the lower tropospheric levels and presence of north-south wind discontinuity caused *excess/normal** rainfall almost over most parts of the country

The seasonal rainfall over the meteorological sub-divisions was *large excess/ /normal** over major parts of the country outside Rajasthan, Madhya Maharashtra, Marathwada, coastal & south interior Karnataka and Islands where it was *deficient/large deficient.*

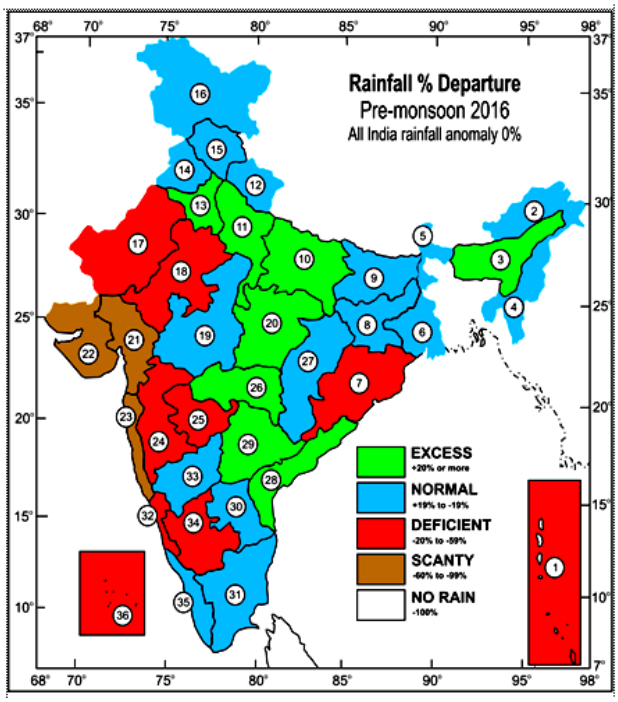

Fig. 1. Sub-divisional rainfall percentage departures (based on Operational data) for the season March-May, 2016. Sub-divisions are indicated by number on the map & bold letters in legend. The rainfall anomaly values for these 36 sub-divisions are indicated below :

1	-57	**7**	-27	**13**	41	**19**	-5	**25**	-34	**31**	-13
2	-8	**8**	6	**14**	13	**20**	44	**26**	21	**32**	-42
3	24	**9**	10	**15**	-5	**21**	-84	**27**	0	**33**	-19
4	-16	**10**	50	**16**	2	**22**	-66	**28**	37	**34**	-26
5	-5	**11**	34	**17**	-48	**23**	-86	**29**	24	**35**	-17
6	-19	**12**	-1	**18**	-32	**24**	-58	**30**	0	**36**	-58

*Definitions of terms in italics other 5 than sub-titles are given in Appendix

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TABLE 1

Sub-division wise rainfall (mm) for each month and season as a whole (March-May 2016) (based on operational data)

S. No.	Meteorological Sub-divisions	March			April			May			Season		
		Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)
1.	Andaman & Nicobar Islands	5.4	25.0	-78	2.4	81.5	-97	191.1	358.5	-47	198.9	465.0	-57
2.	Arunachal Pradesh	128.0	179.7	-29	320.5	278.8	15	273.3	291.9	-6	693.3	750.4	-8
3.	Assam & Meghalaya	62.4	77.7	-20	317.6	181.2	75	316.9	331.3	-4	734.4	590.2	24
4.	Naga., Mani., Mizo. and Tri.	57.3	76.8	-25	137.0	149.4	-8	279.3	267.9	4	574.8	494.1	16
5.	Sub-Himalayan West Bengal & Sikkim	98.0	63.6	54	101.4	123.7	-18	233.7	269.8	-13	434.0	457.1	-5
6.	Gangetic West Bengal	15.0	28.0	-46	5.8	42.1	-86	112.4	94.7	19	133.2	164.8	-19
7.	Orissa	14.6	27.0	-46	8.5	37.5	-77	74.9	70.2	7	98.0	134.7	-27
8.	Jharkhand	17.8	17.1	4	0.9	18.4	-95	65.7	43.9	50	84.4	79.4	6
9.	Bihar	5.5	10.1	-46	3.0	16.3	-81	76.5	51.1	50	85.1	77.5	10
10.	East Uttar Pradesh	9.6	9.1	5	0.0	5.6	-99	38.0	17.0	124	47.6	31.7	50
11.	West Uttar Pradesh	10.4	11.3	-8	0.5	4.6	-90	28.0	13.2	112	38.9	29.1	34
12.	Uttaranchal	44.7	57.6	-22	10.1	33.3	-70	99.2	65.1	52	154.1	156.0	-1
13.	Haryana, Chandigarh & Delhi	20.7	12.7	63	0.6	7.5	-92	26.7	14.0	91	48.1	34.2	41
14.	Punjab	34.6	25.3	37	0.8	12.5	-94	24.8	15.7	58	60.2	53.5	13
15.	Himachal Pradesh	114.4	114.2	0	47.7	65.4	-27	71.7	65.3	10	233.8	244.9	-5
16.	Jammu & Kashmir	191.4	151.9	26	82.0	97.5	-16	58.4	76.6	-24	331.8	326.0	2
17.	West Rajasthan	6.5	3.8	71	0.0	4.2	-99	3.4	11.1	-69	9.9	19.1	-48
18.	East Rajasthan	3.3	3.7	-11	0.0	2.9	-100	8.6	10.8	-20	11.9	17.4	-32
19.	West Madhya Pradesh	2.4	4.6	-47	0.0	2.0	-100	10.3	6.9	50	12.8	13.5	-5
20.	East Madhya Pradesh	17.6	12.5	41	0.1	5.5	-98	18.5	7.1	160	36.2	25.1	44
21.	Gujarat region	0.6	1.0	-42	0.0	0.3	-100	0.4	5.1	-92	1.0	6.4	-84
22.	Saurashtra & Kutch	0.3	1.2	-77	0.0	0.2	-100	1.0	2.5	-58	1.3	3.9	-66
23.	Konkan & Goa	2.9	0.0	28613	0.5	2.7	-82	1.7	34.3	-95	5.0	37.0	-86
24.	Madhya Maharashtra	6.6	2.7	144	1.4	8.9	-84	7.8	26.2	-70	15.8	37.8	-58
25.	Marathawada	10.8	5.7	90	2.9	6.5	-55	6.3	18.1	-65	20.1	30.3	-34
26.	Vidarbha	20.1	12.0	67	5.1	7.7	-34	12.4	11.2	10	37.5	30.9	21
27.	Chattisgarh	24.6	13.3	85	4.7	13.8	-66	16.0	18.1	-12	45.2	45.2	0
28.	Coastal Andhra Pradesh	3.9	11.1	-65	3.0	21.8	-86	126.4	64.1	97	133.2	97.0	37
29.	Telangana	11.3	9.4	21	4.4	16.5	-74	54.8	30.9	77	70.6	56.8	24
30.	Rayalaseema	0.8	6.5	-87	0.4	19.9	-98	80.6	55.6	45	81.8	82.0	0
31.	Tamil Nadu	3.1	18.3	-83	6.3	42.3	-85	102.3	67.5	51	111.6	128.1	-13
32.	Coastal Karnataka	0.4	4.1	-91	3.9	28.1	-86	99.5	146.6	-32	103.8	178.8	-42
33.	North interior Karnataka	6.7	5.2	29	11.9	25.6	-53	49.9	54.3	-8	68.5	85.1	-19
34.	South interior Karnataka	3.2	8.5	-62	9.5	43.8	-78	94.6	92.9	2	107.3	145.2	-26
35.	Kerala	22.7	30.4	-25	33.3	109.5	-70	259.3	239.8	8	315.3	379.7	-17
36.	Lakshadweep	3.2	11.8	-73	2.6	48.9	-95	90.9	171.7	-47	96.7	232.4	-58

TABLE 2

Details of the weather systems during March 2016

S. No.	System	Duration	Place of initial location	Direction of movement	Place of final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**) *Western disturbances/Eastward moving systems*						
(*i*) *Upper air cyclonic circulation*						
1.	Upto mid tropospheric levels	15-20	Eastern parts of Iran and adjoining Afghanistan	Northeast	Eastern parts of Jammu & Kashmir and neighbourhood	Moved away northeastwards on 21 evening
2.	Do	29-30	North Pakistan and neighbourhood	Do	Jammu & Kashmir and neighbourhood	The feeble WD moved away northeastwards on 31
(*ii*) *As a trough*						
1.	Mid & Upper tropospheric levels	8-15	Along Long.51° E to the north of Lat. 35° N (axis at 5.8 kms a.s.l.)	Northeast	Along Long.74° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	It lay as an upper air cyclonic circulation extending upto 4.5 kms a.s.l. with a trough aloft during 11-14. The WD moved away northeastwards on 15 evening
2.	Do	22-28	Along Long.42° E to the north of Lat. 20° N (axis at 5.8 kms a.s.l.)	Do	Along Long.80° E to the north of Lat. 20° N (axis at 5.8 kms a.s.l.)	Moved away east-northeastwards on 29
(*iii*) *As an induced cyclonic circulation*						
1.	Upto mid tropospheric levels	3-7	Central Pakistan and adjoining west Rajasthan	East	Punjab and neighbourhood	It lay as a cyclonic circulation over Haryana and neighbourhood extending between 2.1 & 3.6 kms a.s.l. on 8. Became less marked on 9
2.	Upto lower tropospheric levels	17-20	Central Pakistan and adjoining west Rajasthan	Do	Punjab and neighbourhood	Became less marked on 21
3.	Upto mid tropospheric levels	24-27	Central Pakistan and adjoining northwest Rajasthan	Do	Northeast Rajasthan and adjoining areas of northwest Madhya Pradesh and west Uttar Pradesh	Became less marked on 28
(*iv*) *As an induced low pressure area*						
1.	Low pressure area	11-12	Central Pakistan and adjoining areas of northwest Rajasthan and Punjab	East	Northwest Rajasthan and neighbourhood	It lay as an induced cyclonic circulation extending upto lower tropospheric levels over central Pakistan and adjoining west Rajasthan on 10. It became less marked on 13. However, the associated cyclonic circulation extending upto lower tropospheric levels persisted upto 14 and became less marked on 15
(**B**) *Other upper air cyclonic circulations*						
1.	At lower levels	1-2	North Chhattisgarh and neighbourhood	East	Jharkhand and adjoining areas of Gangetic West Bengal	Less marked on 3
2.	Upto lower tropospheric levels	4-8	Bangla Desh and neighbourhood	Do	Assam & Meghalaya and neighbourhood	It lay as a trough from Assam to north Bay of Bengal extending upto 0.9 km a.s.l. on 8 and became less marked on 9
3.	Do	7-10	Northwest Madhya Pradesh and neighbourhood	Do	East Madhya Pradesh and adjoining areas of Vidarbha and Chhattisgarh	Became less marked on 11
4.	Between Lower & mid tropospheric levels	7-8	Comorin area and neighbourhood	Stationary	*In situ*	Became less marked on 9
5.	Upto lower tropospheric levels	6	Gangetic West Bengal and adjoining areas of Bangla Desh	Do	Do	Became less marked on 7
6.	At lower levels	6	Central parts of south Madhya Pradesh and adjoining Vidarbha	Do	Do	Became less marked on 7
7.	Do	11-12	Comorin area and neighbourhood	Do	Do	Became less marked on 13

TABLE 2 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
8.	At lower levels	12-13	Northwest Madhya Pradesh and neighbourhood	East	West Uttar Pradesh and neighbourhood	Became less marked on 14
9.	Do	13-14	Vidarbha and adjoining areas of south Chhattisgarh & Telangana	Quasi-stationary	Vidarbha and neighbourhood	Became less marked on 15
10.	Do	15	East Rajasthan and neighbourhood	Stationary	*In situ*	Became less marked on 16
11.	Upto lower tropospheric levels	16-17	Vidarbha and neighbourhood	Do	Do	Became less marked on 18
12.	Do	20	Sub-Himalayan West Bengal and neighbourhood	Do	Do	Became less marked on 21
13.	Do	22	Assam & Meghalaya and neighbourhood	Do	Do	Became less marked on 23
14.	At lower levels	23-24	Sub-Himalayan West Bengal and neighbourhood	Do	Do	Became less marked on 25
15.	Upto lower tropospheric levels	23-26	North interior Karnataka and neighbourhood	West	South Madhya Maharashtra and neighbourhood	Became less marked on 27
16.	Do	25-28	Interior Odisha and adjoining Chhattisgarh	North	Eastern parts of Bihar and adjoining areas of Jharkhand & west Bengal	Became less marked on 29
17.	At lower levels	26-27	Comorin area and neighbourhood	Stationary	*In situ*	It lay embedded in the trough at lower level from west Madhya Pradesh to Comorin area on 27. Became less marked on 28
18.	Do	30-31	Comorin area and neighbourhood	Do	Do	Became less marked on 1 April
19.	Upto lower tropospheric levels	30 Mar-4 Apr	North Odisha and adjoining Jharkhand	Northeast	Bangladesh and neighbourhood	It lay embedded in the east-west trough extending from Nagaland-Manipur-Mizoram-Tripura to north Chhattisgarh across Jharkhand on 3 & 4. became less marked on 5 April
(**C**)	*Trough in easterlies/Trough of low*					
1.	At mean sea level	4-6	From southeast Bay of Bengal and adjoining south Andaman Sea	Oscillatory	From southeast Bay of Bengal and adjoining south Andaman Sea & equatorial Indian Ocean	Became less marked on 7
2.	At lower levels	4	From southeast Arabian Sea to Konkan coast	Do	Do	Became less marked on 5
3.	Do	5-6	From Comorin area to south interior Karnataka	Do	Do	Became less marked on 7
4.	Do	9-10	Equatorial Indian Ocean and adjoining southwest Bay of Bengal	Stationary	*In situ*	Became less marked on 11
5.	Do	10-11	From southeast Arabian Sea to south Konkan coast	West	From southeast Arabian Sea to south Madhya Maharashtra across south Konkan	Became less marked on 12
6.	At mean sea level	20-29	Equatorial Indian Ocean and adjoining Malaya Peninsula	Do	Equatorial Indian Ocean and adjoining areas of southwest Bay of Bengal off south Sri-Lanka coast	Became less marked on 30
7.	At lower levels	28	From Comorin area to north interior Karnataka across interior Karnataka	Stationary	*In situ*	Became less marked on 29
(**D**)	*Other troughs/Wind discontinuity*					
1.	At lower levels	12	From the cyclonic circulation over northwest Madhya Pradesh and neighbourhood to south interior Karnataka	Stationary	*In situ*	Became less marked on 13
2.	Do	15	From east Rajasthan and neighbourhood to Rayalaseema across west Madhya Pradesh, Vidarbha and Telangana	Do	Do	Became less marked on 16

TABLE 2 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
3.	At lower levels	13-14	Extended from cyclonic circulation over Vidarbha and adjoining areas of south Chhattisgarh and Telangana to south Tamil Nadu	Quasi stationary	Extended from cyclonic circulation over Vidarbha and adjoining areas of south Chhattisgarh and Telangana to Comorin area across Telangana, Rayalaseema and interior Tamil Nadu	Became less marked on 15
4.	Between mid & upper tropospheric levels	16	Along Long.85° E to the north of Lat. 25° N	Stationary	*In situ*	Became less marked on 17
5.	Upto lower tropospheric levels	16-17	Extended from cyclonic circulation over Vidarbha and neighbourhood to south Tamil Nadu across Telangana and interior Karnataka	Quasi stationary	Extended from cyclonic circulation over Vidarbha and neighbourhood to south Tamil Nadu across Marathwada and interior Karnataka	Became less marked on 18
6.	At lower levels	18-19	Extended from the induced cyclonic circulation over north Rajasthan and adjoining areas of Punjab & Haryana to Marathwada across west Madhya Pradesh and western parts of Vidarbha	Do	Extended from the induced cyclonic circulation over north Rajasthan and adjoining areas of Punjab & Haryana to northwest Madhya Pradesh across east Rajasthan	Became less marked on 20
7.	Do	19	Extended from east Assam to eastern parts of Jharkhand across Gangetic West Bengal	Stationary	*In situ*	Became less marked on 20
8.	Do	19	Extended from Marathwada to Lakshadweep area across interior Karnataka and Kerala	Do	Do	Became less marked on 20
9.	Do	20	Extended from cyclonic circulation over Sub-Himalayan West Bengal and neighbourhood to north Odisha across Gangetic West Bengal	Do	Do	Became less marked on 21
10.	Do	21-22	Extended from the eastern parts of Bihar to north Odisha across Jharkhand	South	Interior parts of Odisha to south Tamil Nadu across Coastal Andhra Pradesh and Rayalaseema	Became less marked on 23
11.	Upto lower tropospheric levels	23-24	From cyclonic circulation over north interior Karnataka & neighbourhood to Lakshadweep area across south interior Karnataka and Kerala	Oscillatory	From cyclonic circulation over north interior Karnataka and neighbourhood to east central Arabian Sea off Karnataka coast	It merged with the wind discontinuity on 25
12.	At lower levels	24	From cyclonic circulation over Sub-Himalayan West Bengal and neighbourhood to north coastal Andhra Pradesh across southern parts of Jharkhand and interior Odisha	Stationary	*In situ*	Became less marked on 25
13.	Do	25	From the cyclonic circulation over south Madhya Maharashtra and neighbourhood	Stationary	Do	Became less marked on 26
14.	Do	27	From west Madhya Pradesh to Comorin area across Madhya Maharashtra, interior Karnataka and interior Tamil Nadu	Do	Do	Became less marked on 28
15.	Do	28	From south Uttar Pradesh to southwest Madhya Pradesh	Do	Do	Became less marked on 29

TABLE 2 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
16.	Upto lower tropospheric levels	29 Mar-7 Apr	From southeast Madhya Pradesh to north interior Karnataka across Vidarbha & Marathwada	Oscillatory	From Vidarbha to Comorin area across Telangana, Rayalaseema and interior Tamil Nadu	Became less marked on 8 April
17.	Mid & Upper tropospheric westerlies	31 Mar-1 Apr	Along Long.87° E to the north of Lat. 20° N (axis at 5.8 kms a.s.l.)	East	Along Long.90° E to the north of Lat. 20° N (axis at 5.8 kms a.s.l.)	Moved away east northeastwards on 2 April

3. Significant features during various months

3.1. *March*

3.1.1. *Weather and associated synoptic features*

The details of the weather systems during the month are summarised in Table 2 and the principal amounts of rainfall are given in Table 5.

The low zonal index phase of the mid-latitude circulation and the passage of active WDs and their induced systems caused fairly widespread to widespread precipitation over parts of northwest India, western Himalayan region & adjoining northern plains and fairly widespread to widespread rainfall over some parts of east & northeast India. Moisture incursion from the convectively active Arabian Sea, thermodynamic instability and the formation of trough/wind discontinuity in the lower levels caused isolated to scattered rainfall over central and Peninsular India during the first half of the month.

In the third week, the change in mid-latitude circulation regime from Low index to High index shifted the core of sub-tropical westerly jet stream (STWJ) northwards resulting into more frequent but faster moving WDs. The rainfall activity over the country during this week can be very well attributed to the induced systems and the troughs/cyclonic circulations in the lower levels which continued in the last week and caused isolated to scattered thundershowers and hailstorms over central & Peninsular India. Further east-northeastward movement of the trough enhanced the precipitation over east and northeast India towards the end of the month.

3.1.2. *Temperature distribution*

(a) *Minimum temperatures*

No cold wave conditions prevailed during the month.

A convectively active Sea area and the prevailing lower tropospheric circulation features led to moisture incursion over the mainland which resulted in above normal temperatures over most parts of the country. Night temperature remained *appreciably above normal* over some parts of west Rajasthan, west Madhya Pradesh and Gujarat Region and *above normal* over most parts of northwest India, some parts of northeast (Bihar, Jharkhand and Gangetic West Bengal) and interior parts of Peninsular India and Tamil Nadu. It was *normal* over the rest of the country.

The month's and the season's lowest minimum temperature over the plains was 9.0 °C, recorded at Najibabad (west Uttar Pradesh) on 3rd March, 2016.

(b) *Maximum temperatures*

Heat wave conditions prevailed on 1 to 3 days over Madhya Pradesh and Gujarat State.

Maximum temperatures were *normal* to *above normal* over most parts of the country outside western Himalayan region and adjoining parts of northwest India and over northern plains and adjoining east India where the active WDs and their induced systems kept the day temperatures below normal during the latter part of first fortnight. In the second half, the day temperatures remained above normal over most parts of the country outside extreme northeastern parts where it was below normal for a couple of days towards the end of the month.

The month's highest maximum temperature over the plains was 43.1 °C, recorded at Akola (Vidarbha) on 26 March, 2016.

3.1.3. *Disastrous weather events and damage*

According to media and other disaster reports, sunstroke claimed around 50 lives in Telangana and Andhra Pradesh. Avalanche and snowfall related incidents claimed 4 lives in Jammu & Kashmir. Thunderstorm /lightning/Hailstorm and rain related incidents claimed 10 lives in Uttar Pradesh, 9 in Madhya Pradesh, 7 in Madhya Maharashtra, 5 each in Odisha and Rajasthan and 2 in Tamil Nadu. Landslide in Madhya Pradesh claimed 3 lives. Hailstorm occurred in initial half

TABLE 3

Details of the weather systems during April 2016

S. No.	System	Duration	Place of initial location	Direction of movement	Place of final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**) *Low Pressure area*						
1.	Low Pressure area	3	Central Pakistan and adjoining west Rajasthan	Stationary	*In situ*	A cyclonic circulation formed over central Pakistan and neighbourhood on 30 March. It formed under the influence of an induced cyclonic circulation extending upto 1.5 kms a.s.l. Became less marked on 4. However the associated cyclonic circulation lay over Punjab and neighbourhood on 4 and became less marked on 5
(**B**) *Western disturbances/eastward moving systems*						
(*i*) *Upper air cyclonic circulation*						
1.	Upto Mid tropospheric levels	1-5	Eastern parts of Iran and neighbourhood	East	Afghanistan and neighbourhood	Initially it lay as a trough in mid & upper tropospheric westerlies on 31 March. A trough aloft with its axis at 5.8 kms a.s.l. during 1-5. Moved away northeastwards on 6
2.	Do	8-10	Afghanistan and adjoining Iran	Do	North Pakistan and neighbourhood	Moved away east-northeastwards on 11. A trough aloft with its axis at 5.8 kms a.s.l. on 8 & 9
3.	Do	11-12	Afghanistan and neighbourhood	Do	Jammu & Kashmir and adjoining Pakistan	Initially it lat as a trough in mid & upper tropospheric level with its axis at 5.8 kms a.s.l. extended along Long.48° E to the north of Lat. 30° N on 9 &10 and thereafter aloft on 11 & 12. The feeble WD moved away on 13
4.	Do	19-24	Western parts of Iran and neighbourhood	Do	Eastern parts of Jammu & Kashmir and neighbourhood	Moved way east-northeastwards on 25. A trough lay aloft with its axis at 7.6 kms a.s.l. during 19-22 and became less marked on 23
(*ii*) *As a trough*						
1.	Mid & Upper tropospheric levels	5-8	Along Long. 55° E to the north of Lat. 25° N (axis at 5.8 kms a.s.l.)	Northeast	Along Long. 78° E to the north of Lat. 25° N (axis at 5.8 kms a.s.l.)	Became less marked on 9
2.	Do	17-18	Along Long. 58° E to the north of Lat. 27° N (axis at 5.8 kms a.s.l.)	Do	Along Long. 68° E to the north of Lat. 35° N (axis at 5.8 kms a.s.l.)	Initially it lay as an upper air cyclonic circulation extending upto upper tropospheric levels over Iran & neighbourhood on 15 & 16. Moved away east-northeastwards on 19
3.	Do	18-20	Along Long. 51° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	Do	Along Long. 64° E to the north of Lat. 35° N (axis at 5.8 kms a.s.l.)	Moved away east-northeastwards on 21
4.	Do	26-28	Along Long. 68° E to the north of Lat. 25° N (axis at 5.8 kms a.s.l.)	Do	Along Long. 76° E to the north of Lat. 32° N (axis at 5.8 kms a.s.l.)	Initially the feeble WD lay as an upper air cyclonic circulation extending upto mid tropospheric levels over Afghanistan and neighbourhood on 25. The trough moved away northeastwards on 29
5.	Do	30 Apr-6 May	Along Long.45° E to the north of Lat. 20° N (axis at 5.8 kms a.s.l.)		Along Long. 74° E to the north of Lat. 20° N (axis at 5.8 kms a.s.l.)	Moved away east-northeastwards on 7 May
(*iii*) *As an induced cyclonic circulation*						
1.	Upto lower tropospheric levels	6-7	West Rajasthan and neighbourhood	East	Haryana and neighbourhood	Became less marked on 8
2.	Do	9-10	Rajasthan	Stationary	*In situ*	Became less marked on 11
3.	Do	11	Punjab and adjoining Pakistan	Do	Do	Became less marked on 12

TABLE 3 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
4.	Upto lower tropospheric levels	15-18	Central parts of Pakistan and neighbourhood	East	Haryana and neighbourhood	Became less marked on 19
5.	Do	19	Punjab and neighbourhood	Stationary	*In situ*	Became less marked on 20
6.	Do	22	Central Pakistan and adjoining west Rajasthan	Do	Do	Became less marked on 23
7.	Do	25-28	Central Pakistan and adjoining west Rajasthan	East	East Rajasthan and adjoining northwest Madhya Pradesh	Became less marked on 29
(**C**)	*Other upper air cyclonic circulations*					
1.	Upto lower tropospheric levels	6-12	Telangana and adjoining north interior Karnataka	West	North interior Karnataka and neighbourhood	Became less marked on 13
2.	At lower levels	6-7	Sub-Himalayan West Bengal & Sikkim and neighbourhood	East	Bangla Desh and neighbourhood	Became less marked on 8
3.	Upto lower tropospheric levels	1	Western parts of Assam and adjoining Bangla Desh	Stationary	*In situ*	Became less marked on 2
4.	Do	7-8	South Pakistan and adjoining southwest Rajasthan and Kutch	Do	Do	Became less marked on 9
5.	Between 3.1 & 3.6 kms a.s.l.	7	Lakshadweep area and neighbourhood	Do	Do	Became less marked on 8
6.	At lower levels	8	Chhattisgarh and adjoining interior Odisha	Do	Do	Became less marked on 9
7.	Do	9-14	Assam & neighbourhood	East	Eastern parts of Assam & neighbourhood	Became less marked on 15
8.	Upto lower tropospheric levels	19-20	Marathwada and neighbourhood	Oscillatory	North interior Karnataka and neighbourhood	Became less marked on 21
9.	At lower levels	15	Bangla Desh and adjoining Gangetic West Bengal	Stationary	*In situ*	Became less marked on 16
10.	Do	18	Jharkhand and neighbourhood	Do	Do	Became less marked on 19
11.	Upto lower tropospheric levels	6	Vidarbha and adjoining Marathwada & Telangana	Do	Do	It lay embedded in the trough IV (10) and became less marked on 7
12.	At lower levels	26-27	Assam and neighbourhood	East	Eastern parts of Assam and neighbourhood	Became less marked on 28
13.	Do	26	Coastal Odisha and neighbourhood	Stationary	*In situ*	Became less marked on 27
14.	Do	27-29	Eastern parts of Bihar and adjoining Sub-Himalayan West Bengal	East	Sub-Himalayan West Bengal & Sikkim and neighbourhood	Became less marked on 30
15.	Do	22-23	Bangla Desh and neighbourhood	Quasi-stationary	Bangla Desh and adjoining West Bengal	Became less marked on 24
16.	Do	29-30	North Rajasthan and neighbourhood	Southeast	Northwest Madhya Pradesh neighbourhood	Became less marked on 1 May
17.	Do	28	Comorin and adjoining Lakshadweep area	Stationary	*In situ*	Became less marked on 29
(**D**)	*Other troughs/wind discontinuity*					
1.	Upto lower tropospheric levels	5-7	From Sub-Himalayan West Bengal & Sikkim to north coastal Odisha across Gangetic West Bengal	Oscillatory	From the cyclonic circulation over Bangla Desh and neighbourhood to north Bay of Bengal across Gangetic West Bengal	Became less marked on 8
2.	At lower levels	10-11	From cyclonic circulation over north interior Karnataka and neighbourhood to Comorin area across south interior Karnataka and Tamil Nadu	Stationary	*In situ*	Became less marked on 112
3.	Do	9	From east Uttar Pradesh to Vidarbha across east Madhya Pradesh	Do	Do	Became less marked on 10

TABLE 3 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
4.	At lower levels	11-12	From north Gangetic West Bengal to north Bay of Bengal	Oscillatory	From Cyclonic circulation over eastern parts of Assam & Meghalaya to north Bay of Bengal across Bangla Desh	Became less marked on 13
5.	Between 1.5 & 2.1 kms a.s.l.	12-13	Lakshadweep and neighbourhood	Stationary	*In situ*	Became less marked on 14
6.	Upto mid tropospheric levels	13-14	Sub-Himalayan West Bengal to north Bay of Bengal across Gangetic West Bengal	Do	Do	Became less marked on 15
7.	At lower levels	13-14	From south Vidarbha to Lakshadweep across north interior Karnataka	East	From Marathwada to Comorin area across interior Tamil Nadu	It lay as a cyclonic circulation extending upto lower tropospheric levels over interior Karnataka and adjoining Marathwada on 15 and became less marked on 16
8.	Do	15	From cyclonic circulation over Bangla Desh and adjoining Gangetic West Bengal to south Chhattisgarh across north Odisha	Stationary	*In situ*	Became less marked on 16
9.	Upto lower tropospheric levels	16-17	From Meghalaya to central parts of Madhya Pradesh	Southwest	From east Bihar to Vidarbha across east Madhya Pradesh	Became less marked on 17. A cyclonic circulation lay embedded over east Bihar and adjoining Jharkhand & west Bengal on 16 and became less marked on 18
10.	Do	20 Apr-13 May	From north interior Karnataka to Comorin area across south interior Karnataka and interior Tamil Nadu	Oscillatory	From east Vidarbha to south Tamil Nadu across Telangana and Rayalaseema	It merged with the trough at lower tropospheric levels extended from the cyclonic circulation over east Uttar Pradesh and adjoining Bihar to Marathwada across east Madhya Pradesh and Vidarbha on 13
11.	Do	24-25	From Sub-Himalayan West Bengal & Sikkim to north Bay of Bengal across Bangla Desh	Stationary	Sub-Himalayan West Bengal & Sikkim across Gangetic West Bengal	Became less marked on 26
12.	At lower levels	28Apr-1 May	From the cyclonic circulation over eastern parts of Bihar and adjoining Sub-Himalayan West Bengal to north Odisha across Gangetic West Bengal	Oscillatory	East Bihar to north Bay of Bengal across Gangetic West Bengal	It was seen as an upper air cyclonic circulation extending upto lower tropospheric levels on 2 & 3 May and became less marked on 3 May
(**E**)	*Trough in easterlies*					
1.	At lower levels	2	From Comorin area to east central Arabian Sea off Karnataka coast	Stationary	*In situ*	Became less marked on 2
2.	Do	15-18	From the cyclonic circulation over interior Karnataka and adjoining Marathwada to Comorin area across interior Tamil Nadu	Do	From Marathwada to Comorin area across interior Karnataka ad interior Tamil Nadu	Became less marked on 19
3.	At mean sea level	18-22	Equatorial Indian Ocean and adjoining Maldives	West	Equatorial Indian Ocean and adjoining central parts of south Arabian Sea	Moved away westwards on 23
4.	Do	23	Equatorial Indian Ocean and adjoining Maldives	Stationary	*In situ*	Became less marked on 24
(**F**)	*Trough in east-weast*					
1.	At lower levels	3-4	From Nagaland-Manipur-Mizoram-Tripura to north Chhattisgarh across Jharkhand	Stationary	*In situ*	Two cyclonic circulations extending upto 2.1 kms a.s.l. lay embedded in the trough on 4. The trough became less marked on 5
2.	Do	17-19	From east Uttar Pradesh to Assam across northern parts of Gangetic West Bengal and Bihar	Oscillatory	From east Uttar Pradesh to Manipur across Bihar and Assam & Meghalaya	Became less marked on 19
3.	At mean Sea level	21-24	From Bihar to Nagaland across West Bengal and Assam & Meghalaya	Do	From northern parts of Bihar to Manipur to Bangla Desh across West Bengal	Became less marked on 25

TABLE 4

Details of the weather systems during May 2016

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 / Severe Cyclonic Storm*					
1.	Cyclonic Storm 'ROANU'	17-22	Southwest Bay of Bengal off north Tamil Nadu coast centred near Lat. 11° N / Long.81° E. 240,kms south southeast of Chennai	North-northeast	Centred near Lat. 24.5° N /Long.94.7° E. 80 kms east-southeast of Imphal	Details are given in the article on Storms & Depressions over the north Indian Ocean-2016. (July-2017 issue of Mausam)
(**B**)	*Western disturbances/eastward moving systems*					
(*i*)	*Upper air cyclonic circulation*					
1.	Upto Mid tropospheric levels	30-31	North Pakistan and neighbourhood	East	Eastern parts of Jammu & Kashmir and neighbourhood	Moved away east-northeastwards on 1 June
(*ii*)	*As a trough*					
1.	Upto Mid & upper tropospheric levels	8-9	Along Long. 60° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	East	Eastern parts of Jammu & Kashmir and neighbourhood	Moved away eastwards on 10
2.	Do	10-13	Along Long. 56° E to the north of Lat. 38° N (axis at 4.5 kms a.s.l.)	Do	Along Long.70° E to the north of Lat. 35° N (axis at 5.8 kms a.s.l.)	It lay as an upper air cyclonic circulation extending upto 3.1 kms a.s.l. on 13 and moved away northeastwards on 14
3.	Do	13-16	Along Long. 55° E to the north of Lat. 30° N (axis at 4.5 kms a.s.l.)	Do	Along Long.72° E to the north of Lat. 35° N (axis at 4.5 kms a.s.l.)	Moved away northeastwards on 17
4.	Do	12-13	Along Long. 83° E to the north of Lat. 20° N (axis at 4.5 kms a.s.l.)	Do	Along Long.88° E to the north of Lat. 25° N (axis at 4.5 kms a.s.l.)	Moved away northeastwards on 14
5.	Do	21-29	Along Long. 50° E to the north of Lat. 30° N (axis at 4.5 kms a.s.l.)	Do	Along Long.90° E to the north of Lat. 28° N (axis at 4.5 kms a.s.l.)	Moved away east-northeastwards on 30
6.	Between 3.1 & 5.8 kms a.s.l.	22	Along Long. 90° E to the north of Lat. 18° N (axis at 4.5 kms a.s.l.)	Stationary	*In situ*	Moved away northeastwards on 23
7.	Mid & Upper tropospheric levels	26 May-1 June	Along Long. 52° E to the north of Lat. 35° N (axis at 4.5 kms a.s.l.)	East	Along Long.89° E to the north of Lat. 25° N (axis at 4.5 kms a.s.l.)	Moved away east-northeastwards on 2 June
(*iii*)	*As an Induced cyclonic circulation*					
1.	Upto lower tropospheric levels	2-6	Central Pakistan and neighbourhood	East	Punjab, Haryana Chandigarh & Delhi	Became less marked on 7
2.	Do	23-25	Punjab and neighbourhood	Do	North Haryana and neighbourhood	It lay as an upper air cyclonic circulation over Haryana and adjoining areas of west Uttar Pradesh and Uttarakhand on 26 and became less marked the same evening of 26
3.	Do	30-31	Haryana and adjoining Punjab	Do	Haryana and neighbourhood	Became less marked on 1 June
(**C**)	*Other upper air cyclonic circulations*					
1.	Upto mid tropospheric levels	2-5	Assam & Meghalaya and neighbourhood	Stationary	*In situ*	It lay embedded in the east-west trough during 3-5 and became less marked on 6
2.	Do	3-5	East Uttar Pradesh and adjoining northeast Madhya Pradesh	East	East Uttar Pradesh and adjoining Bihar	It lay embedded in the east-west trough during 3-5 and became less marked on 6
3.	Upto Lower tropospheric levels	6-7	North Bangla Desh and adjoining West Bengal & Sikkim	Stationary	*In situ*	Became less marked on 8
4.	Do	7-9	Assam & Meghalaya and adjoining Nagaland-Manipur-Mizoram-Tripura	East	Eastern parts of Assam and neighbourhood	Became less marked on 10

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
5.	Upto Lower tropospheric levels	10-18	Northwest Uttar Pradesh and neighbourhood	East	East Uttar Pradesh and adjoining Bihar	Became less marked on 19. Initially it lay as an induced cyclonic circulation extending upto 2.1 kms a.s.l. over Haryana and adjoining north Rajasthan on 9
6.	Do	7-8	East Rajasthan and adjoining northeast Madhya Pradesh	Do	Northwest Uttar Pradesh and neighbourhood	It merged with the east-west trough on 9
7.	Do	8	Jharkhand and neighbourhood	Stationary	*In situ*	Became less marked on 9
8.	Do	8-9	South Madhya Maharashtra and neighbourhood	Do	Do	Became less marked on 10
9.	Do	15	East central Arabian Sea off south Maharashtra-Karnataka coasts	Do	Do	Became less marked on 16
10.	Between lower & mid tropospheric levels	14-16	Western parts of Assam and neighbourhood	West	Sub-Himalayan West Bengal and neigbourhood	Became less marked on 17
11.	Upto Lower tropospheric levels	19	Assam & Meghalaya and neighbourhood	Stationary	*In situ*	Became less marked on 20
12.	Do	19	Southwest Madhya Pradesh and adjoining north Maharashtra	Do	Do	Became less marked on 20
13.	Do	19-21	Northwest Rajasthan and adjoining area of Punjab and Haryana	Do	Do	Became less marked on 22
14.	Do	23-24	Northwest Bay of Bengal and neighbourhood	East	North Bay of Bengal and neighbourhood	Became less marked on 25
15.	At lower levels	25-31	Assam & meghalaya	Do	Do	Became less marked on 1 June
16.	Upto Lower tropospheric levels	26-31	South Uttar Pradesh and neighbourhood	Do	North Chhattisgarh and neighbourhood	Became less marked on 1 June
17.	Between lower & mid tropospheric levels	28-29	Eastern parts of Bihar and adjoining areas of West Bengal	Stationary	*In situ*	Became less marked on 30
18.	Upto mid tropospheric levels	31	Southern parts of Maharashtra and neighbourhood	Do	Do	Became less marked on 1 June
19.	Between lower & mid tropospheric levels	29 May-11 Jun	Lakshadweep and adjoining areas of Kerala	Northwest	East central Arabian Sea off Karnataka-Goa coasts	Became less marked on 12 June
(**D**)	*East-West trough/shear zone*					
1.	At mean sea level	3-5	From east Uttar Pradesh to Assam & Meghalaya and neighbourhood across Bihar, Jharkhand and northern parts of west Bengal	Stationary	*In situ*	Two Cyclonic circulations lay embedded on 4 & 5. Both became less marked on 6
2.	Do	8-11	From west Rajasthan to coastal Odisha across north Madhya Pradesh and Chhattisgarh	Oscillatory	From north Rajasthan to coastal Odisha across Madhya Pradesh and Chhattisgarh	Became less marked on 12
3.	Do	20 May-4 Jun	From Punjab to the centre of cyclonic storm Roanu across east Rajasthan, north Madhya Pradesh, Chhattisgarh, and Odisha	Do	From Punjab to interior Odisha across Haryana, south Uttar Pradesh and north Chhattisgarh	It extended upto lower tropospheric levels during 22-24 and became less marked on 5 June
4.	Between 3.1 & 7.6 kms a.s.l.	28	Along Lat. 9° N	Stationary	*In situ*	Became less marked on 29
(**E**)	*Other troughs / wind discontinuity*					
1.	At lower levels	1-2	From east Uttar Pradesh to southeast Madhya Pradesh	Oscillatory	From central parts of Uttar Pradesh to south Chhattisgarh across east Madhya Pradesh	It merged with the east-west trough on 3
2.	At mean sea level	7-8	South Andaman Sea and neighbourhood	Stationary	*In situ*	Became less marked on 9

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
3.	At meansea level	9-11	Maldives-Lakshadweep area and neighbourhood	Oscillatory	From equatorial Indian Ocean to south Tamil Nadu across Comorin area	Became less marked on 12
4.	Do	17	From Bihar and to Tripura across Sub-Himalayan West Bengal & Sikkim and Assam & Meghalaya	Stationary	*In situ*	Became less marked on 18
5.	Upto lower tropospheric levels	13-16	From the cyclonic circulation over east Uttar Pradesh and adjoining Bihar to south Tamil Nadu across east Madhya Pradesh, Vidarbha, Telangana and interior Karnataka	Oscillatory	From the cyclonic circulation over northeast Madhya Pradesh and neighbourhood to north interior Karnataka, across Vidarbha and Marathwada	Became less marked on 17
6.	Do	18	From the cyclonic circulation over east Uttar Pradesh and adjoining Bihar to Marathwada across east Madhya Pradesh and Vidarbha	Stationary	*In situ*	Became less marked on 19
(**F**)	*Trough in easterlies*					
1.	At lower levels	2	From Rayalaseema to Comorin area across interior Tamil Nadu	Stationary	*In situ*	It merged with the wind discontinuity from Marathwada to Comorin area on 3

of March damaged crops in 1007 villages of 54 Tehsil of Alwar, Baran, Bharatpur, Churu, Dholpur, Hanumangati, Jaipur, Jaisalmer, Jalore, Jhalawar, Jhunjhunu, Jodhpur, Nagaur, Pali, Sawai Madhopur, Sikar, Sirohi, Tonk and Udaipur districts of Rajasthan.

3.2. *April*

3.2.1. *Weather and associated synoptic features*

The details of the weather systems during the month are given in Table 3 and the principal amounts of rainfall are given in Table 5.

During the first fortnight, passage of WDs and cyclonic circulations induced by them caused *scattered to fairly widespread* precipitation over Jammu & Kashmir and *isolated to scattered* rainfall activity over northwest India and adjoining western Himalayan regions. Presence of an anomalous ridge along Long. 80° E to the north of Lat. 20° N indicated rather weaker westerly systems affecting the Indian latitudes during the month. The presence of trough/wind discontinuity in the lower tropospheric levels over Peninsular India during the first week, aided by moisture incursion caused thunderstorm activity over the Peninsular India and over northeastern subdivisions. The absence of moisture incursion inland in the second week led to dry conditions over most parts of the country.

The High Index pattern in the mid-latitude circulation regime in the second half of the month once again led to more frequent and faster movement of WDs resulting in reduced rainfall activity over western Himalayan region and adjoining northwest India. However the pre-dominance of westerlies in the lower troposphere, presence of shallow pressure belt along the northern plains, topography and upper level divergence led to conducive conditions for intense convection over northeast India causing *fairly wide spread* to *widespread* rainfall accompanied with hailstorms and thunder squalls over major parts of northeast India.

3.2.2. *Temperature distribution*

Severe Heat wave conditions prevailed on 1 to 3 days over Gangetic West Bengal, Odisha, Jharkhand, east Madhya Pradesh and Coastal Andhra Pradesh. *Heat wave conditions* prevailed on 18 days over Odisha, on 9 to 11 days over Gangetic West Bengal and Jharkhand, on 6 days over Bihar and east Madhya Pradesh and 1 to 3 days over east Uttar Pradesh, Haryana Chandigarh & Delhi, Punjab, Himachal Pradesh, Rajasthan, west Madhya Pradesh, Marathwada, Vidarbha, Chhattisgarh, Andhra Pradesh, Telangana and Kerala.

Reduced rainfall activity over northwest India led the day temperatures to remain *above normal* over most parts of northwest, central and Peninsular India during the first week. The anomalous heating of land further extended the warmer temperatures to the eastern parts of India during the second week in the absence of moisture incursion over inland, keeping the day temperatures *above normal* in general. The severity and extent of heating

TABLE 5

Some representative amounts of rainfall in cm for the months March, April and May 2016 (7 cm and above)

Date	March	April	May
1.	Mahbubabad 8, Dondilohara, Sirsilla, Ahiri, Sindewahi and Saoli 7 each	Dhubri 8, Belonia 7	Roing 10, Vaikom 8, Cherrapunji 7
2.	Nil	Bari ARG 8	Nil
3.	Nil	Nil	Nil
4.	Nil	Lakhipur, Kailashahar and Khowai 13 each, Sonamura 12, Matijuri 11, Chhamonu, Khowai AWS and Agartala AP 10 each, Arundhutinagar 9, Silchar, Bishalgarh, Dharmanagar / Panisagar and Chottabekra 7 each	Kailashahar 9, Dharmanagar / Panisagar and Kamalpur 8 each
5.	Nil	Matijuri 15, B P Ghat 8, Karimganj 7	Nil
6.	Kishngarhwas 9, Nabha 7	Hasimara 21, Mawsynram 17, Cherrapunji 15, Matijuri 14, Chengmari / Diana and Cherrapunji (Rkm) 12 each, Alipurduar Cwc and B P Ghat 11 each, Tinsukia 10, Karimganj 8, Miao, Dharmanagar / Panisagar, Bhagamandala, Dholai and Rangiya 7 each	Ghumarwin 11, Perinthalamanna 8, Hyderabad, Bharamsagara, Saroornagar, Sarkaghat, Mallial, Angadipuram and Jukkal 7 each
7.	Ghumarwin 13, Bihubar 8	Margherita 9, Nalbari / Pagladia 8, Deomali, Dholla Bazar, Naharlagun and Nahar Katia 7 each	Padalur 13, Vedasandur and Aravakurichi 11 each, Venkatagiri Kota and Paramathivelur 8 each, Kamatchipuram 7
8.	Gondia AP 10	Cherrapunji 24, Roing and Mawsynram 21 each, Cherrapunji (Rkm) 14	Pithoragarh 9, Chevella, Kalyani Smo and Mustabad 7 each
9.	Nil	Roing 16	Thali 10, Soro, Kolar Gold Field, Ambalavayal and Mannarkad 7 each
10.	Nil	Nil	Mehbubnagar 11
11.	Nil	Ballupet 8	Jogindarnagar 18, Dharmasala 17, Arki 12, Basudevpur AWS and Jandhaha 11 each, Idukki, Sarkaghat and Neyyattinkara 9 each, Mandi and Mashobra AGRO 8 each, Kollegal Pottangi, Tihidi ARG, Banganar, Cheslea School AWS, Gohar, Enamakkal, Vadakkancherry, Alathur, Agali, Banganaf and Sunibhajji 7 each
12.	Bharmaur 15, Dalhousi Alha AWS and Batote 9 each, Bharwain, Saloni, Banihal and Udaipur 7 each	Miao10	Nil
13.	Tissa 8, Gohar 7	Roing 10, Passighat 9	Batote 8
14.	Nil	Cherrapunji 21, Mawsynram 16, Cherrapunji (Rkm) 15, Roing 14, Tezu 10	Shella 10, Kamalpur 9, Guttal 7
15.	Tuting 10	Cherrapunji and Cherrapunji (Rkm) 7 each	Gangtok 13, Kurudamannil 9, Similiguda AWS and Vellanikkara 8 each, Cooch Behar, Tikrikilla and Agartala AP 7 each
16.	Bengaluru AP and Bengaluru Hal AP 7each	Alur 9, Hassan, Kailashahar, Cherrapunji (Rkm) , Karimganj , Matijuri and Cherrapunji 7 each	Cherrapunji 16, Cherrapunji (Rkm) 15, Mawsynram 12, Vedaranniyam and Mangan 10 each, Rangiya, Matijuri and Rameswaram 9 each, Karimganj, Pamban, Panbari, Tezu and Chungthang 8 each, Puthimari, Dillighat, Gangtok, Namsai, Miao, Nagapattnam and Sivasagar 7 each

TABLE 5 (*Contd.*)

Date	March	April	May
17.	Tuting 8	Cherrapunji 14, Mawsynram 12, Cherrapunji (Rkm) 11, B P Ghat 9, Kokrajhar AWS 8	Cherrapunji (Rkm) 31, Cherrapunji 29, Haflong 27, Mawsynram 23, Nannilam 14, Kokrajhar 13, Tiruvarur and Chembarabakkam 12 each, Sirkali, Panbari, Chembarambakkam ARG and Manash Nh Xing 11 each, Cuddalore, Mayiladuthurai, Kodavasal, Kumargram and Bahalpur 10 each, Karaikal, Samayapuram, Gossaigaon, Goalpara CWC, Tiring, Tezu, Majbhat, Chidambaram, K.M.Koil, Anna University, Aie Nh Xing, Anaikaranchatram (Kollid), Madukkur and Manchikeri 9 each, Barobhisha, Barpeta, Anna Uty ARG, Vedaranniyam, Needamangalam, Kolapakkam ARG, Tezpur, Beky Rly. Bridge, Mannargudi, Kokrajhar AWS, Valangaiman and Thiruthuraipoondi 8 each, Neyveli AWS, Pandavaiyar Head, Rameswaram, Sethiathope, Kelambakkam, Gandarvakottai, Satyabama Uty ARG, Sriperumbudur, Chennai AP, Puttukottai, Thogamalai, Konni, Tamulpur, Muthupet, Karimganj, Chennai city, Thiruvidaimaruthur, Thiruvananthapuram, Rangiya, Peravurani, Taramani ARG, Goalpara, Pullambadi, Aduthurai AWS and Koppa 7 each
18.	Manali 7	Goalpara 7	Matijuri 31, Karimganj 27, Mawsynram 26, Cherrapunji 25, Dholai and Kelambakkam 23 each, Gharmura and Chottabekra 22each, Silchar 21, Kollam Rly and Cherrapunji (Rkm) 16 each, Shar, Ponneri, Amraghat, Annapurnaghat and Tada 15 each, Mahabalipuram, Satyabama Uty ARG and Sullurpeta 14 each, B P Ghat and Kailashahar 13 each, Chembarabakkam, Williamnagar and Chennai AP 12 each, Cholavaram, Kancheepuram, Lakhipur and Chembarambakkam ARG 11 each, Satyavedu, Anna Uty ARG, Tiruvallur and Cherthala 10 each, Tirupathi (AGR), Gossaigaon, Chennai city, Hasimara, Cheyyur, Hvf Avadi ARG, Punalur, Tambaram, Poondi, Red Hills, Aryankavu, Thamaraipakkam, Rangiya, Puzhal ARG and Alappuzha 9each, Haflong, Anna University, Poonamallee, Roing, Kvk Kattukuppam ARG, Kokrajhar AWS, Sriperumbudur and Thoubal AWS 8 each, Thiruvananthapuram AP, Tezu, Imphal, Passighat, Neyyattinkara, Melabazar / Matunga, Burdwan, Colachel, Beki Mathungari, Tiruvallur ARG, Kurudamannil, Peermade To, Beky Rly. Bridge, Lengpui, Mundgod, Nedumangad and Jia Bharali N T Xing 7 each
19.	Batote 10, Banihal and Baramulla AWS 7 each	Cherrapunji 19, Cherrapunji (Rkm) 15, Mawsynram 11, Rangiya 9, Barpathar 8, Tawang AWS, Udala, Margherita and Hasimara 7 each	Amalapuram 22, Kakinada 17, Anakapalle 14, Bapatla and Ambajipeta (Arg) 13 each, Avanigadda, Atmakur, Chodavaram and Matijuri 12 each, Visakhapatnam and Narsapur 11 each, Purnea, Katihar, Williamnagar and Gudivada 10 each, Vizianagaram, Palakoderu, Beki Mathungari, Visakhapatnam AP, Thamaraipakkam, Peddapuram, Kaveli, Soundatti (S.F), Belonia and Denkada 9 each, Poonamallee, Machilipatnam, Thondebhavi, Gantyada, Pallipattu, Pusapatirega, Colachel, Cholavaram and Tenali 8 each, Repalle, Vuyyuru AP, Ongole, Bheemavaram, Red Hills, Vepada, Garividi, Karamchedu, Kailashahar, Cheepurupalle, Palasamudram, Srungavarapukota, Tanuku, Peermade To and Dholai 7 each

TABLE 5 (*Contd.*)

Date	March	April	May
20.	Nil	Cherrapunji and Itanagar 9 each, Cherrapunji (Rkm) and Matijuri 8 each, Jorhat and Bokajan 7 each	Eraniel 24, Kuzhithurai and Colachel 19 each, Ichchapuram and Kalingapatnam 15 each, Thiruvananthapuram AP and Ranasthalam 14each, Thiruvananthapuram and Neyyattinkara 13 each, Thuckalay, Kujanga ARG and Krishnagiri 12 each, Amalapuram, Palasa, Nedumangad, Rayalpadu and Avanigadda 11 each, Tekkali, Thali, Kallakkurichchi and Mandasa 10 each, Burdwan, Birpur, Mangan, Bhograi, Muthupet, Kakatpur, Sompeta, Grand Anaicut, Barur, Attur and Harur 9 each, Marsaghai ARG, Hosur, Repalle, Gopalpur, Visakhapatnam, Nagercoil, Nannilam and Thuvakudi Imti 8 each, Pusapatirega, Devanahalli, Thanjavur, Thanjavur PTO, Thiruthuraipoondi, Arogyavaram, Machilipatnam, Aska, Enamakkal, Ambajipeta (Arg), Ariyalur, Perumpavur, Mandapalle, Amarpur and Tenali 7 each
21.	Nil	Tadong 13, Gangtok and Kokrajhar 11 each, Majbhat 10, Dillighat 9, Bahalpur, Naharlagun, Sivasagar, Tawang AWS and Jia Bharali N T Xing 8each, Aie Nh Xing, Passighat, Manash Nh Xing, Numaligarh, Goalpara and N. Lakhimpur 7 each	Balikuda ARG 21, Tirtol ARG 19, Astaranga ARG 18, Kujanga ARG 17, Paradip 16, Garadapur ARG and Marsaghai ARG 15 each, Bhograi and Nh5 Gobindpur 11 each, Digha, Derabis ARG, Udaipur, Alipingal and Sonamura 10 each, Contai, Rajghat, Kendrapara and Puri 9 each, Jaipur, Nilgiri, Binjharpur ARG, Chandbali, Gokulpur AWS, Sabroom, Amarpur and Ramnagar 8 each, Mandasa, Kantapada ARG, Cherrapunji (Rkm), Tuting, Mawsynram, Canning Town, Jagatsinghpur AWS, Bari ARG, Pattamundai, Rajkanika, Remuna ARG, Bonth and Sompeta 7 each
22.	Nil	Jia Bharali N T Xing 12, Matijuri 10, Majbhat, Cherrapunji and Jorhat 9 each, Tawang AWS , Namsai, Beki Mathungari , Beky Rly. Bridge, Tezu, Cherrapunji (Rkm) , Tinsukia and Mawsynram 7 each	Haflong 20, Agartala AP 15, Arundhutinagar 14, Matijuri 12, Bishalgarh and Belonia 10 each, Aizawal, Imphal and Chottabekra 9 each, Khowai, Rosera and Chandel AWS 8 each, Thoubal AWS, Kamalpur, Lengpui, Kohima, Khowai AWS and Maya Bandar 7 each
23.	Alappuzha 8, Kottayam 7	Gharmura 20, Cherrapunji (Rkm) 12, Lakhipur 10, Cherrapunji and Matijuri 9 each, Mangan 7	Nil
24.	Nil	Cherrapunji 42, Cherrapunji (Rkm) 36, Mawsynram 21, Haflong and Roing 19 each, Nalbari / Pagladia 12, Chottabekra and Thoubal AWS 10 each, Miao and Imphal 8 each	Nil
25.	Nil	Cherrapunji 14, Cherrapunji (Rkm) 11, B P Ghat 10, Matijuri 9, Chottabekra 8, Haflong and Silchar 7 each	Bihubar 13, Kayamkulam 11, Tuting 10, Kayamkulam Agri 7
26.	Nil	Nil	Kanjirappally 14, Namthang 9, Majitar 7
27.	Nil	Nil	Bhilai 10, Port Blair and Tadong 8 each, Jalpaiguri 7
28.	Alipurduar Cwc 19, Barobhisha 10, Chepan and Gossaigaon 9 each, Chengmari / Diana, Mawsynram, Champasari and Nagarkata 7 each	Matijuri 7	Bhilai 10, Valparai 9, Williamnagar 8, Cherrapunji and Aravakurichi 7 each
29.	Khowai 14, Khowai AWS 11, Chhamonu 10, Kamalpur and Belonia 9 each	Malbazar ARG 13, Neora 11, Murti 8, Deomali and Tezu 7 each	Kailashahar 14, Thali and Tribeni / Balmiki 10 each, Anantpur, Guntakal, Mani and Thondebhavi 9 each, Udaipur, Madakasira and Alampur 8 each, C Belagal, Simhadripuram, Ramagiri, Gorantla, Champawat, Bantwal, Gokulpur AWS, Kamalpur, Allagadda, Pattikanda, Chintamani PTO, Dharmavaram and Hata 7 each

TABLE 5 (*Contd.*)

Date	March	April	May
30.	Nil	Nil	Goibargaon 16, Drf 15, Kumargram 13, Taibpur 12, Jia Bharali N T Xing and Galgalia 10 each, Thakurganj, Dhekiajuli, Barobhisha and Majbhat 8 each, Jorhat, Panbari, Beki Mathungari and Sevoke 7 each
31.	Nil	-	Williamnagar 27, Quilandi 12, Port Blair 11, Panbari and Bahalpur 10 each, Nalbari / Pagladia 9, Agumbe, Piravam and Vaikom 8 each, Kokrajhar, Vadakara and Ernakulam South 7 each

thereafter increased further over this region and extended to parts of south India except for northeastern subdivisions where the rainfall activity kept the day temperatures *below normal*. The severity of heating was such that many stations of central and Peninsular India recorded highest day temperatures for the month.

The month's highest maximum temperature over the plains was 48.5 °C recorded at Titlagarh (Odisha) on 24 April, 2016.

3.2.3. *Disastrous weather events*

According to media and other disaster reports, first wave of flood in Assam from last week of April onwards claimed 12 lives and affected nearly 1 lakh people across 6 districts, *viz*., Jorhat, Sivasagar, Tinsukia, Dibrugarh, Cachar and Charaideo. Crops around 5000 hectares were inundated by flood water. Rivers Burhidehing and Desang Naglamuraga in Sivasagar were over flowing above danger mark. Thunderstorms/lightning related incidents claimed 6 lives in Odisha, 3 in Karnataka, 2 in Telangana and 1 in Andhra Pradesh. Incessant rain for couple of days during the last week triggered landslide in Tawang district which led to 30 houses damage permanently and claimed 19 lives. Hailstorm in Mizoram and Meghalaya damaged crops and around 200 houses.

Apart from this, the *severe Heat wave* /*Heat wave* incidents since March claimed 137 lives in Andhra Pradesh, 122 in Telangana, 112 in Odisha, 14 lives in Maharashtra, 4 in Kerala, 3 in West Bengal and 2 in Tamil Nadu.

3.3. *May*

3.3.1. *Weather and associated synoptic features*

(a) *Advance of southwest monsoon*

Genesis phase of the Cyclonic Storm (CS) 'Roanu' created the synoptic situation conducive for the advent of southwest monsoon current into parts of south Bay of Bengal, Nicobar Islands and adjoining Andaman Sea on 18th May, 2 days ahead of its normal date. It further advanced into some more parts of southeast Bay of Bengal, remaining parts of Andaman Sea and Andaman Islands on 20th May.

(b) *Other synoptic features and rainfall*

The details of weather systems and the track of the Cyclonic Storm during the month are given in Table 4 and Fig 2. The principal amounts of rainfall are given in Table 5.

During the first week, perturbations in the westerly and easterly wind regime caused *scattered* to *widespread* precipitation over parts of northeast India and isolated rainfall over peninsular India. As the week progressed, the zone of convection shifted eastwards, causing moisture incursion from the Bay of Bengal which resulted in thundershower activity over Peninsular & central India. Further, the strengthening of cross equatorial flow over southern parts of Bay of Bengal and Andaman Sea and the convective phase of Madden Julian Oscillation (MJO) during the mid of May, aided the formation of a couple of low pressure systems over north & south Indian Ocean (the northern hemispheric system intensified into CS 'Roanu') and advance of SWM into parts of south Bay of Bengal, Nicobar Islands and adjoining Andaman Sea. The northward movement of CS 'Roanu' along the east coast of India before making landfall over the south coast of Bangla Desh caused heavy rainfall along the east coast and parts of northeast India. In the last week, a combination of mid-latitude westerly troughs in the mid & upper tropospheric levels, moisture laden winds in the lower troposphere and presence of a shallow trough along the Indo-Gangetic plains generated conducive conditions for convective rainfall over major parts of India.

The subdued cross equatorial flow led to more organised Southern Hemispheric Equatorial Trough

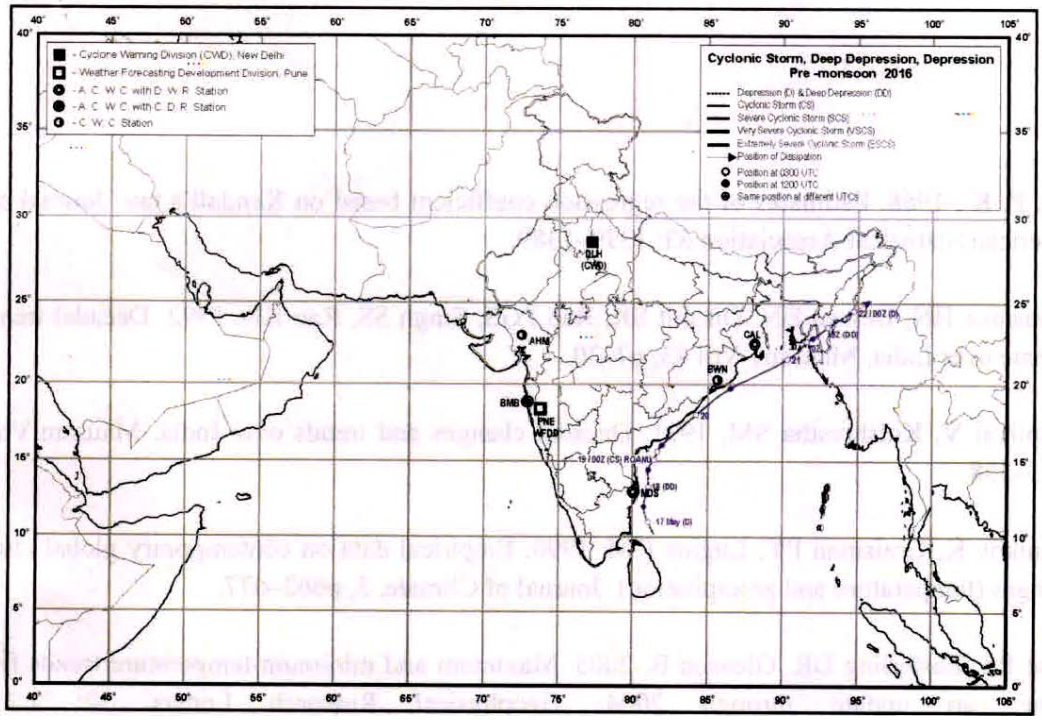

Fig. 2. Track of Cyclonic Storm 'Roanu' during Pre-Monsoon Season 2016

(SHET) along Lat. 10° S since last week of May stalled the further advance of monsoon over the Bay of Bengal and onset of monsoon over Kerala. However, a well distributed convective rainfall occurred over Kerala during the last two of days of May month.

3.3.2. *Temperature distribution*

In the initial half of the month the lack of moisture incursion from the Seas resulted in dry conditions and above normal day maximum temperatures, thereby spreading of heat wave conditions both in spatial extent and severity over most parts of the country. Some parts of western Himalayan region, east, central and south peninsular India received rainfall thereby keeping the day & night temperatures below normal.

Towards the later half, with the decrease of rainfall due to the high-index mid latitude circulation, the day and night temperatures were above normal over parts of northwest, west, central India and interior Peninsular India. Thereafter, with the change in wind pattern and formation of intense pressure systems over the Sea area abated the heat wave conditions from most parts of the country except over parts of Peninsular India towards the end of month.

Severe heat wave conditions prevailed on 5 days over west Rajasthan and on 1 day each over east Rajasthan, west Madhya Pradesh and Gujarat State. *Heat wave* conditions prevailed on 9 to 11 days over west Rajasthan and Madhya Pradesh; on 4 days over east Rajasthan; and on 1 to 3 days over Gangetic West Bengal, Odisha, Uttar Pradesh, Haryana, Chandigarh & Delhi, Punjab and Saurashtra & Kutch.

A few places in west Rajasthan has set a new record of Extreme highest maximum temperatures this month**.** They are (i) Phalodi [50.5 °C on 18th May; past record 49.6 °C on 23rd May, 2010]. (ii) Jaisalmer [48.8 °C on 18th May; past record 48.0 °C on 26rd May, 2010].

Thus, the month's as well as the season's highest maximum temperature of 50.5 °C was recorded at Phalodi (west Rajasthan) on 18 May, 2016.

3.3.3. *Disastrous weather events and damage*

According to media and other disaster reports, intense convective activity termed as cloudburst by media occurred in Himachal Pradesh over Chewadi in Shimla district in the first week triggered flash floods and swept away 5 people. It also occurred in Uttarakhand in the last week at Suri and Chinyalisaur villages in Tehri and

Uttarkashi districts respectively. It led to Landslide in Ghansali town of Tehri district and claimed 10 lives and several cattle and also damaged houses. Thunderstorm/lightning/ rain related incidents claimed 20 lives in Bihar, 13 in Maharashtra, 12 in Uttar Pradesh, 8 in West Bengal, 7 in Madhya Pradesh, 5 in Telangana, 4 each in Karnataka and Andhra Pradesh and 1 each in Haryana and Tamil Nadu. Heavy rain triggered Landslide claimed 11 lives in Assam and 3 each in Jammu & Kashmir and Mizoram. Severe Dust Storm in Uttar Pradesh damaged several houses, uprooted trees & poles and claimed 7 lives. During the first week Hailstorm incidents occurred over several places Madhya Pradesh, Vidarbha and in Bihar where it claimed 10 lives. Heatwave/Sunstroke during pre-monsoon season claimed 317 lives in Telangana, 137 in Andhra Pradesh, 113 in Odisha, 87 in Gujarat State, 33 in Maharashtra and 8 in Madhya Pradesh.

Appendix

Definitions of the terms given in '*Italics*':

Temperatures

Heat Wave : Heat wave is considered if maximum temperature of a station reaches at least 40 °C or more for Plains and at least 30 °C or more for Hilly regions.

(a) *Based on Departure from Normal*

Heat Wave - Departure from normal is 4.5 °C to 6.4 °C

Severe Heat Wave - Departure from normal is >6.4 °C

(b) *Based on Actual Maximum Temperature*

Heat Wave - When actual maximum temperature ≥ 45 °C

Severe Heat Wave - When actual maximum temperature ≥47 °C

(c) *Warm Night*

It should be considered only when maximum temperature remains 40 °C or more. It may be defined based on departures or actual minimum temperatures as follows:

Warm night - minimum temperature departure is 4.5 °C to 6.4 °C

Very Warm night - minimum temperature departure is >6.4 °C

(d) *Criteria for describing Heat Wave for coastal stations*

Heat Wave : When maximum temperature departure is 4.5 °C or more from normal, Heat Wave may be described provided actual maximum temperature is 37 °C or more.

Rainfall

Very light - 0.1 to 2.4 mm

Light - 2.5 to 15.5 mm

Moderate - 15.6 to 64.4 mm

Heavy - 64.5 to 115.5 mm

Very Heavy - 115.6 to 204.4 mm

Extremely Heavy - ≥204.5 mm

Large Excess - Percentage departure from normal rainfall is + 60% or more.

Excess - Percentage departure from normal rainfall is + 20% to +59%.

Normal - Percentage departure from normal rainfall is +19% to –19%.

Deficient - Percentage departure from normal rainfall is –20% to –59%.

Large Deficient - Percentage departure from normal rainfall is –60% or less.

No rain - –100%