MAUSAM, **67**, 3 (July 2016), 723-744

Weather in India

MONSOON SEASON (JUNE - SEPTEMBER 2015)†

1. Introduction

The seasonal rainfall (during June to September 2015) over the country as a whole was 86% of its Long Period Average (LPA) and thus categorized as a below normal monsoon characterized by pronounced spatial and temporal variability. It is the fourth case of two consecutive (2014 & 2015) all India deficient monsoon years during last 15 years. It was also one of the warmest monsoon seasons since 1901. The pace of advance of southwest monsoon was steady this year. The eastward propagating convective phase of the Madden - Julian Oscillation (MJO) and its strengthening since first week of the June aided in the setting in of southwest monsoon over Kerala. With the formation of two Depressions in succession one each over the Bay of Bengal and Arabian Sea during the third week of June led to rapid advance and it covered the entire country by 26th June, thereby becoming the third fastest since 1950. Except for June month, the rainfall remained below normal for the subsequent months. In all 11 low pressure areas formed during the monsoon season this year, out of which two intensified into Cyclonic Storm (CS) 'Ashobaa' and 'Komen', another 8 into Depressions, against the normal frequency of 4-6 monsoon Depressions.

2. Various aspects of southwest Monsoon - 2015

2.1. *Onset and advance*

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

During the third week of May, cross equatorial winds in the lower troposphere strengthened and cyclonic shear vorticity increased over southern parts of the Bay of Bengal and Andaman & Nicobar Islands. This enhanced the convective activity over the region. The resultant increase in rainfall indicated the arrival of southwest monsoon over this region on 16th May. It advanced over entire south Andaman Sea and Nicobar Islands and some parts of southeast Bay of Bengal, north Andaman Sea and Andaman Islands on 16th May and remaining parts of

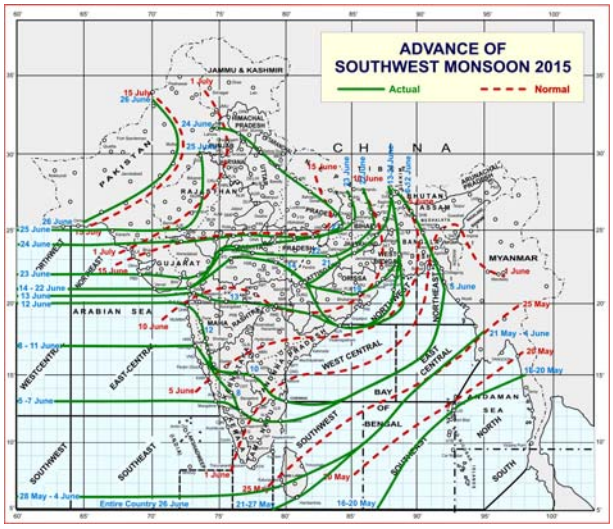


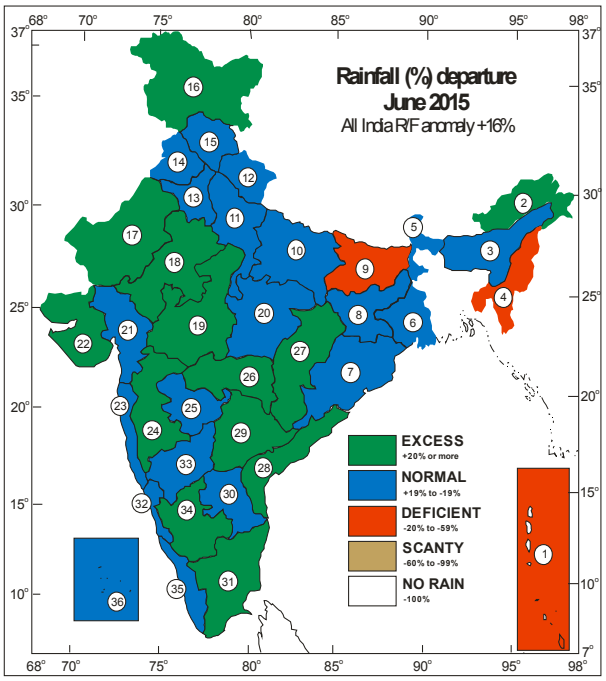
Fig. 1. Isochrones of advance of southwest monsoon 2015

Andaman Sea, some parts of southeast Bay of Bengal and some parts of southwest and east central Bay of Bengal on 21st May. Thus the southwest monsoon current reached over south Andaman Sea, 4 days before the normal date of 20th May.

The strengthening of (MJO) as it propagated eastward, led to the setting of Southwest Monsoon over Kerala on 5th June, which also aided the intensification of the onset vortex over the eastcentral Arabian Sea into Cyclonic Storm 'Ashobaa' (7 - 12 June). Its initial north-northwest movement along with a shear zone at 3.1 kms a.s.l. resulted in increase in the rainfall activity over south peninsula causing further advance of southwest monsoon along the west coast upto Lat. 17° N. Its subsequent movement away from the India coast along the southern periphery of the sub-tropical ridge caused a brief lull in the further advance of southwest monsoon. However, the moist southerly winds from the Bay of Bengal caused persistent very heavy/extremely heavy rainfall over the region and the southwest monsoon covered the northeastern states by 10th June and peninsular India by 17th June.

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

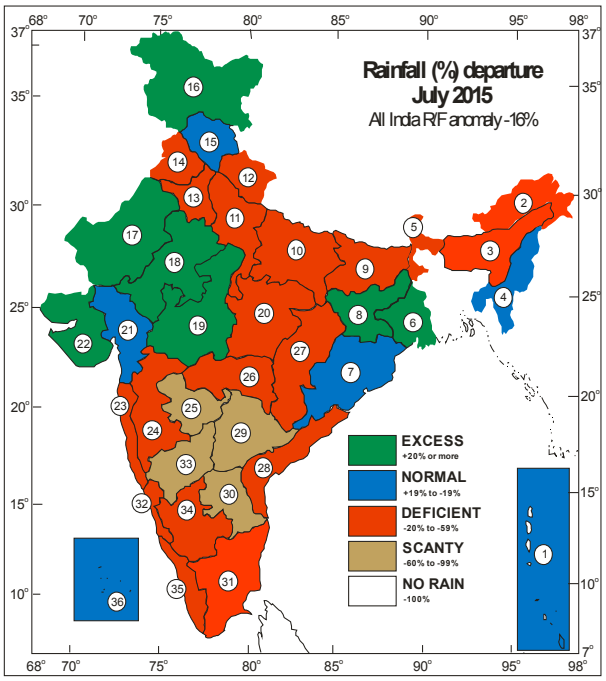
†*Compiled by* : P. C. S. Rao, Sunitha Devi S. and A. P. Kundale, Meteorological Office, Pune – 411 005, India



EXCESS -13 NORMAL -20 DEFICIENT - 03 SCANTY -00 NO RAIN -00

Fig. 2. Rainfall for the month of June 2015 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	-21	**7**	11	**13**	-5	**19**	46	**25**	-17	**31**	36
2	27	**8**	-7	**14**	9	**20**	4	**26**	52	**32**	-18
3	9	**9**	-28	**15**	-7	**21**	5	**27**	41	**33**	-14
4	-31	**10**	-12	**16**	89	**22**	59	**28**	97	**34**	55
5	5	**11**	4	**17**	78	**23**	14	**29**	59	**35**	-13
6	-4	**12**	11	**18**	54	**24**	22	**30**	-2	**36**	-10



EXCESS -07 NORMAL -06 DEFICIENT - 19 SCANTY -04 NO RAIN -00

Fig. 3. Rainfall for the month of July 2015 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	-19	**7**	-13	**13**	-21	**19**	47	**25**	-85	**31**	-36
2	-39	**8**	28	**14**	-30	**20**	-25	**26**	-56	**32**	-33
3	-46	**9**	-33	**15**	-15	**21**	13	**27**	-34	**33**	-71
4	0	**10**	-40	**16**	21	**22**	35	**28**	-41	**34**	-48
5	-36	**11**	-25	**17**	128	**23**	-49	**29**	-67	**35**	-44
6	86	**12**	-21	**18**	32	**24**	-54	**30**	-62	**36**	-11

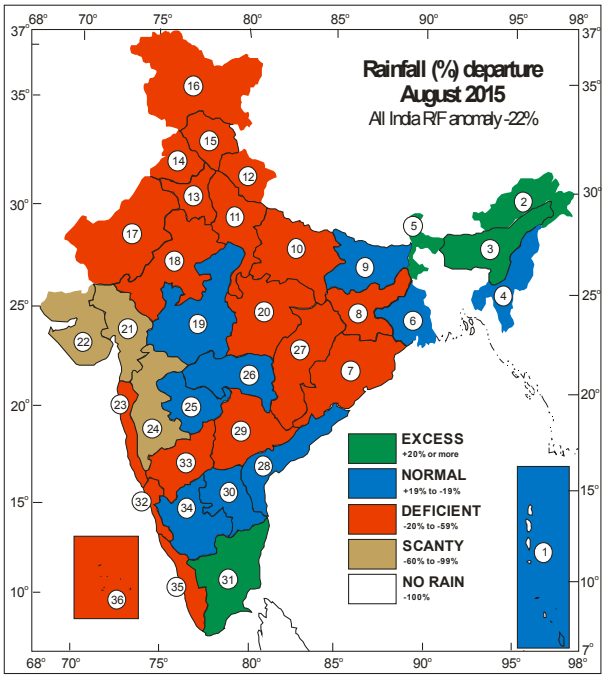
There was nearly simultaneous formation of Depressions, one each over Bay of Bengal and Arabian Sea during the second half of June, of which one formed over Arabian Sea and intensified further into Deep Depression, thereby causing *active/vigorous* monsoon activity over the region. Its northeastward movement towards Gujarat cause widespread to fairly widespread rainfall over Konkan & Goa and Madhya Maharashtra and scattered to isolated rainfall over Gujarat region and Saurashtra & Kutch with isolated extremely heavy rainfall for a couple of days. The presence of perturbations in the form of trough and cyclonic vortex in mid latitude westerlies caused active monsoon conditions over extreme north and western Himalayan region. Consequently, the southwest monsoon advanced further and covered major parts of central India, northern plains and western Himalayan region by 24th June and the entire country by 26th June.

2.2. *Monthly rainfall distribution*

Figs. 2-5 show the month wise spatial distribution of rainfall.

In June, except for 3 sub-divisions (Bihar, Nagaland, Manipur, Mizoram & Tripura, and Andaman & Nicobar Islands), which received *deficient** rainfall, all the other sub-divisions (33 out of 36) received *normal* (20 sub-divisions) or *excess* (13 sub-divisions) rainfall.

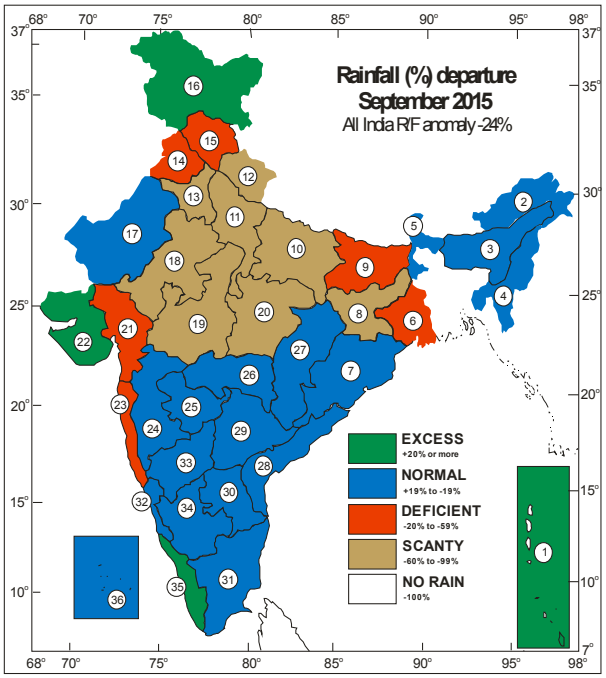
In July, majority of the sub-divisions over Peninsular India and that over north India received *deficient* or *scanty* rainfall. In all, 19 sub-divisions received *deficient* rainfall, 4 sub-divisions received *scanty* rainfall and 6 sub-divisions received *normal* rainfall. The remaining 7 sub-divisions (3 from northwest India and 2 each from central and east India) received *excess* rainfall. The *scanty* rainfall



EXCESS -03 NORMAL -10 DEFICIENT - 20 SCANTY -03 NO RAIN -00

Fig. 4. Rainfall for the month of August 2015 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	19	**7**	-27	**13**	-49	**19**	-10	**25**	-40	**31**	-7
2	65	**8**	-24	**14**	-48	**20**	-26	**26**	-6	**32**	-31
3	42	**9**	-2	**15**	-24	**21**	-85	**27**	-24	**33**	-35
4	-12	**10**	-40	**16**	-31	**22**	-89	**28**	11	**34**	-15
5	27	**11**	-50	**17**	-32	**23**	-49	**29**	-31	**35**	-40
6	-17	**12**	-28	**18**	-37	**24**	-64	**30**	8	**36**	-33



EXCESS -04 NORMAL -18 DEFICIENT - 06 SCANTY -08 NO RAIN -00

Fig. 5. Rainfall for the month of September 2015 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	21	**7**	0	**13**	-61	**19**	-67	**25**	-6	**31**	-15
2	1	**8**	-65	**14**	-24	**20**	-64	**26**	-1	**32**	-10
3	-15	**9**	-55	**15**	-47	**21**	-36	**27**	1	**33**	3
4	-12	**10**	-89	**16**	41	**22**	32	**28**	5	**34**	17
5	-13	**11**	-82	**17**	-14	**23**	-26	**29**	-5	**35**	20
6	-44	**12**	-75	**18**	-80	**24**	-4	**30**	9	**36**	-2

sub-divisions were Marathwada, North Interior Karnataka, Telangana and Rayalaseema.

In August, majority of the sub-divisions from northwest India, central India and neighbouring Peninsula received *deficient/scanty* rainfall. On the other hand, majority of the sub-divisions from northeast India received *normal/ excess* rainfall. During August, 3 sub-divisions received *excess* rainfall, 10 sub-divisions received normal rainfall, 20 sub-divisions received deficient and 3 sub-divisions received *scanty* rainfall. The excess sub-divisions were Sub Himalayan West Bengal & Sikkim, Assam & Meghalaya and Arunachal Pradesh and the *scanty* sub-divisions were Saurashtra and Kutch, Gujarat and Madhya Maharashtra.

In September, majority of the sub-divisions from northwest India, west central India and east India received *deficient/scanty* rainfall. On the other hand, majority of the sub-divisions from south Peninsula and neighbouring central India, and northeast India received *normal/ excess* rainfall. During September, 4 sub-divisions received *excess* rainfall, 18 sub-divisions received *normal* rainfall, 6 sub-divisions received *deficient* and 8 sub-divisions received *scanty* rainfall. The *excess* sub-divisions were Jammu & Kashmir, Saurashtra & Kutch, Kerala and Andaman & Nicobar Islands.

From the monthly distribution, it can be seen that all the sub-divisions have received *deficient/scanty* monthly rainfall during at least one of the four months. However, none of the sub-divisions were *deficient/ scanty* during all the four months of the season. Except in June, during each of the other 3 months, at least 14 out of the 36 sub-divisions had received *deficient/scanty* rainfalls. During the peak rainfall months of July and August, 23

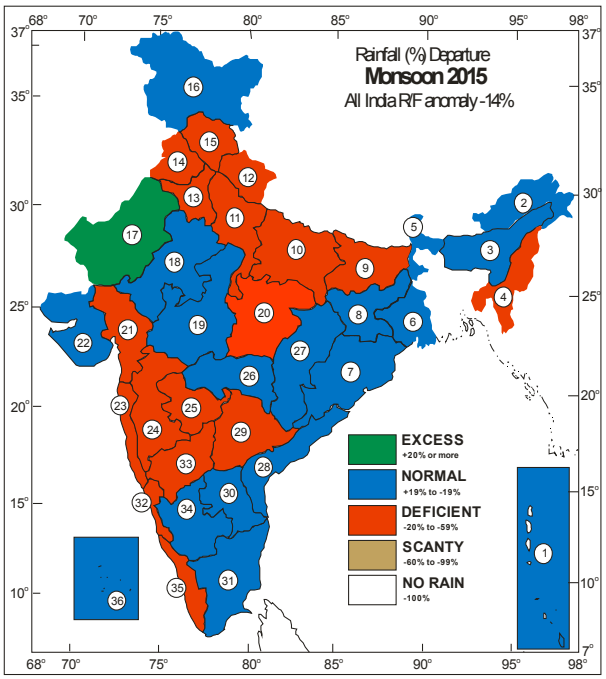


Fig. 6. Rainfall for the month of monsoon 2015 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	0	**7**	-10	**13**	-37	**19**	4	**25**	-40	**31**	-10
2	6	**8**	-14	**14**	-32	**20**	-29	**26**	-11	**32**	-26
3	-3	**9**	-28	**15**	-23	**21**	-27	**27**	-12	**33**	-29
4	-30	**10**	-47	**16**	15	**22**	6	**28**	10	**34**	-8
5	-6	**11**	-43	**17**	46	**23**	-31	**29**	-20	**35**	-26
6	8	**12**	-28	**18**	-10	**24**	-33	**30**	-10	**36**	-14

sub-divisions each had received *deficient/scanty* rainfall. Saurashtra & Kutch received *scanty* rainfall during August but received *excess* rainfall during all the other 3 months.

The rainfall figures (mm) for each month and season as a whole (June - September 2015) Real - time has been shown in the Table 5 and some representative amounts of rainfall in cm for June, July, August and September 2015 (25 cm and above) has been shown in the Table 6.

2.3. *Seasonal rainfall distribution*

Meteorological sub-divisionwise seasonal rainfall distribution in terms of percentage departures from *normal* is given in Fig. 6. Out of the total 36 meteorological sub-divisions, the season rainfall was *normal* in 18 sub-divisions and *deficient* in 17 sub-divisions. Only one sub-division *viz*., west Rajasthan received *excess* rainfall and no sub-divisions reported *scanty* rainfall by the end of the season. Out of the 17 *deficient* sub-divisions, 6 sub-divisions were from northwest India, 5 from central India, 2 from northeast India and 4 from south Peninsula.

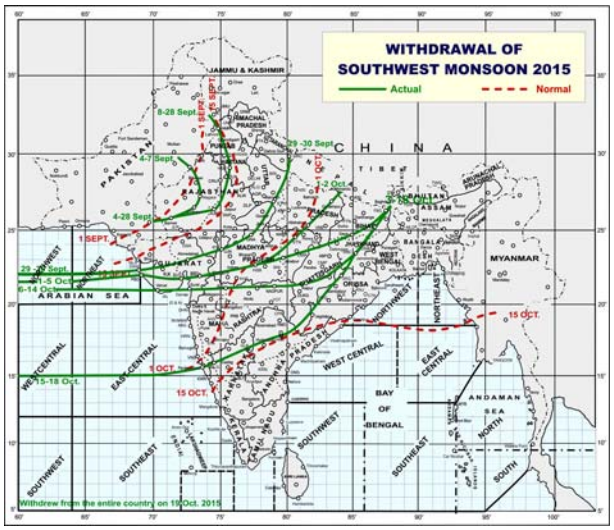


Fig. 7. Isochrones of withdrawal of southwest monsoon 2015

2.4. *Withdrawal of southwest monsoon*

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

The rainfall activity over the northwestern parts of Rajasthan remained subdued since last week of August. A change over in the lower tropospheric circulation pattern over the region from cyclonic to anti cyclonic indicated the beginning of the withdrawal of southwest monsoon from the region. Hence the withdrawal of southwest monsoon commenced from 4th September and the withdrawal line passed through Anupgarh, Nagaur, Jodhpur and Barmer. It withdrew from some more parts of Rajasthan and some parts of Punjab and Haryana and the withdrawal line passed through Amritsar, Hissar, Ajmer and Barmer on 9th September. Thereafter, the formation of a Depression and its west-northwestwards movement across central India led to moisture incursion from the Bay of Bengal and thus halted the further withdrawal of monsoon. The southwest monsoon remained *active* to *vigorous* over parts of central India, south peninsula and northeastern states. Towards the end of the month, the eastward extension of the ridge caused intrusion of dry air in the lower & mid-tropospheric levels leading to further withdrawal from remaining parts of Rajasthan, Punjab, Haryana, Chandigarh & Delhi, entire Jammu & Kashmir, Himachal Pradesh, Uttarakhand, most parts of west Uttar Pradesh and some parts of west Madhya Pradesh, Gujarat

TABLE 1

Details of the weather systems during June 2015

S. No.	System	Duration	Place of initial location	Direction of movement	Place of Final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**) *Cyclonic storm*						
1.	Cyclonic Storm (Ashobaa)	7 - 12	Eastcentral Arabian Sea and neighbourhood, near Lat. 14.5° N / Long. 68.5° E	North northwest and then west northwest and southwest	Near Lat.20.8° N / Long. 59.5° E 60 kms east-northeast of Masirah	Became well marked low pressure area over the same region on 12 evening. Details are given in the article on Storms & Depressions over the north Indian Ocean-2015
(**B**) *Deep depression/depression*						
1.	Depression	20-21 (1200 UTC)	Northwest and adjoining west central Bay of Bengal near Lat. 18.0° N / Long. 86.0° E	Northwest	Interior Odisha near Lat. 20.5° N / Long. 84.5° E	Details are given in the article on Storms & Depressions over the north Indian Ocean - 2015
2.	Deep Depression	22-24 (1200 UTC)	Northeast and adjoining east central Arabian Sea near Lat. 20.0° N / Long. 67.0° E	Northeast	Gujarat region and adjoining areas of west Madhya Pradesh and south Rajasthan near Lat. 23.0° N / Long. 73.8° E	Do
(**C**) *Western disturbances /eastward moving systems*						
(*i*) *Upper air cyclonic circulation*						
1.	Upto Mid tropospheric levels	28 Jun - 2 Jul	Western parts of Afghanistan and neighbourhood	Northeast	Northern parts of Jammu & Kashmir and neighbourhood	Moved away on 3 July
(*ii*) *As a trough*						
1.	Upto Mid tropospheric levels	8 - 11	Along Long. 65° 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. 30° N (axis at 5.8 kms a.s.l.)	The feeble WD moved away northeastwards on 12
2.	Do	22 - 26	Along Long. 65° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	Do	Along Long.77° E to the north of Lat. 35° N (axis at 5.8 kms a.s.l.)	Moved away northeastwards on 27
3.	Do	30 Jun - 2 Jul	Along Long. 70° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	Do	Do	Moved away northeastwards on 3 July
(*iii*) *As an Induced cyclonic circulation*						
1.	Upto lower tropospheric levels	1 - 5	Central Pakistan and adjoining west Rajasthan	East	Punjab and adjoining Haryana	Became less marked on 6
2.	Upto Mid tropospheric levels	10	Central Pakistan and adjoining areas of west Rajasthan and Punjab	Stationary	*In situ*	Became less marked on 11
(**D**) *Other upper air cyclonic circulations*						
1.	Upto lower tropospheric levels	1	Central parts of north Madhya Pradesh and adjoining south Uttar Pradesh	Stationary	*In situ*	Became less marked on 2
2.	Upto lower levels	5	North Odisha and neighbourhood	Do	Do	Merged with the trough from eastern parts of Bihar to coastal Andhra Pradesh on 6
3.	At Mid tropospheric levels	7 - 12	North coastal Andhra Pradesh and adjoining west central Bay of Bengal	North	Northwest Bay of Bengal off south Odisha-north Andhra Pradesh coasts	Became less marked on 13
4.	Upto Lower tropospheric levels	11 - 13	Western parts of Assam and neighbourhood	East	Assam & Meghalaya and neighbourhood	Became less marked on 14

TABLE 1 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
5.	Upto Lower tropospheric levels	12 - 17	West Uttar Pradesh and adjoining areas of Haryana and Uttarakhand	East	West Uttar Pradesh and neighbourhood	Less marked on 17
6.	Upto mid tropospheric levels	15 - 17	Central Pakistan and adjoining west Rajasthan	Do	Northwest Rajasthan and neighbourhood	Merged with the Heat Low on 18
7.	Upto Lower tropospheric levels	15 - 16	Jharkhand and adjoining Bihar	Stationary	*In situ*	Less marked on 17
8.	Do	21 - 22	Northwest Madhya Pradesh and adjoining south Uttar Pradesh	Do	Do	Merged with the east-west trough on 13
9.	Between 2.1 & 5.8 kms a.s.l.	25	Northeast Bay of Bengal and adjoining south Bangladesh	Do	Do	It merged with the associated cyclonic circulation extending upto mid tropospheric levels over southeastern parts of Bangla Desh and neighbourhood on 26
10.	Between Lower & mid tropospheric levels	30 Jun - 2 Jul	North Bay of Bengal and neighbourhood	Northwest	Northwest Bay of Bengal and adjoining areas of Gangetic West Bengal	It merged with the trough extended from Sub-Himalayan West Bengal & Sikkim to northwest Bay of Bengal across Gangetic West Bengal on 3
(**E**)	*East-West trough*					
1.	At mean sea level	15 - 25	Northwest Rajasthan to northwest Bay of Bengal across Haryana, Uttar Pradesh, Bihar, Jharkhand and Gangetic West Bengal	Oscillatory	West Rajasthan to Mizoram across the centre of low pressure area over northwest Madhya Pradesh and adjoining south Uttar Pradesh, Jharkhand, west Bengal and the centre of other low pressure area over Bangladesh	It established as a Monsoon trough on 26
(**F**)	*Other troughs / wind discontinuity*					
1.	Between mid & upper tropospheric levels	3 - 4	North Pakistan and adjoining Jammu & Kashmir to south Gujarat	Stationary	*In situ*	Became unimportant on 5.It extended from western disturbance as a cyclonic circulation over north Pakistan and adjoining Jammu & Kashmir on 4
2.	At lower levels	4 - 5	East Madhya Pradesh to interior Tamil Nadu across Vidarbha , Telangana and Rayalaseema	Oscillatory	East Madhya Pradesh to Rayalaseema across Vidarbha and Telangana	Became less marked on 6
3.	Upto lower tropospheric levels	6 - 9	Eastern parts of Bihar to coastal Andhra Pradesh across Jharkhand and Odisha	East	Sub-Himalayan West Bengal & Sikkim to northwest Bay of Bengal across Gangetic West Bengal	Became less marked on 10
4.	Do	10 - 11	Northern parts of Bihar to northwest Bay of Bengal across Jharkhand and Gangetic West Bengal	Stationary	*In situ*	Became less marked on 12
5.	At mid tropospheric levels	14 - 16	East Bihar to south Chhattisgarh across Jharkhand	Do	East Bihar to south Odisha across Jharkhand	Became less marked on 17
(**G**)	*East-West shear zone*					
1.	Mid tropospheric levels	12	Along Lat. 16° N	Stationary	*In situ*	Became less marked on 13

TABLE 2

Details of the weather systems during July 2015

S. No.	System	Duration	Place of initial location	Direction of movement	Place of Final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**) *Cyclonic storm*						
1.	Cyclonic storm 'Komen'	26 Jul - 2 Aug	Northeast Bay of Bengal and adjoining coastal areas of Bangladesh & West Bengal centred near Lat. 22.0° N / Long. 90.8° E	West-northwest-north-northwest west-southwest	East Madhya Pradesh and adjoining Chhattisgarh centred near Lat. 22.7° N/ Long. 80.5° E	Details are given in the article on Storms & Depressions over the north Indian Ocean - 2015
(**B**) *Deep depression/depression*						
1.	Land Depression	10 - 12 (0900 UTC)	Jharkhand and neighbourhood. (30 kms southwest of Ranchi) near Lat. 23.1° N / Long. 85.1° E	West northwest and northwest	Haryana and neighbourhood close to Delhi. Near Lat. 28.5° N / Long. 77.3° E	Do
2.	Land Deep Depression	27 (1200 UTC) – 30 (0000 UTC)	Southwest Rajasthan and neighbourhood (100 kms east southeast of Jaisalmer) centred near Lat. 26.2° N / Long. 71.8° E	North-northeast	West Rajasthan and neighbourhood centred near Lat. 28.7° N / Long. 73.4° E	Do
(**C**) *Well marked low/low pressure area*						
1.	Low pressure area	19 - 20	North Madhya Pradesh and adjoining south Uttar Pradesh	Stationary	*In situ*	It formed under the influence of a cyclonic circulation extending up to mid tropospheric levels over east Uttar Pradesh and adjoining north Madhya Pradesh. It merged with the monsoon trough on 21. However, the associated cyclonic circulation persisted upto 22 and merged with the trough at mean sea level on 23
(**D**) *Western disturbances/eastward moving systems*						
(*i*) *Upper air cyclonic circulation/ trough in westerlies*						
1.	Upto mid tropospheric levels	4 - 8	Western parts of Afghanistan and neighbourhood	East northeast	Jammu & Kashmir and neighbourhood	Moved away east northeastwards on 9
2.	Do	8 - 12	Afghanistan and neighbourhood	Do	Do	Moved away northeastwards on 13
3.	Do	12 - 17	Do	Northeast	Eastern parts of Jammu & Kashmir	Moved away northeastwards on 17 evening
4.	Do	16 - 24	Do	Do	Jammu & Kashmir and neighbourhood	Moved away northeastwards on 25
5.	Do	25 - 27	North Pakistan and neighbourhood	Do	Eastern parts of Jammu & Kashmir	Moved away northeastwards on 28
6.	Do	30 Jul - 3 Aug	Afghanistan and neighbourhood	Do	North Pakistan and neighbourhood	It lay as a trough in mid & upper tropospheric westerlies (axis at 5.8 kms a.s.l.) during (27 - 29 July) and on 4 August. It moved away northeastwards on 28. A trough aloft with its axis at 5.8 kms a.s.l. persisted during (30 July - 3 August)

TABLE 2 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**E**) *Other upper air cyclonic circulations*						
1.	Upto mid tropospheric levels	2	Central Pakistan and adjoining west Rajasthan	Stationary	*In situ*	Less marked on 3
2.	Upto lower tropospheric levels	7 - 8	Do	East	Northwest Rajasthan and neighbourhood	Merged with the Monsoon trough on 9
3.	Upto mid tropospheric levels	9 - 11	Southern parts of Uttar Pradesh and adjoining north Madhya Pradesh	West	Southwest Uttar Pradesh and adjoining areas of Haryana and northeast Rajasthan	Merged with the Depression over west Uttar Pradesh and adjoining areas of Haryana on 12
4.	Do	15 - 17	Western parts of Assam and neighbourhood	East	Nagaland-Manipur-Mizoram-Tripura & neighbourhood	Became unimportant on 18
5.	Do	14	West central Bay of Bengal off north Tamil Nadu-south Andhra Pradesh coasts	Stationary	*In situ*	Became less marked on 15
6.	Do	16 - 19	Northwest Bay of Bengal and adjoining coastal areas of west Bengal and Odisha	Northwest	Gangetic West Bengal and adjoining Jharkhand	Merged with the monsoon trough on 20
7.	Do	17 - 20	Central Pakistan and adjoining west Rajasthan	East	Punjab and neighbourhood	Less marked on 21
8.	Do	19 - 20	Bangladesh and adjoining areas of Assam & Meghalaya	South	Coastal areas of Bangladesh & adjoining north Bay of Bengal	Less marked on 21
9.	Upto lower tropospheric levels	21 - 23	West Rajasthan and neighbourhood	Stationary	*In situ*	It merged with the monsoon trough on 24
10.	Upto mid tropospheric levels	22 - 24	Gujarat region and neighbourhood	West	Saurashtra & Kutch and adjoining northeast Arabian Sea	Became unimportant on 25
11.	Do	22 - 24	Odisha and neighbourhood	North	North Chhattisgarh and adjoining areas of Jharkhand and Odisha	It merged with the monsoon trough on 25
(**F**) *North-south trough*						
1.	Between lower & mid tropospheric levels	3 - 5	Sub-Himalayan West Bengal & Sikkim to northwest Bay of Bengal across Gangetic West Bengal	Oscillatory	Eastern parts of Bihar to northwest Bay of Bengal across Jharkhand and Gangetic West Bengal	Became less marked on 6
2.	Upto mid tropospheric levels	13 - 15	Eastern parts of Bihar to northwest Bay of Bengal across Jharkhand and Gangetic West Bengal	East	Sub-Himalayan West Bengal & Sikkim to north Bay of Bengal	Became less marked on 16. It initially lay as a cyclonic circulation extending between lower & mid tropospheric levels over Gangetic West Bengal & neighbourhood on 12

TABLE 3

Details of the weather systems during August 2015

S. No.	System	Duration	Place of initial location	Direction of movement	Place of Final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**)	*Depression*					
1.	Depression	4 Aug (0300 UTC - 1200 UTC)	East Madhya Pradesh and adjoining Chhattisgarh centred near Lat. 22.7° N/ Long. 80.5° E	West	Central parts of Madhya Pradesh centred near Lat. 22.7° N / Long. 77.8° E	Details are given in the article on Storms & Depressions over the north Indian Ocean - 2015
(**B**)	*Well marked low/low pressure area*					
1.	Low pressure area	11 - 15	West central and adjoining northwest Bay of Bengal off north Andhra Pradesh-south Odisha coasts	Northwest	Southeast Uttar Pradesh and adjoining Bihar & northeast Madhya Pradesh	It formed under the influence of a cyclonic circulation extending upto mid tropospheric levels over northwest Bay of Bengal and adjoining east central Bay of Bengal off Odisha and north coastal Andhra Pradesh. It merged with the monsoon trough on 16. However, the associated cyclonic circulation extending up to mid tropospheric levels persisted upto 18 and became less marked on 19
2.	Well marked Low pressure area	26 - 29	West central and adjoining northwest Bay of Bengal off south Odisha-north Andhra Pradesh coasts	Do	Jharkhand and neighbourhood	It formed under the influence of a cyclonic circulation extending between mid & upper tropospheric levels over west central and adjoining northwest Bay of Bengal off south Odisha-north Andhra Pradesh coasts. It became less marked on 30. Associated cyclonic circulation lay embedded in the trough extended from east Bihar to south Odisha across Jharkhand on 30 and became less marked on 31
(**C**)	*Western disturbances / eastward moving systems*					
(*i*)	*Upper air cyclonic circulation/ trough*					
1.	Mid tropospheric levels	4 - 11	West Afghanistan and adjoining Iran	Northeast	Along Long. 72° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	Moved away east northeastwards on 12
2.	Do	12 - 14	Along Long. 65° E to the north of Lat. 30° 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.)	Moved away northeastwards on 15
3.	Do	14 - 17	Along Long. 65° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	Do	Along Long. 72° E to the north of Lat. 32° N (axis at 5.8 kms a.s.l.)	Moved away northeastwards on 18
4.	Do	19 - 21	North Pakistan and neighbourhood	Do	Jammu & Kashmir and neighbourhood	Moved away northeastwards on 22
5.	Do	22 - 24	Do	Do	Do	Moved away northeastwards on 25
6.	Do	28 - 29	Do	Do	Do	Moved away northeastwards on 30. A trough aloft at 5.8 kms a.s.l persisted on 28 & 29
7.	Mid & Upper tropospheric levels	31 Aug	Along Long. 68° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	Stationary	*In situ*	Moved away northeastwards on 1 September
(**D**)	*Other upper air cyclonic circulations*					
1.	Between mid & upper tropospheric levels	1	West Madhya Pradesh and neighbourhood	Stationary	*In situ*	Became less marked on 2

TABLE 3 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.	Upto mid tropospheric levels	4 - 6	Punjab and neigbourhood	East	Haryana and Punjab	Merged with the monsoon trough on 7
3.	Between mid & upper tropospheric levels	5 - 9	North Bay of Bengal and neighbourhood	Stationary	*In situ*	It merged with the cyclonic circulation over northwest Bay of Bengal and adjoining east central Bay of Bengal off Odisha and north coastal Andhra Pradesh on 10. It extended between lower & mid tropospheric levels during 7 - 9
4.	Between mid & upper tropospheric levels	7 - 9	West central Bay of Bengal and neighbourhood	Do	Do	Merged with the cyclonic circulation over northwest bay of Bengal and adjoining east central Bay of Bengal off Odisha and north coastal Andhra Pradesh on 10
5.	Upto mid tropospheric levels	8 - 11	Central Pakistan and adjoining northwest Rajasthan & Punjab	East	West Uttar Pradesh and adjoining Haryana, Chandigarh & Delhi	It merged with the monsoon trough on 12
6.	Upto lower tropospheric levels	6 - 7	Sub-Himalayan West Bengal and neighbourhood	Do	Assam & Meghalaya and neighbourhood	Became less marked on 8
7.	Upto mid tropospheric levels	10	Assam and neighbourhood	Stationary	*In situ*	Became less marked on 11
8.	Between lower & mid tropospheric levels	10 - 11	South Chhattisgarh and neighbourhood	West	South Chhattisgarh and adjoining Vidarbha	Became less marked on 12
9.	Do	11	Saurashtra & Kutch and neighbourhood	Stationary	*In situ*	Became less marked on 12
10.	Upto mid tropospheric levels	12	Northwest Madhya Pradesh and adjoining east Rajasthan	Do	Do	It merged with the monsoon trough on 13
11.	Upto Lower tropospheric levels	14 - 16	Haryana and adjoining northwest Rajasthan	Do	Do	It merged with the monsoon trough on 17
12.	Between Lower & Mid tropospheric levels	17 - 20	Southwest Bay of Bengal off Tamil Nadu coast	West	Southeast Arabian Sea and neighbourhood	It became un-important on 21
13.	Upto Mid tropospheric levels	21 - 25	North Bangladesh and neighbourhood	West	Sub-Himalayan West Bengal & Sikkim and adjoining Bangladesh	Became less marked on 26
(**D**)	*North-south trough*					
1.	Upto mid tropospheric levels	19 - 20	From eastern parts of Bihar to north Odisha across Jharkhand	Oscillatory	From eastern parts of Bihar to north Bay of Bengal across Jharkhand & Gangetic West Bengal	Became less marked on 21
2.	Upto Mid tropospheric levels	22 - 25	From cyclonic circulation over north Bangla Desh and adjoining Sub-Himalayan West Bengal & Sikkim to north Bay of Bengal	Quasi-stationary	From cyclonic circulation over Sub-Himalayan West Bengal & Sikkim and neighbourhood to northwest Bay of Bengal across Gangetic West Bengal	Became less marked on 26
3.	Do	30 Aug - 6 Sep	From east Bihar to south Odisha across Jharkhand	-	-	-
(**E**)	*East-west shear zone*					
1.	Between Mid & Upper tropospheric levels	27 - 29	Along Lat.18° N	South	Along Lat.17° N	Became less marked on 30

TABLE 4

Details of the weather systems during September 2015

S. No.	System	Duration	Place of initial location	Direction of movement	Place of Final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**)	*Deep Depression / depression*					
1.	Deep Depression	16 (0600 UTC) – 19 (0000 UTC)	South Odisha and neighbourhood	Northwest-west – southwest -west	Vidarbha and neighbourhood	Details are given in the article on Storms & Depressions over the north Indian Ocean - 2015
(**B**)	*Well marked low/low pressure area*					
1.	Low pressure area	18 - 23	North Andaman Sea and adjoining east central Bay of Bengal	Northwest-north northwest	North Bangladesh and neighbourhood	It formed under the influence of a cyclonic circulation extending upto mid tropospheric levels over Tenasserim coast and neighbourhood. The low pressure area with associated cyclonic circulation became less marked on 24
(**C**)	*Western disturbances / eastward moving systems*					
(*i*)	*Upper air cyclonic circulation / trough*					
1.	Mid & Upper tropospheric levels	2 - 3	Along Long. 63° E to the north of Lat. 32° N (axis at 5.8 kms a.s.l.)	East	Long. 70° E to the north of Lat. 32° N (axis at 5.8 kms a.s.l.)	Moved away northeastwards on 4
2.	Do	4 - 8	Along Long. 60° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	Do	Along Long. 73° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	The feeble trough moved away northeastwards on 9. It lay as a cyclonic circulation extending upto mid tropospheric levels over northeast Afghanistan and neighbourhood on 5 and over Afghanistan and adjoining north Pakistan on 6 with a trough aloft
3.	Upto mid tropospheric levels	9 - 12	North Pakistan and neighbourhood	Northeast	Northern parts of Jammu & Kashmir and neighbourhood	Moved away northeastwards on 13
4.	Do	15 - 16	Do	Do	North Pakistan and adjoining Jammu & Kashmir	A trough aloft was seen on 16. The cyclonic circulation lay as a trough in mid & upper tropospheric westerlies with its axis at 7.6 kms a.s.l extended along Long. 72° E to the north of Lat. 30° E on 17 and moved away northeastwards on 18
5.	Mid & Upper tropospheric levels	18 - 24	Along Long. 62° E to the north of Lat. 30° N	Do	Along Long. 76° E to the north of Lat. 28° N (axis at 5.8 kms a.s.l.)	Moved away northeastwards on 25. It lay as a cyclonic circulation between mid & upper tropospheric westerlies with a trough aloft on 20, 22 & 23
6.	Do	26 - 27	Along Long. 72° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	Stationary	*In situ*	Initially it lay as a upper air cyclonic circulation extending upto mid tropospheric levels over north Pakistan and neighbourhood on 25. The WD as a trough moved away northeastwards on 28.
7.	Do	29 Sep - 1 Oct	Along Long. 65° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	-	Along Long. 70° E to the north of Lat. 30° N (axis at 5.8 kms a.s.l.)	Moved away northeastwards on 2 October
(**D**)	*Other upper air cyclonic circulations*					
1.	Upto lower tropospheric levels	2 - 4	Coastal areas of Bangladesh and adjoining northeast Bay of Bengal	Northeast	Western parts of Assam & Meghalaya and neighbourhood	Initially it lay as a north-south trough extending upto mid tropospheric levels during 31 August - 1 September and on 5 & 6 September. Became less marked on 7

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.	Upto lower tropospheric levels	2 - 3	South Pakistan and neighbourhood	East	Central Pakistan and adjoining west Rajasthan	Became less marked on 18
3.	Between lower & mid tropospheric levels	3 - 4	Northeast Arabian Sea and adjoining areas of Saurashtra & Kutch	Do	Saurashtra & neighbourhood	Became less marked on 5
4.	Do	4 - 7	Comorin area and neighbourhood	West	Southeast Arabian Sea and neighbourhood	Became less marked on 8
5.	Do	7 - 10	South Pakistan and neighbourhood	East	South Pakistan and adjoining Kutch	Became less marked on 11
6.	Upto lower tropospheric levels	10	Northeast and adjoining east central Bay of Bengal	Stationary	*In situ*	It merged with the cyclonic circulation over west central bay of Bengal and neighbourhood on 11
7.	Do	12 - 13	East Uttar Pradesh and adjoining Bihar	West	North Madhya Pradesh and neighbourhood	Became less marked on 14
8.	At lower levels	15 - 16	Northwest Madhya Pradesh and neighbourhood	Stationary	*In situ*	Became less marked on 17
9.	Between 3.1 & 4.5 kms a.s.l.	16	South Pakistan and adjoining Kutch	Do	Do	Became less marked on 17
10.	Do	23 - 24	Lakshadweep area and neighbourhood	Do	Do	Became less marked on 25
11.	Upto lower tropospheric levels	23	Tamil Nadu and neighbourhood	Do	Do	Became less marked on 24
12.	Upto mid tropospheric levels	28 - 29	West central Bay of Bengal and adjoining areas of coastal Andhra Pradesh	-	Rayalaseema and neighbourhood	It lay as a trough /wind discontinuity extending upto mid tropospheric levels during 25 - 27. The cyclonic circulation became less marked on 30
13.	Between 2.1 & 4.5 kms a.s.l.	25 - 26	Comorin area and neighbourhood	West	Lakshadweep area and neighbourhood	Became less marked on 27
14.	Upto mid tropospheric levels	28 Sep - 4 Oct	Gulf of Siam and neighbourhood	Northwest	West central & adjoining northwest Bay of Bengal off north Andhra Pradesh-south Odisha coasts	Became less marked on 5
15.	Upto lower tropospheric levels	30 Sep – 3 Oct	Lakshadweep- Maldives areas	Do	West central & adjoining southwest Arabian Sea	Became un-important on 4 October
(**E**)	*Other troughs*					
1.	Upto lower tropospheric levels	2 - 9	From Rayalaseema to Gulf of Mannar across Tamil Nadu	Oscillatory	North Madhya Maharashtra to Lakshadweep area across interior Karnataka	Became less marked on 10. However, a cyclonic circulation extending upto lower tropospheric levels lay over Lakshadweep area and neighbourhood on 10 and became less marked on 11
2.	Upto lower tropospheric levels	24 - 26	From Sub-Himalayan West Bengal & Sikkim to northeast Bay of Bengal	Quasi -stationary	Western parts of Assam to northeast Bay of Bengal	Less marked on 27
(**F**)	*East-west shear zone/wind discontinuity*					
1.	Between 3.1 & 7.6 kms a.s.l.	7 - 14	Along Lat. 15° N	North	Along Lat. 16° N	Became less marked on 15
2.	Between 3.1 & 5.8 kms a.s.l.	29 Sep - 6 Oct	Along Lat. 13° N	Oscillatory	Along Lat. 14° N	Became less marked on 7 October

TABLE 5

Rainfall figures (mm) for each month and season as a whole (June - September 2015) Real - time

S. No.	Meteorological Sub-divisions	June			July			August			September			Monsoon		
		Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)	Actual (mm)	Normal (mm)	Dep. (%)
1.	A. & N. Islands	346.4	438.6	-21	328.9	407.7	-19	480.0	403.8	19	523.2	432.4	21	1678.5	1682.5	0
2.	Arunachal Pradesh	637.9	500.4	27	329.3	536.1	-39	595.5	359.9	65	374.2	371.6	1	1875.0	1768.0	6
3.	Assam & Meghalaya	545.5	502.3	9	298.8	553.9	-46	584.1	410.3	42	277.0	326.3	-15	1747.7	1792.8	-3
4.	Naga., Mani., Mizo. and Tri.	283.9	412.1	-31	413.6	415.0	0	334.2	380.1	-12	255.9	289.7	-12	1050.3	1496.9	-30
5.	Sub-Himalayan West Bengal & Sikkim	508.2	485.2	5	393.3	615.8	-36	626.6	495.2	27	354.9	410.0	-13	1883.0	2006.2	-6
6.	Gangetic West Bengal	235.4	244.4	-4	615.3	331.7	86	257.8	312.3	-17	156.9	279.5	-44	1265.5	1167.9	8
7.	Orissa	238.6	214.1	11	294.8	337.0	-13	264.0	362.1	-27	237.0	236.7	0	1034.4	1149.9	-10
8.	Jharkhand	183.3	197.5	-7	429.7	334.6	28	240.7	315.8	-24	85.0	244.0	-65	941.9	1091.9	-14
9.	Bihar	122.1	168.5	-28	231.5	343.5	-33	287.0	291.6	-2	101.7	224.0	-55	742.3	1027.6	-28
10.	East Uttar Pradesh	95.2	107.8	-12	179.1	298.0	-40	175.8	294.5	-40	21.9	197.3	-89	472.1	897.6	-47
11.	West Uttar Pradesh	74.0	71.1	4	194.4	258.2	-25	144.8	291.6	-50	26.6	148.5	-82	439.9	769.4	-43
12.	Uttarakhand	186.6	167.8	11	337.0	428.1	-21	305.3	426.3	-28	52.6	206.9	-75	881.5	1229.1	-28
13.	Haryana, Chandigarh & Delhi	43.8	45.9	-5	130.4	165.8	-21	89.4	173.6	-49	32.0	81.0	-61	295.5	466.3	-37
14.	Punjab	48.4	44.4	9	130.2	186.0	-30	88.6	170.4	-48	69.2	91.1	-24	336.3	491.9	-32
15.	Himachal Pradesh	88.7	95.4	-7	260.6	306.9	-15	215.1	283.0	-24	73.9	140.0	-47	638.3	825.3	-23
16.	Jammu & Kashmir	121.4	64.1	89	233.2	192.4	21	129.2	186.0	-31	130.2	92.1	41	614.0	534.6	15
17.	West Rajasthan	53.2	29.9	78	234.6	102.7	128	60.5	89.3	-32	35.7	41.3	-14	384.0	263.2	46
18.	East Rajasthan	96.3	62.5	54	297.2	225.2	32	142.9	228.4	-37	20.1	99.7	-80	556.6	615.8	-10
19.	West Madhya Pradesh	154.1	105.4	46	428.2	291.6	47	276.6	308.7	-10	55.6	170.4	-67	914.5	876.1	4
20.	East Madhya Pradesh	139.2	133.7	4	262.2	347.8	-25	272.1	369.7	-26	71.6	200.0	-64	745.1	1051.2	-29
21.	Gujarat region	136.3	129.9	5	381.4	336.7	13	40.7	277.7	-85	101.0	156.7	-36	659.4	901.0	-27
22.	Saurashtra & Kutch	136.3	85.9	59	254.1	188.2	35	13.6	124.6	-89	98.5	74.8	32	502.5	473.5	6
23.	Konkan & Goa	800.2	700.0	14	562.3	1110.0	-49	388.7	759.6	-49	253.8	344.7	-26	2005.0	2914.3	-31
24.	Madhya Maharashtra	177.0	145.6	22	111.7	242.2	-54	67.2	189.1	-64	146.6	152.4	-4	488.1	729.3	-33
25.	Marathawada	118.3	143.3	-17	27.4	187.2	-85	112.2	188.2	-40	154.3	164.2	-6	412.4	682.9	-40
26.	Vidarbha	254.6	168.0	52	137.2	311.9	-56	288.9	305.7	-6	167.5	169.0	-1	848.2	954.6	-11
27.	Chattisgarh	258.3	182.8	41	249.5	376.2	-34	285.1	373.3	-24	216.9	215.0	1	1009.8	1147.3	-12
28.	Coastal Andhra Pradesh	204.8	103.9	97	93.9	160.4	-41	175.6	157.7	11	167.7	159.1	5	642.0	581.1	10
29.	Telangana	216.1	135.9	59	79.2	238.2	-67	151.4	218.8	-31	154.2	162.3	-5	600.8	755.2	-20
30.	Rayalaseema	66.3	67.7	-2	36.2	94.2	-62	111.3	103.3	8	144.5	133.1	9	358.3	398.3	-10
31.	Tamil Nadu	62.4	46.0	36	43.5	68.0	-36	81.6	87.4	-7	98.4	115.8	-15	285.8	317.2	-10
32.	Coastal Karnataka	715.7	867.7	-18	776.4	1159.7	-33	521.2	755.5	-31	271.7	300.9	-10	2285.0	3083.8	-26
33.	North interior Karnataka	89.6	104.6	-14	38.5	135.0	-71	78.4	120.4	-35	150.8	146.0	3	357.3	506.0	-29
34.	South interior Karnataka	218.7	141.5	55	112.0	216.1	-48	136.6	161.4	-15	164.5	141.0	17	607.4	660.0	-8
35.	Kerala	563.6	649.8	-13	406.0	726.1	-44	252.2	419.5	-40	292.9	244.2	20	1514.7	2039.6	-26
36.	Lakshadweep	296.6	330.2	-10	257.5	287.7	-11	146.4	217.5	-33	160.4	163.1	-2	860.9	998.5	-14

TABLE 6

Some representative amounts of rainfall in cm for June, July, August and September 2015 (25 cm and above)

Date	Some representative amounts of rainfall in cm for June, July, August September 2015 (25cm and above)
1 Jun	Cherrapunji (Rkm) 56, Cherrapunji 54, Mawsynram 29
2 Jun	Nil
3 Jun	Nil
4 Jun	Nil
5 Jun	Nil
6 Jun	Mawsynram 50, Cherrapunji 41, Cherrapunji (Rkm) 37, Kokrajhar 25
7 Jun	Mawsynram 40, Cherrapunji 34, Cherrapunji (Rkm) and Passighat 27 each
8 Jun	Mawsynram 62, Cherrapunji 58, Cherrapunji (Rkm) 54
9 Jun	Cherrapunji (Rkm) 51, Cherrapunji 40, Mawsynram 37, Roing 26
10 Jun	Cherrapunji (Rkm) 55, Cherrapunji 51, Mawsynram 39, Alipurduar CWC 30
11 Jun	Nil
12 Jun	Nil
13 Jun	Cherrapunji 25
14 Jun	Dunguripalli 25
15 Jun	Nil
16 Jun	Nil
17 Jun	Nil
18 Jun	Sevoke 25
19 Jun	Mumbai (SCZ) 28
20 Jun	Nil
21 Jun	Jhorigam ARG 33, Hosanagara 28
22 Jun	Hosanagar 41, Mahabaleshwar* 37, Kottigehara 34, Khed 26, Mandangad 25
23 Jun	Hosanagara 30
24 Jun	Una 32, Hosanagar 31, Mahabaleshwar* and Malia 27 each, Kottigehara 25
25 Jun	Bagasra 64, Dhari 51, Vadia 39, Gondal 26, Lodhika, Palitana, Kottigehara and Wanakbori 25 each
26 Jun	Bhagamandala 26
27 Jun	Nil
28 Jun	Nil
29 Jun	Nil
30 Jun	Nil
1 Jul	Garubathan 28
2 Jul	Nil
3 Jul	Nil
4 Jul	Nil
5 Jul	Nil
6 Jul	Nil
7 Jul	Nil
8 Jul	Nil
9 Jul	Nil
10 Jul	Kota 28, Udupi 27, Deganga 26, Mulki and Bongaon 25 each
11 Jul	Kolebira 39, Sundargarh 26, Balisankara ARG 25

TABLE 5 (*Contd.*)

Date	Some representative amounts of rainfall in cm for June, July, August September 2015 (25cm and above)
12 Jul	Nil
13 Jul	Nil
14 Jul	Nil
15 Jul	Nil
16 Jul	Daltonganj 29
17 Jul	Arki 27
18 Jul	Nil
19 Jul	Narsingarh 39, Ujjain and Ujjain - AWS 32 each, Sarangpur 31, Badnagar 25
20 Jul	Nusrulgunj – Arg 35, Kollur 30, Budhni 28, Agumbe and Khachrod 27 each
21 Jul	Palgharagri 48
22 Jul	Ariyalur 30
23 Jul	Raidih 26
24 Jul	Cherrapunji (Rkm) 29, Agar 27, Cherrapunji 26
25 Jul	Nil
26 Jul	Jaora 38, Mahidpur 29, Khachrod and Agar 28 each, Sailana 26, Petlawad and Sardarpur 25 each
27 Jul	Mount Abu and Mounntabu Tehsil 45 each, Gudamalani 33, Raniwada 32, Jaswantpura 29
28 Jul	Dhanera 43, Wav 42, Deesa 40, Bhabhar 35, Kankrej 34, Tharad, Mount Abu, Mounntabu Tehsil and Dantiwada 33 each, Radhanpur 32, Nakhatrana 31, Deodar, Jamshedpur and Bhuj AP 25 each
29 Jul	Vadgam 49, Abu Road 41, Deesa 36, Bhachau 33, Mount Abu, Mounntabu Tehsil and Palanpur 32 each, Amirgadh 31, Dhanera and Kotda 30 each, Siddhpur 28, Mahesana, Patan and Dharoi Colony 27 each, Danta and Unjha 25 each
30 Jul	Nil
31 Jul	Nil
1 Aug	Nil
2 Aug	Nil
3 Aug	Nil
4 Aug	Nil
5 Aug	Khandwa, Khandwa - AWS and Khirkiya - Arg 29 each, Jalgaon Jamod 27
6 Aug	Nil
7 Aug	Nil
8 Aug	Nil
9 Aug	Nil
10 Aug	Nil
11 Aug	Nil
12 Aug	Nil
13 Aug	Nil
14 Aug	Nil
15 Aug	Cherrapunji (Rkm) 25
16 Aug	Mawsynram 41, Kumargram 25
17 Aug	Nil
18 Aug	Mawsynram 53, Cherrapunji (Rkm) 37, Cherrapunji 31
19 Aug	Mawsynram 75, Cherrapunji (Rkm) 57, Cherrapunji 47
20 Aug	B. P. Ghat 42, Cherrapunji (Rkm) 34, Mawsynram and Williamnagar 33 each, Cherrapunji 31, Aie Nh Xing 29, Cheria B. Pur 28, Beki Mathungari 27, Parbatta 26, Kodawanpur / C. Bii 25

TABLE 5 (*Contd.*)

Date	Some representative amounts of rainfall in cm for June, July, August September 2015 (25cm and above)
21 Aug	Kokrajhar 34, Mawsynram 31, Gossaigaon 26, Cherrapunji and Gossaigaon AWS 25 each
22 Aug	Nil
23 Aug	Nil
24 Aug	Nil
25 Aug	Nil
26 Aug	Nil
27 Aug	Nil
28 Aug	Nil
29 Aug	Nil
30 Aug	Roing 28, Cherrapunji (Rkm) 26
31 Aug	Cherrapunji 39, Cherrapunji (Rkm) 36
1 Sep	Nil
2 Sep	Nil
3 Sep	Nil
4 Sep	Nil
5 Sep	Nil
6 Sep	Nil
7 Sep	Nil
8 Sep	Kollur 34
9 Sep	Nil
10 Sep	Nil
11 Sep	Nil
12 Sep	Nil
13 Sep	Nil
14 Sep	Nil
15 Sep	Araku Valley 27
16 Sep	Tentulikhunti ARG 28, Muniguda ARG 26
17 Sep	Nil
18 Sep	Nil
19 Sep	Mewat Nuh AWS 28, Dangs (Ahwa) 27, Nuh 25
20 Sep	Visavadar 25
21 Sep	Nil
22 Sep	Nil
23 Sep	Mawsynram 42, Cherrapunji (Rkm) 37, Cherrapunji 31
24 Sep	Nil
25 Sep	Nil
26 Sep	Nil
27 Sep	Nil
28 Sep	Nil
29 Sep	Nil
30 Sep	Nil

State and north Arabian Sea and the withdrawal line passed through Dharchula, Etawah, Guna, Ratlam, Ahmedabad, Dwarka, Lat. 22° N / Long. 65° E and Lat. 22° N / Long. 60° E on 29th September and from remaining parts of west Uttar Pradesh, most parts of east Uttar Pradesh and some more parts of Madhya Pradesh, Gujarat state and north Arabian Sea on 1st October. It withdrew further from remaining parts of east Uttar Pradesh, most parts of Bihar, some parts of east Madhya Pradesh and some parts of north Chhattisgarh on 3rd October and from some more parts of Bihar, Chhattisgarh & Gujarat state, remaining parts of Madhya Pradesh, some parts of Jharkhand, Vidarbha, Madhya Maharashtra and some more parts of north Arabian Sea on 6th. By 7th October it withdrew from remaining parts of north India, some more parts of central India and some parts of east India. The moisture incursion and rainfall caused by a Deep Depression (9th - 12th October) formed over the Arabian Sea and a well marked low pressure area over the north Bay of Bengal again stalled the further withdrawal of SW monsoon. But the intrusion of dry air from the northwest and western parts of the Arabian Sea led the system to dissipate over the sea itself and subsequently the withdrawal of SW monsoon from the remaining parts of the mainland took place on 19th October, 2015.

3. Chief synoptic features of southwest monsoon 2015

The synoptic disturbances which affected the Indian Monsoon region during June, July, August & September are given in Tables 1 to 4 respectively.

In all 12 low pressure areas formed. Out of which 8 further intensified into Depression as against a normal of 4 - 6 Depressions during the season. Two of which intensified into Cyclonic storms *viz*., 'Ashobaa' (7 - 12 June) & 'Komen' (26 July - 2 August), over Arabian Sea and Bay of Bengal respectively and the three as Deep Depressions with two over land (27 - 30 July & 16 - 19 September) and one over Arabian Sea (22 - 24 June). The three Depressions of which two formed as land Depression over Jharkhand and neighbourhood (10 - 12 July) and over east Madhya Pradesh and adjoining Chhattisgarh (4 August). The remaining formed over the Bay of Bengal (20 - 21 June). Of 4 low pressure areas, one intensified as a well marked low pressure area. The tracks of the low pressure systems during SW monsoon 2015 has been shown in the Fig. 8.

The off-shore trough along different parts of the west coast persisted from 11th June - 29th August except during 4th - 9th July, 14th - 19th July, 22nd - 24th July and 29th July - 27th August. It was quite feeble from 28th June - 3rd July, 21st July and 28th August.

4. Extra Indian features

4.1. *Cross equatorial flow*

4.1.1. *Over the Arabian sea*

The Cross Equatorial flow along the equatorial belt (equator to 5° N / 5° S) over Arabian Sea was stronger than normal in June except for the 2nd week in which it was close to normal. It was close to normal in 1st & 3rd weeks of July but stronger in 2nd & 4th weeks. It was stronger than normal during August and stronger than normal in September except for the 2nd week in which it was weaker.

The surface winds over Arabian Sea to the north of 5° N were close to normal in June and stronger in 4th week. It was close to normal in July and stronger in its 4th week. It was stronger than normal in 1st & 4th weeks of August except for the 2nd week in which it was normal and 3rd week it was weaker. It was close to normal in 1st & 4th weeks of September but weaker in 2nd & 3rd weeks.

4.1.2. *Over the Bay of Bengal*

The Cross Equatorial flow along the equatorial belt (equator to 5° N / 5° S) over Bay of Bengal was stronger than normal in June except for the 2nd week in which it was normal. Stronger than normal in July except for the 3rd week in which it was normal. It was stronger than normal in August. It was stronger than normal in September, except for the 3rd week in which it was normal.

The surface winds over the Bay of Bengal to the north of 5° N were stronger than normal in 3rd & 4th weeks in June and close to normal in 1st & 2nd week. It was stronger than normal in July. It was stronger than normal in August, except for the 3rd week in which it was close to normal. It was close to normal in September, except for the 4th week in which it was stronger than normal.

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

There were in all 16 low pressure systems (reaching the intensity of Tropical depression and above) in the northwest Pacific Ocean / South China Sea during June - September 2015.

4.3. *Troughs in mid & upper westerlies affecting the Indian region to the south of 30° N*

The number of troughs in mid & upper tropospheric westerlies affecting the Indian region which penetrated

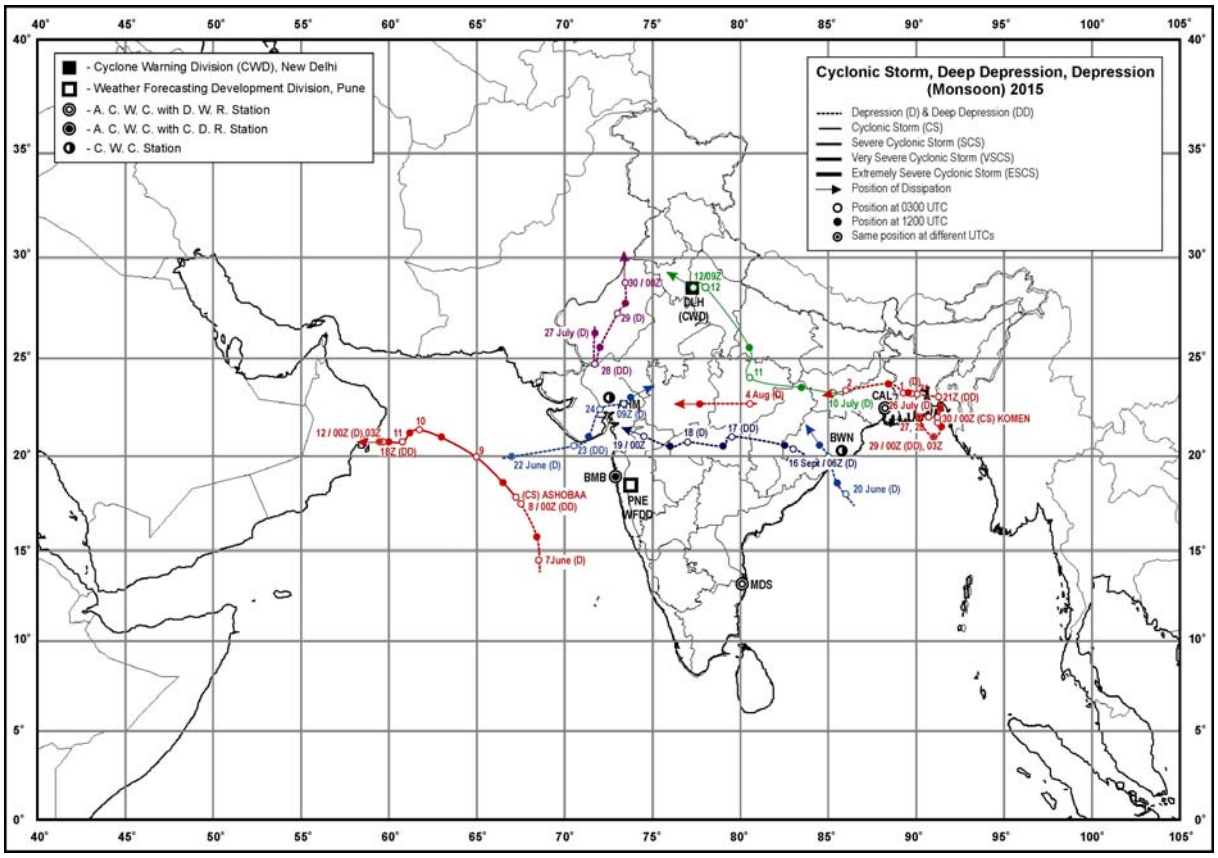


Fig. 8. Tracks of the low pressure systems during SW monsoon 2015

south of 30° N is 2 in June and 3 each in July, August and September at 300 hPa, 4 each in June & September, 2 in July and 3 in August at 500 hPa.

4.4. *Troughs in mid & upper tropospheric westerlies over the south Indian Ocean to the north of Lat. 30° S*

There were 42 troughs in mid & upper tropospheric westerlies which moved across the Indian Ocean from west to east, to the north of Lat. 30° S, in the Southern Hemisphere, during June to September 2015. The month wise break-up is 12 each in June & August, 10 in July and 8 in September.

4.5. *Systems in southern hemisphere*

4.5.1. *Tropical storms/depressions*

No intense low pressure system (TD, TS or Typhoon) was reported in Southern Hemisphere during June - September 2015.

4.5.2. *Mascarene HIGH*

The Mascarene HIGH with its mean position at 31.9° S / 65.7° E was stronger than normal by 2.2 hPa during the monsoon period June to September. It was above normal by 3.7, 2.1, 0.7 & 2.2 hPa during the months of June, July, August and September respectively.

5. Semi-permanent systems

5.1. *Heat low*

This year, the continued presence of the mid-latitude circulation regime and passage of western disturbances caused delay in its setting. It established in its near normal position over west Pakistan and neighbourhood on 13th June. It was mostly seen in its near normal position during June, July and August. The Heat Low started gradually filling up from first week of September and became less marked in the third week of September.

5.2. *Axis of the monsoon trough*

This year, the higher than normal mean sea level pressure anomalies over the northwestern parts of India and, presence of mid-latitude circulation regime and passage of western disturbances during end of May and first week of June delayed the establishment of an organized Heat Trough. A trough at mean sea level made its first appearance from 15th June extending along Indo-Gangetic plain. With the southwest monsoon covering the entire country, this trough got established as the monsoon trough on 26th June with the western part remaining in near normal position whereas the eastern part to the north of its normal position except on 27th & 28th June when its western part lay close to foothills of Himalayas for the remaining days of June month. The western part of monsoon trough remained in its near normal / normal position and eastern part to the north of its normal position for most of the days during July. It was noticed close to foothills of Himalayas for a couple of days during first week and mid of July month. It extended up to mid tropospheric levels without its characteristic tilt. In the month of August, the trough was seen mostly to the north/close to its normal position for first half and from second half of August it was more shifted north or close to foot hills of the Himalayas either by parts (western). The vertical extension was shallow (upto lower tropospheric levels only) and confined to the mean Seal level towards the end of third week of August. Thereafter, it became less delineated since 4th September.

With the shifting of monsoon trough to the foot hills of Himalayas since third week of August, the circulation features and rainfall pattern resembled typical break like situation during 6th - 9th August & 20th - 25th August.

5.3. *Tibetan Anticyclone/High*

This year, the meandering of westerly winds in the mid & upper tropospheric levels affected the location and intensity of Tibetan anticyclone. It was seen to its east / southeast of its normal position upto third week of July and, thereafter upto mid August it was seen to the west/northwest of its normal position. It established in its near normal position at 200 hPa on 14th August. Towards the end of the month, the centre again shifted gradually eastwards. Thereafter, it oscillated between east and its normal position for the rest of the season and finally became un-important during the first week of October.

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

The STWJ started shifting northwards from the third week of June. Patiala reported 60 knots wind (at 200hPa) at 0000 UTC of 14th June. Subsequently, the core of STWJ shifted to the north of the Himalayas. However, it made occasional re-appearances along the latitude of Srinagar during later half of August. In the first week of September, it once again shifted southwards as evidenced by the 75 knots westerly wind reported over Srinagar at 197 hPa on 2nd September (0000 UTC).

5.5. *Tropical Easterly Jet (TEJ)*

The TEJ got established over the southern tip of Peninsular India by 20th May with Thiruvananthapuram reporting easterlies of 66 kts at 153 hPa level. A wide latitudinal spread of the easterly jet speed winds was observed during August and September while during June and July; the stations over the Peninsular India only reported jet wind speeds. The highest wind speed of 107 kts at 164/145 hPa and at 105/104 hPa was reported at Chennai on 1st & 16th July respectively.

Apart from Thiruvananthapuram, Chennai, Panjim and Port Blair, Jet speed winds were reported over Ahemdabad, Bhubaneswar, Gwalior, Hyderabad, Jagdalpur, Kochi, Kolkata, Nagpur, Raipur and Visakhapatnam on several days during the season.

6. Other features

6.1. *Monthly wind anomalies during southwest Monsoon 2015*

The month wise circulation anomaly features at lower, middle & upper tropospheric levels *viz*., 850, 700, 500 & 200 hPa during the southwest Monsoon season are discussed below.

6.1.1. *June wind anomaly features*

In the monthly wind pattern, three anomalous cyclonic circulations were seen at 850hPa, one over Madhya Pradesh (MP) & neighborhood extending upto 700 hPa, second over Assam - Meghalaya & neighborhood and third over East Central (EC) Arabian Sea off Maharashtra coast extending upto 700 hPa. At 700 hPa, anomalous cyclonic circulation was seen over Chattisgarh & neighborhood.

During week ending 3rd June, three anomalous cyclonic circulations were seen at 850 hPa, one over Assam Meghalaya & neighborhood, second over South East (SE) Bay of Bengal extending upto 700 hPa and third over South East (SE) Arabian Sea. At 700 hPa, two anomalous cyclonic circulations were seen, one over North East (NE) Arabian sea off North Maharashtra-Gujarat coasts and second over West Rajasthan & neighborhood.

During week ending 10th June, four anomalous cyclonic circulations were seen at 850 hPa, one over Assam Meghalaya & neighborhood, second over East Rajasthan & neighborhood, third over EC Arabian Sea off Maharashtra coast and fourth over Lakshadweep area & neighborhood. At 700 hPa, an anomalous cyclonic circulation was seen over West Central (WC) Bay of Bengal off Andhra Pradesh coast. Two Anomalous anticyclonic circulations were seen at 700 hPa, one over Gangetic West Bengal (GWB) & neighborhood and second over Gujarat region & neighborhood.

During week ending 17th June, three anomalous cyclonic circulations were seen at 850 hPa, one over Arunachal Pradesh & neighborhood extending upto 700 hPa, second over West MP & neighborhood extending upto 700 hPa and third over Maharashtra coast & neighborhood.

During week ending 24th June, three anomalous cyclonic circulations were seen at 850 hPa, one over Nagaland-Manipur-Mizoram-Tripura (NMMT) & neighborhood, second over North West (NW) Bay of Bengal off Odisha coast extending upto 300 hPa and third over West MP & neighborhood extending upto 300 hPa.

During week ending 1st July, four anomalous cyclonic circulations were seen at 850 hPa, one over GWB & neighborhood extending upto 500 hPa, second over East Uttar Pradesh & neighborhood extending upto 700 hPa level, third over Rajasthan neighborhood extending upto 500 hPa and forth over Maharashtra coast & neighbourhood. The axis of ridge at 200 hPa laid along Lat. north of 25° N.

6.1.2. *July wind anomaly features*

In the monthly wind pattern, two anomalous cyclonic circulations were seen at 850 hPa, one over NMMT & neighborhood extending upto 500 hPa and other over East Rajasthan & neighborhood extending upto 500 hPa.

During week ending 8th July, two anomalous cyclonic circulations were seen at 850 hPa, one over NMMT & neighborhood extending upto 500 hPa and other over Jammu & Kashmir & neighborhood and extending upto 500 hPa.

During week ending 15th July, four anomalous cyclonic circulations were seen at 850 hPa, one over NMMT & neighborhood extending upto 500 hPa, second over Chattisgarh & neighborhood extending upto 700 hPa, third over Uttar Pradesh & neighborhood extending upto 500 hPa and fourth over South West (SW) Bay of Bengal off Tamil Nadu coast. The axis of ridge at 200 hPa laid along Lat. north of 32° N.

During week ending 22nd July, three anomalous cyclonic circulations were seen at 850 hPa, one over Assam & Meghalaya and neighborhood extending upto 500 hPa, second over West MP & neighborhood extending upto 500 hPa and third over South West (SW) Bay of Bengal off Tamil Nadu-Andhra Pradesh coast and extending upto 500 hPa. A Ridge at 200 hPa extended along 35° N.

During week ending 29th July, two anomalous cyclonic circulations were seen at 850 hPa, one over NMMT & neighborhood extending upto 700 hPa and the other over Rajasthan & neighborhood extending upto 300 hPa.

6.1.3. *August wind anomaly features*

During week ending 5th August, two anomalous cyclonic circulations were seen at 850 hPa, one over Assam & Meghalaya and neighborhood extending upto 300 hPa and another over Haryana & neighborhood extending upto 300 hPa level. A Ridge at 200 hPa, extended along 30° N.

During week ending 12th August, two anomalous cyclonic circulations were seen at 850 hPa, one over North Andaman Sea & neighborhood extending upto 200 hPa and another over WC Bay of Bengal off Coastal Andhra Pradesh extending upto 300 hPa.

During week ending 19th August, an anomalous cyclonic circulation was seen at 850 hPa over Bihar & neighborhood.

During week ending 26th August, three anomalous cyclonic circulations were seen at 850 hPa, one over Assam & neighborhood, second over SW Bay of Bengal off Tamil Nadu coast & third over Lakshadweep area & neighborhood.

During week ending 2nd September, four anomalous cyclonic circulations were seen at 850 hPa, one over Chattisgarh & neighborhood extending upto 500 hPa, second over Coastal Andhra Pradesh & neighborhood, third over Comorin area & neighborhood and fourth over EC Arabian Sea off Karnataka coast. The axis of ridge at 200 hPa laid along Lat. north of 17° N.

6.1.4. *September wind anomaly features*

In the monthly wind pattern, three anomalous cyclonic circulations were seen at 850 hPa, one over NW Bay of Bengal off Odisha coast extending upto 500 hPa, Second over EC Arabian Sea off Maharashtra coast extending upto 500 hPa and third over SE Arabian Sea off Lakshadweep area extending upto 700 hPa. At 850 hPa,

anomalous anticyclonic circulation was seen over Jharkhand & neighborhood.

During week ending 9th September, an anomalous cyclonic circulation was seen at 850 hPa over Gujarat - Rajasthan extending upto 700 hPa. At 700 hPa an anomalous anticyclonic circulation was seen over Chattisgarh & neighborhood.

During week ending 16th September, 2015, an anomalous cyclonic circulation was seen at 850 hPa over NW Bay of Bengal off Odisha coast extending upto 300 hPa level.

During week ending 23rd September, two anomalous cyclonic circulations were seen at 850 hPa, one over Jharkhand & neighborhood and second over EC Arabian Sea off Gujarat- North Maharashtra coast extending upto 700 hPa level. The axis of ridge at 200 hPa laid along Lat. north of 26° N.

During week ending 30th September, an anomalous cyclonic circulation was seen at 850 hPa over North Andaman Sea & neighborhood extending upto 700 hPa. An anomalous anticyclonic circulation was seen at 850 hPa over Central India.

8. Disastrous weather events and damage during monsoon months

8.1. *June*

According to media reports, Assam witnessed the flood situations in the first and towards the last week of the month with rivers Brahmaputra, Jiabharali, Puthimari and Beki flowing above the danger level. Around 3 lakh people in almost around 800 villages were affected and damaged roads, bridges and standing crops in around 14000 hectares. In Gujarat, Meghal, Vrajmi, Sarasvati, Raval, Raydi, Thebi, Navli, Bhadar and Shetrunji Rivers were overflowing as a consequence of torrential rain for 2 days which caused flooding in 17 districts with Amreli getting worst affected. It claimed 83 lives across the state. Similarly, Jammu & Kashmir and Kerala experiend flood like situations which led to flooding of Jhelum and Bharatpuzha & Shokanasini rivers respectively. It caused damage to houses and standing crops in several thousand hectares of land and transport and communication systems. Incessant heavy rains triggered major landslides in Meghalaya, West Bengal and Konkan & Goa and claimed around 45 lives and also damaged several homes.

8.2. *July*

According to media reports, heavy rains, floods/flash floods and landslides took a toll of 276 lives (98 in West Bengal, 73 in Gujarat, 48 in Rajasthan, 13 in Himachal Pradesh, 10 in Madhya Pradesh, 8 in Uttarakhand, 7 in Odisha, 6 in Uttar Pradesh, 5 in Bihar, and 2 each in Jammu & Kashmir and Maharashtra). Lightning claimed 9 lives in Bihar, 8 in Odisha, 7 in Rajasthan, 6 in Telangana and 3 in Madhya Pradesh.

Incessant heavy rain led to flooding of Bramhaputra and its several tributaries during mid July in Assam caused breach of several embankments and damage of roads and bridges. Around 2 lakh people across 13 districts affected. Near about 530 villages submerged and crops in around 20,000 hectares were damaged. In Uttar Pradesh, around 200 villages across several districts were flooded. During last week of July incessant rain caused flooding of river Baitrani in Bhadrak and Keonjhargarh district of Odisha and river Damodar in West Bengal. It affected around 4.9 lakh people across 7 districts in Odisha and 89 lakh people across 12 districts of West Bengal. Around 1.25 lakh houses were permanently and 4 lakh temporarily and crops in 4.7 lakh hectares were damaged in West Bengal. Incessant downpour affected normal life in Gujarat and adjoining Rajasthan and affected around 40 lakh people across 14 districts.

As reported by media, two incidence of cloud burst occurred in Jammu & Kashmir and one in Himachal Pradesh during the month. Of which one occurred at Adhu in Pahalgam on 12 July and the other over Gangangir & Sonmarg areas on 16 July. Around 11 people lost their lives. The cloud burst which occurred on 9 July over Banjar of Kullu subdivision caused cutoff of 12 villages and left 15000 people stranded. About 17 footbridges were washed away.

8.3. *August*

Heavy rains, floods/flash floods and landslides took a toll of 73 lives (29 in Madhya Pradesh, 20 in Manipur, 15 in Assam, 4 each in Himachal Pradesh, Maharashtra and Karnataka. Lightning claimed 7 lives in Assam, 5 in Tamil Nadu and 1 each in Chhattisgarh, Telangana and Karnataka.

Incessant rains triggered second wave of flood in Assam and thus over flowing of river Bramhaputra and its tributaries Beki, Puthimari, Jia Bharali, Burhidehing, Dikhow, Disang, Dhansiri, Pagladiya and Kushiyara since mid August and continued upto first week of September. Around 16.4 lakh people in 2111 villages across 20 districts were affected. Crops in 1.7 lakh hectares of land and around 3.4 lakh animals and poultry got damaged. It was one of the worst floods in Assam in last five years.

8.4. *September*

According to media reports, heavy rains and floods/flashfloods took a toll of 53 people (46 in Assam, 2 each in Arunachal Pradesh and Tamil Nadu and 1 in Maharashtra). Thunderstorm/lightning claimed 29 lives in Andhra Pradesh, 16 in Telangana, 12 in Maharashtra, 9 in Odisha, 7 in Karnataka and 3 in Tamil Nadu.

Incessant rain led to swelling of rivers in Dibang district of Arunachal Pradesh. It washed away 134 houses and affected 103 families in two villages.

The inputs from the offices of India Meteorological Department *viz*., (1) Director General of Meteorology (Hydromet), New Delhi and (2) Additional Director General of Meteorology (Research), Pune are gratefully acknowledged. Thanks are due to Smt. J C. Natu, P. N. Chopade and Padma Kulkarni for their help in bringing out this summary.

Appendix

Definitions of the terms given in 'Italics'

Rainfall

Excess - Percentage departure from normal rainfall is + 20% or more.

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

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

Scanty - Percentage departure from normal rainfall is between – 60% to – 99%.

Heavy rain - Rainfall amount from 6.5 cm to 12.4 cm.

Very heavy rain - Rainfall amount more than 12.5 cm to 24.4 cm.

Extremely heavy rainfall - Rainfall amount more than 24.5 cm.

Monsoon activity

Active - Average rainfall of a sub-division is more than 1½ to 4 times the normal with minimum 5 cms along the west coast and 3 cms elsewhere in at least two stations in the sub-division.

Vigorous - Average rainfall of a sub-division is more than 4 times or more than the normal with minimum 7 cm along the west coast and 5 cm elsewhere in at least two stations in the sub-division.