MAUSAM, **64**, 3 (July 2013), 569-584

Weather in India

MONSOON SEASON (JUNE – SEPTEMBER 2012)†

1. Introduction

The seasonal rainfall (during June to September 2012) over the country as a whole was 93% of its Long Period Average (LPA) and thus categorized as a normal monsoon. However the rainfall over west Uttar Pradesh, Haryana, Punjab, Gujarat State, Madhya Maharashtra, Marathwada, north interior Karnataka and Kerala consistently was *deficient.* The second half of the season - especially the month of September - registered above *normal* rainfall, while the month of June and July experienced *deficient* rainfall.

As in the recent past years of 2002 & 2010, none of the 10 low pressure systems that formed during the monsoon season, this year, concentrated into a depression. Typical break condition did not occur all through the season, due to the occurrence of convective rainfall over the monsoon trough zone.

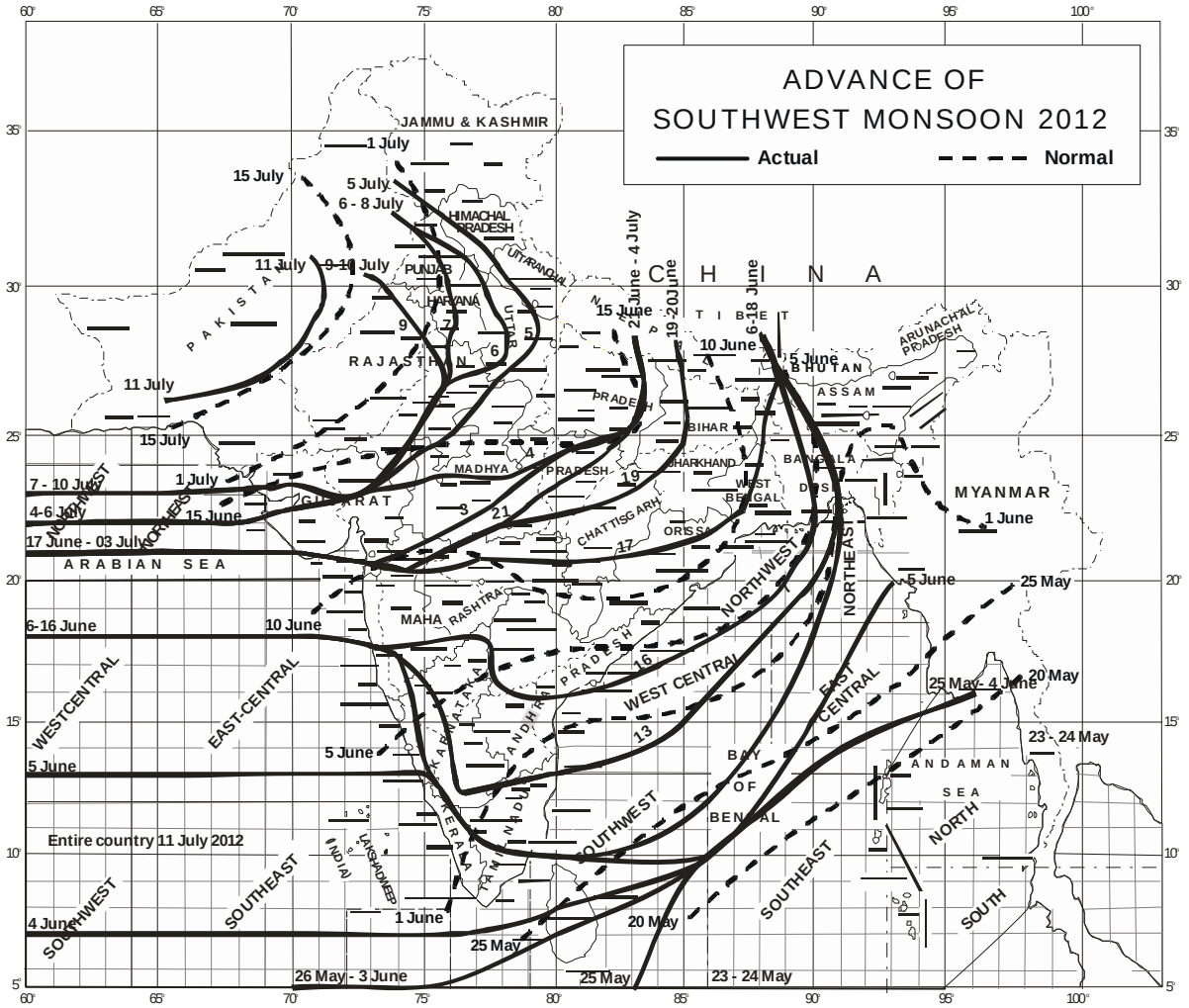

Fig. 1. Isochrones of advance of monsoon 2012

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

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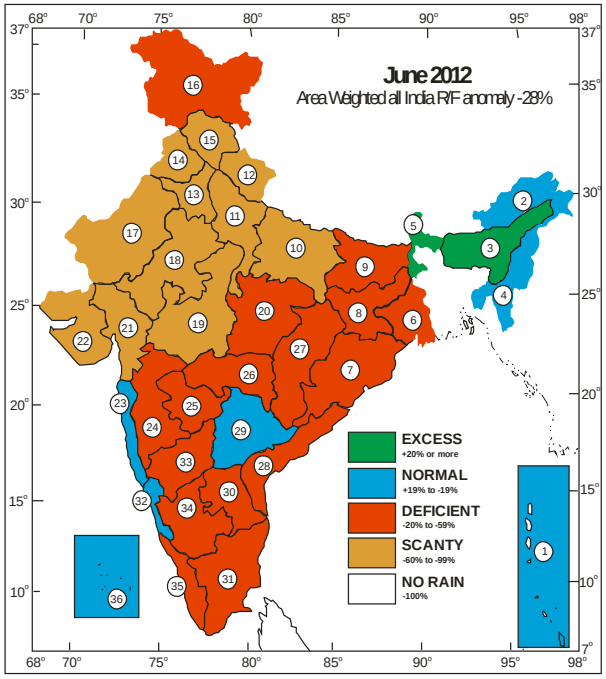


Fig. 2. Rainfall for the month of June 2012 as percentage departure from normal. 36 Sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	6	**7**	-23	**13**	-90	**19**	-62	**25**	-51	**31**	-51
2	5	**8**	-35	**14**	-78	**20**	-52	**26**	-30	**32**	-10
3	30	**9**	-43	**15**	-73	**21**	-75	**27**	-26	**33**	-47
4	-7	**10**	-76	**16**	-33	**22**	-73	**28**	-22	**34**	-49
5	26	**11**	-90	**17**	-79	**23**	-13	**29**	-14	**35**	-32
6	-43	**12**	-71	**18**	-76	**24**	-54	**30**	-48	**36**	-1

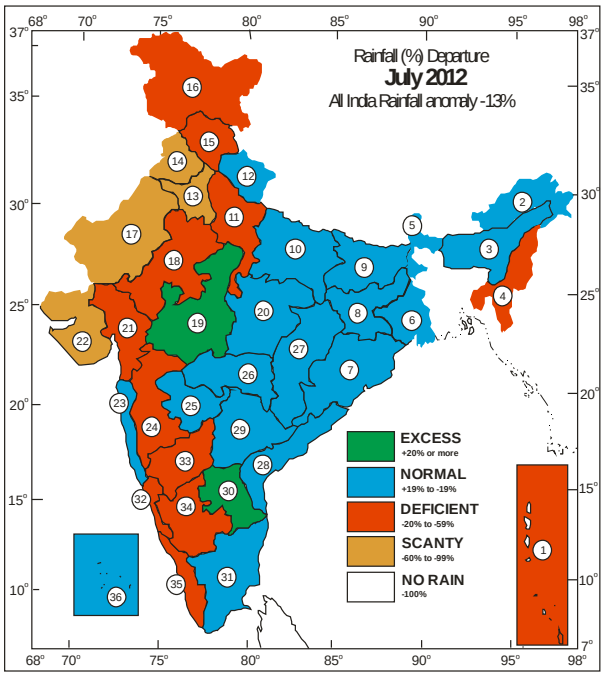


Fig. 3. Rainfall for the month of July 2012 as percentage departure from normal. 36 Sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	41	**7**	–40	**13**	–53	**19**	6	**25**	29	**31**	–6
2	3	**8**	–52	**14**	–54	**20**	–9	**26**	–19	**32**	0
3	–28	**9**	–25	**15**	–46	**21**	–19	**27**	–28	**33**	4
4	–37	**10**	–28	**16**	–36	**22**	7	**28**	4	**34**	–12
5	–2	**11**	–10	**17**	–9	**23**	29	**29**	10	**35**	–26
6	–32	**12**	6	**18**	–13	**24**	1	**30**	16	**36**	22

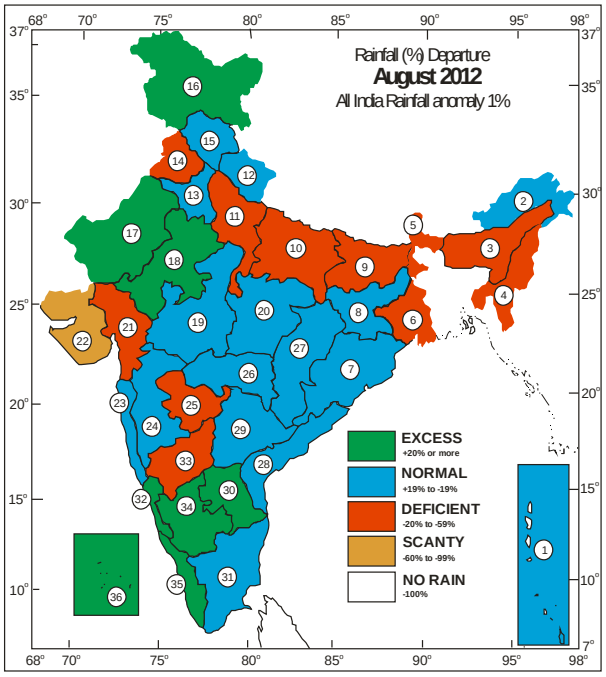
Though the NINO regions over the Pacific exhibited warming tendency during the first half of the season, the atmospheric circulation pattern resembled El-Nino - Modoki situation. Near neutral Indian Ocean Dipole pattern was present during the first half of the season which turned positive during the second half.

2. Various aspects of southwest monsoon – 2012

2.1. *Onset and advance*

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

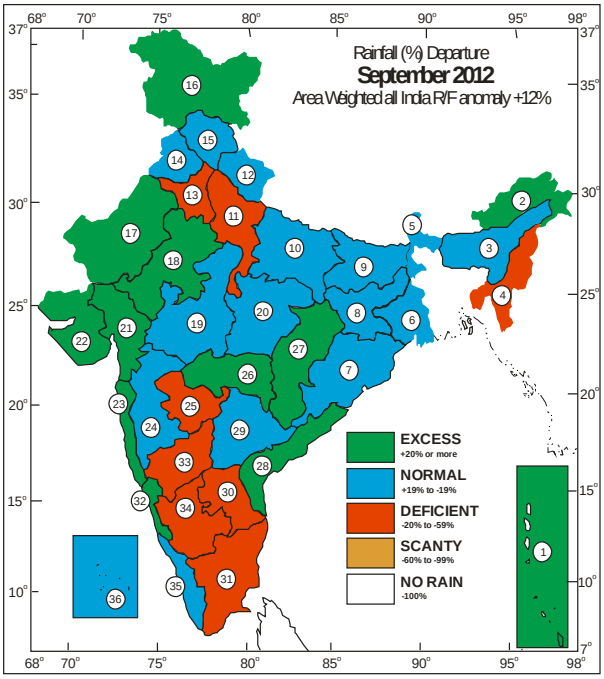
The monsoon set in over Kerala on 5th June, 4 days later than the normal date of 1st June. Though the arrival of monsoon was delayed by about 2 days over the Andaman Sea and by 3 days over Kerala, it rapidly covered south west peninsular India on 5th June itself. With the formation of a vortex in the form of an embedded upper air cyclonic circulation off Karnataka coast (6th - 7th June) in the trough off the west coast, the monsoon covered entire Goa and some parts of Konkan on 6th June. Thus, the advance of SW Monsoon along the west coast of India was very rapid. The monsoon also covered entire northeast India and some parts of Sub-Himalayan West Bengal & Sikkim on the same day. Thereafter, there was a hiatus of 6 days, during which, the off-shore trough was feeble and the vortex also became less marked. Again, with the strengthening of the Arabian Sea branch of the monsoon current, the SW monsoon advanced into most parts of peninsular India including interior Maharashtra by 17th June. Also, due to the formation of an upper air cyclonic circulation over the northwest Bay of Bengal & neighbourhood, the eastern branch of the monsoon advanced further during the subsequent days and covered Vidarbha, West Bengal & Sikkim and Odisha on 19th June and Chhattisgarh, Jharkhand and Bihar on 21st June.



EXCESS - 08 NORMAL - 16 DEFICIENT - 11 SCANTY - 01 NO RAIN - 00

Fig. 4. Rainfall for the month of August 2012 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	-6	**7**	14	**13**	-6	**19**	14	**25**	-44	**31**	-1
2	-17	**8**	-10	**14**	-38	**20**	4	**26**	1	**32**	48
3	-35	**9**	-30	**15**	10	**21**	-26	**27**	14	**33**	-21
4	-31	**10**	-21	**16**	38	**22**	-75	**28**	18	**34**	33
5	-32	**11**	-20	**17**	79	**23**	0	**29**	2	**35**	20
6	-20	**12**	8	**18**	59	**24**	-11	**30**	20	**36**	88



EXCESS - 12 NORMAL - 16 DEFICIENT - 08 SCANTY - 00 NO RAIN - 00

Fig. 5. Rainfall for the month of September 2012 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	105	**7**	4	**13**	-29	**19**	15	**25**	-24	**31**	-35
2	41	**8**	-10	**14**	-8	**20**	-12	**26**	45	**32**	33
3	7	**9**	-1	**15**	9	**21**	58	**27**	21	**33**	-48
4	-21	**10**	14	**16**	50	**22**	198	**28**	25	**34**	-32
5	16	**11**	-32	**17**	118	**23**	50	**29**	13	**35**	-2
6	-8	**12**	8	**18**	29	**24**	-19	**30**	-44	**36**	10

The shifting of east-west trough at sea level close to the foot hills of the Himalayas from 25th June - 3rd July caused prolonged stagnation of the Northern Limit of Monsoon (NLM) and there was a hiatus in advance for about 11 days from 22nd June - 2nd July. A break like situation prevailed during 25th - 29th June. During the period of hiatus, systems in westerlies gave rainfall over the northeast India and the feeble off-shore trough prevailing off the west coast gave rise to rainfall along the west coast. Due to the sluggish advance, there was a lag of nearly 2 weeks in the advance of the SW Monsoon over the west central and parts of east Uttar Pradesh for the monsoon rainfall to commence. *Heat wave* to *severe heat wave* conditions prevailed over the northern plains during this period.

With the formation of upper air cyclonic circulations over northeast Bay of Bengal as well as over the Arabian Sea off Gujarat coast during the 1st week of July and a low pressure area over north Madhya Pradesh and adjoining South Uttar Pradesh and east Rajasthan during the 2nd week of July, the east-west trough shifted southwards and became more pronounced and made conditions favourable for further advance of monsoon. Thus, there had been a rather steady advance from 3rd July and the southwest monsoon covered the entire country on 11th July, 4 days earlier than its normal date of 15th July.

2.2. *Monthly rainfall distribution*

Figs. 2-5 show monthwise distribution of rainfall.

The monthly monsoon rainfall for the country as a whole during September (112% of LPA) and August (101%) were above the respective LPA. However, the rainfall during June (72% of LPA) and July (87 % of LPA) were below the LPA.

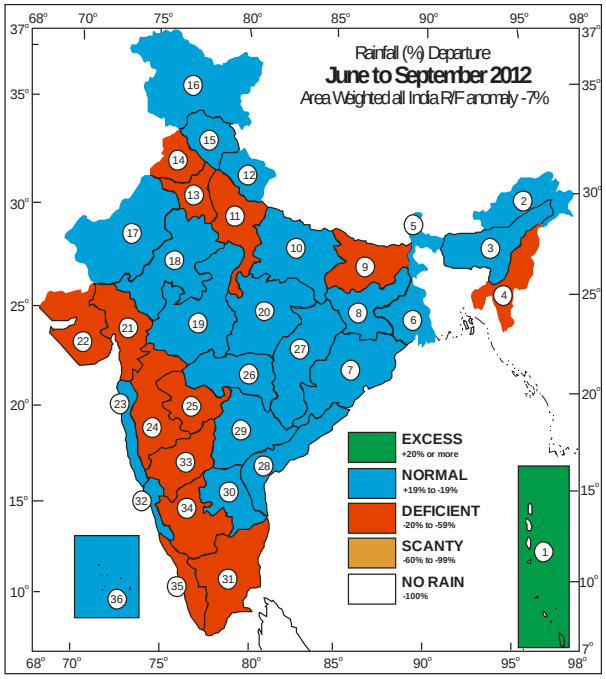


Fig. 6. Rainfall for the season as a whole (June - September) 2012 as percentage departure from normal. 36 Sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	22	**7**	-1	**13**	-39	**19**	14	**25**	-33	**31**	-23
2	4	**8**	-14	**14**	-46	**20**	-3	**26**	8	**32**	0
3	-3	**9**	-21	**15**	-16	**21**	-28	**27**	7	**33**	-36
4	5	**10**	-11	**16**	5	**22**	-34	**28**	13	**34**	-23
5	4	**11**	-29	**17**	12	**23**	-3	**29**	4	**35**	-24
6	-18	**12**	-9	**18**	10	**24**	-25	**30**	-10	**36**	15

A large rainfall deficiency was observed over major parts of the country except over northeast India and parts of west coast during June due to delayed monsoon advance over northern parts of the state, cooler than normal Sea Surface Temperatures (SSTs) over the Arabian Sea and the Bay of Bengal and near neutral or very weak IOD which turned negative towards the end of the month. No low pressure area formed during the month in either basin, of the North Indian Ocean. During the month of July, *normal* rainfall was received over most of the sub-divisions except over a few sub-divisions over the northern parts of the country, western parts of south Peninsular India and Nagaland-Manipur-Mizoram-Tripura, where it was *deficient*. During August, the sub-divisions which received *deficient* or *scanty* rainfall during the month of July; received *excess* or *normal* rainfall except for Nagaland-Manipur-Mizoram-Tripura, Punjab and Gujarat State which continued to receive *deficient* rainfall. The rainfall in Marathwada and most of the sub-divisions along the foot hills of Himalayas was also *deficient* during the month. During September, Nagaland-Manipur-Mizoram-Tripura and Marathwada continued to receive *deficient* rainfall. Many sub-divisions of Peninsular India and a few sub-divisions of northern India also received *deficient* rainfall.

2.3. *Seasonal rainfall distribution*

Meteorological sub-divisionwise seasonal rainfall distribution in terms of percentage departures from normal is given in Fig. 6. The seasonal rainfall was *excess* in 1, *normal* in 22 and *deficient* in the remaining 13 met. Sub-divisions. No sub-division reported *scanty* rainfall.

2.4. *Withdrawal of southwest monsoon*

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

The southwest monsoon withdrew from extreme western parts of Rajasthan on 24th September with a delay of more than 3 weeks as the normal date of withdrawal from this region is 1st September. On the same day, it also withdrew from some parts of northwest India, Saurashtra & Kutch and north Arabian Sea. It further withdrew from some more parts of northwest India, Gujarat State and west Madhya Pradesh on 26th September. With the formation of a well marked low pressure over the west central Bay and neighbourhood, there was moisture incursion in the lower levels and there was no further withdrawal till 7th October. Gradual penetration of dry air from north in the lower tropospheric levels with the southward shifting of Inter Tropical Convergence Zone (ITCZ), led to further withdrawal from most parts of Uttar Pradesh, some parts of Bihar, some more parts of Madhya Pradesh and Gujarat on 8th October. The ITCZ continued to shift southwards leading to the subsequent withdrawal of monsoon from remaining parts of the country.

The tendency of delayed withdrawal of southwest Monsoon from Rajasthan is being continued since 2006. The dates of initiation of withdrawal from the extreme west Rajasthan for the past five years are 30th, 29th, 25th, 27th and 23rd September respectively in the years 2007, 2008, 2009, 2010 & 2011.

The southwest monsoon withdrew from the entire country on 18th October, 3 days later than the respective normal date of 15th October. The northeast monsoon commenced over the south Peninsular India on 19th October.

TABLE 1

Details of low pressure systems for the month of June 2012

S. No.	System	Duration	Place of first location	Direction of movement	Final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**)	*Upper air cyclonic circulations*					
1.	Upto lower tropospheric levels	5 - 9	Assam & Meghalaya and neighbourhood	Stationary	*In situ*	Less marked on 10
2.	Mid & upper troposphere	11 - 13	West central Bay of Bengal off Andhra coast	East	East central and adjoining southeast Bay of Bengal	Less marked on 14
3.	Do	18 - 24	Northwest Bay of Bengal and neighbourhood	Northwest	Bihar and neighbourhood	Less marked on 25
4.	Between 2.1 & 5.8 kms a.s.l.	15	Off Goa-Maharashtra coasts	–	–	Less marked on 16
5.	Do	14 - 17	Northwest Bay of Bengal off Odisha coast	Northeast	Assam & Meghalaya and neighbourhood	Less marked on 18. It tilted southward with height on 14
6.	Upto mid tropospheric levels	14 - 21	Northeast Arabian Sea off Gujarat coast	Northnorthwest	South Pakistan and adjoining west Rajasthan	Merged with the heat low over central Pakistan on 22. It was first observed as an embedded cyclonic circulation in the off-shore trough, which lay along the west coast
7.	Between 2.1 & 5.8 kms a.s.l.	16 - 17	East central Bay of Bengal and neighbourhood	Stationary	*In situ*	Less marked on 18
8.	Mid and upper tropospheric levels	23	Gujarat Region and neighbourhood	Do	Do	Less marked on 24
9.	Upto mid tropospheric levels	28 June - 8 July	Northeast Bay of Bengal and neighbourhood	Northwest	Jharkhand and neighbourhood	It was first seen at lower levels. Merged with the cyclonic circulation associated with the low pressure area over northwest Madhya Pradesh and adjoining south Uttar Pradesh on 9 July
10.	Mid & upper tropospheric levels	28 - 29	West central Bay of Bengal off Andhra coast	Stationary	*In situ*	Merged with the cyclonic circulation (S. No. 9) on 30
(**B**)	*East-west troughs*					
1.	Lower levels/mean sea level	6 - 7	Jaisalmer to northeast Bay of Bengal	East	Bihar to central Bay of Bengal	Less marked on 8
2.	*Do*	19 June - 10 July	West Uttar Pradesh to north Bay of Bengal	Oscillatory	Rajasthan to northwest Bay of Bengal	On 25 & 26, it shifted northward and extended from Uttarakhand to Assam & Meghalaya through the foothills of the Himalayas
(**C**)	*East-west shear zone*					
1.	Between 3.1 & 4.5 kms a.s.l.	12	Along 17° N	–	–	Less marked on 13
2.	Between 5.8 & 7.6 kms a.s.l.	22 - 23	Along 17° N	North	Along 22° N	Less marked on 24
(**D**)	*Western disturbances and other eastward moving systems*					
(*i*)	*Western disturbances*					
1.	As an upper air cyclonic circulation (up to mid-tropospheric levels)	3 - 9	Northeast Afghanistan and adjoining Pakistan	Eastnortheast	Jammu & Kashmir and neighbourhood	Moved away on 10.

TABLE 1 (*Contd*.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.	As an upper air cyclonic circulation (up to mid-tropospheric levels)	12 - 17	North Pakistan and neighbourhood	Eastnortheast	Jammu & Kashmir and neighbourhood	Moved away on 18
3.	Do	18 - 20	North Pakistan and neighbourhood	Do	Do	Moved away on 21
4.	Do	22 Jun - 4 Jul	Afghanistan and neighbourhood	Do	Eastern parts of Jammu & Kashmir	Moved away on 5 July
(*ii*)	*Troughs in westerlies*					
1.	Mid and Upper Tropospheric levels. (up to 7.6 kms a.s.l)	2 - 4	Assam & Meghalaya to north Bay of Bengal	Oscillatory	Assam & Meghalaya to Arakan coast	Less marked on 5
2.	Mid Tropospheric levels (between 3.1 & 5.8 kms a.s.l)	8 - 10	North Bay of Bengal to north Andaman Sea	Do	Bihar to east central Bay of Bengal	Less marked on 11
3.	Mid troposphere	26 - 27	Sub-Himalayan West Bengal & Sikkim to Arakan coast	Do	Sub-Himalayan West Bengal & Sikkim to north Bay of Bengal	Less marked on 28

3. Chief synoptic features of southwest monsoon 2012

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

Based on the recorded history of Cyclonic Storms and Depressions, about 7 monsoon depressions develop over the Indian region during the monsoon season with a standard deviation of about 2.5. It includes two each during July, August and September and 1 during June.

No depression formed during the season.

In all, there had been 10 low pressure areas / well marked low pressure areas formed during the season. Most of them originated as upper air cyclonic circulations. Eight of them formed over the Bay of Bengal and two over the land. The Arabian Sea remained inactive throughout the season. Month wise breakup of the systems is 2 in July, 5 in August and 3 in September.

Off-shore trough along different parts of the west coast persisted from 4th June - 18th September except during 10th - 11th June and 2nd - 4th August. It was quite feeble on a few days including 8th - 9th June, 20th - 27th June, 12th - 14th July, 23rd August - 1st August, 5th August and 20th - 26th 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 (5° N - 5° S) over the Arabian Sea was stronger than normal by more than 5 kts during the first week of June. The flow was weaker than normal by about 5 kts during fourth week of June, third & fourth weeks of July and first to fourth week of August. During the rest of the season, the cross equatorial flow along the equatorial belt was close to the normal.

The surface winds over the Arabian Sea to the north of 5° N were stronger than normal by about 5 kts during first & second weeks of June and third week of September and they were weaker than normal by about 5 kts during second week of July, first, second & fourth weeks of August. They were weaker than normal by about 5-10 kts during first & third weeks of July and third week of August. They were stronger than normal by about 5-10 kts during first & second week of September 2012.

4.1.2. *Over the Bay of Bengal*

The Cross Equatorial flow along the equatorial belt (5° N - 5° S) over the Bay of Bengal was stronger

TABLE 2

Details of low pressure systems for the month of July 2012

S. No.	System	Duration	Place of first location	Direction of movement	Final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**)	*Low pressure areas*					
1.	Low pressure area	7 - 11	Northeast Madhya Pradesh and adjoining south Uttar Pradesh	Northwest	Rajasthan and neighbourhood	Merged with the seasonal low pressure area on 12. Associated cyclonic circulation extended upto mid tropospheric levels. The associated cyclonic circulation lay over Punjab and neighbourhood on 13. It moved east-northeastward and lay over east Uttar Pradesh and adjoining Bihar on 15 and became less marked on 17
2.	Do	20 - 22	Northwest Bay of Bengal	Northwest	Northeast Madhya Pradesh and adjoining areas of Chhattisgarh	Merged with the monsoon trough on 23. The associated cyclonic circulation extended upto mid tropospheric levels tilting southwards with height. It was first observed as a cyclonic circulation between 2.1 & 5.8 kms a.s.l. over north Bay of Bengal and neighbourhood
(**B**)	*Upper air cyclonic circulations*					
1.	Between 1.5 & 5.8 kms a.s.l.	1 - 7	Northeast Arabian Sea and adjoining Gujarat coast	West–northwest	South Gujarat	Less marked on 8. It was observed as an embedded cyclonic circulation at 0.9 km a.s.l. in the off-shore trough, off north Maharashtra coast on 29 June
2.	Upto mid tropospheric levels	9 - 10	Northwest Bay of Bengal and adjoining Gangetic West Bengal & Odisha	West	Odisha and neighbourhood	Became less marked on 11
3.	Upto lower levels	11	Gangetic West Bengal and neighbourhood	–	–	Less marked on 12
4.	Between 3.6 & 5.8 kms a.s.l.	13 - 14	Andaman Sea and neighbourhood	West	Southeast Bay of Bengal and neighbourhood	Less marked on 15
5.	Between 2.1 & 5.8 kms a.s.l.	13	Southwest Bay of Bengal off north Tamil Nadu coast	–	–	Less marked on 14
6.	Upto 4.5 kms a.s.l.	16 - 17	South Tamil Nadu and adjoining Sri Lanka	Stationary	*In situ*	Less marked on 18
7.	Between 3.1 & 4.5 kms a.s.l.	17	Goa coast	–	–	Less marked on 18
8.	Between 1.5 & 4.5 kms a.s.l.	23 - 27	Jharkhand and adjoining Odisha	Northwest	Punjab and neighbourhood	Less marked on 28
9.	Upto mid tropospheric levels	25	Jharkhand and adjoining areas of Odisha & Gangetic West Bengal	–	–	Less marked on 26

TABLE 2 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
10.	Upto mid tropospheric levels	26 Jul - 1 Aug	Northwest Bay of Bengal and adjoining coastal areas of Gangetic West Bengal	Northwest	West Uttar Pradesh and neighbourhood	Less marked on 2 August
11.	Do	27 - 31	Northwest Madhya Pradesh and adjoining south Uttar Pradesh	Do	Punjab and neighbourhood	Less marked on 1 August
12.	Do	30 Jul - 1 Aug	Gangetic West Bengal and neighbourhood	Do	Gangetic West Bengal and adjoining Jharkhand	Less marked on 2 August
(**C**)	*East-west shear zone*					
1.	Between 3.1 & 7.6 kms a.s.l.	1 - 4	Along Lat. 17° N	North	Along Lat. 20° N	Less marked on 5
(**D**)	*Western disturbances and other eastward moving systems*					
(*i*)	*Western disturbances*					
1.	As an upper air cyclonic circulation (upto mid tropospheric levels)	15 - 17	Nnorth Pakistan and adjoining Jammu & Kashmir	Northeast	Northern parts of Jammu & Kashmir	Moved away on 18
2.	Do	30 Jul - 1 Aug	Do	Do	Eastern parts of Jammu & Kashmir	Moved away on 2 August
(*ii*)	*Troughs in westerlies*					
1.	Mid & upper troposphere	12 - 13	Along Long. 72° E to the north of Lat. 35° N (at 5.8 kms a.s.l)	East	Long. 78° E to the north of Lat. 35° N	Moved away on 14
2.	Lower levels	18	Sub-Himalayan West Bengal & Sikkim to east central Bay of Bengal	Stationary	*In situ*	Less marked on 19

than normal by more than 5 kts during first week of June, first & second weeks of July, third week of August and first & third weeks of September. It was also stronger than normal by 5-10 kts during fourth week of July.

The surface winds over the Bay of Bengal to the north of 5° N were stronger than normal by 5-10 kts during first week of June, second & fourth weeks of July, first & fourth weeks of August and second & third weeks of September. They were also stronger than normal by about 5 kts during second & third weeks of June, first week of July and first & fourth weeks of September. They were almost normal for the remaining weeks during the season.

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 2012. The month wise break-up is 4 each in June & July, 5 in August and 3 in September.

4.3. *Systems in southern hemisphere*

4.3.1. *Tropical storms/depressions*

There was only one low-pressure system, a tropical storm during the month of June, (reaching the intensity

TABLE 3

Details of low pressure systems for the month of August 2012

S. No.	System	Duration	Place of first location	Direction of movement	Final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**) *Low pressure areas*						
1.	Low pressure area	3 - 9	Northwest Bay of Bengal and adjoining coastal areas of north Odisha and Gangetic West Bengal	Northwest	Northwest Madhya Pradesh and neighbourhood	Merged with the monsoon trough on 10. It was observed as a cyclonic circulation between 2.1 and 3.6 kms a.s.l. over northwest Bay of Bengal and adjoining Gangetic West Bengal. It moved inland on 3rd evening. The associated cyclonic circulation extending upto lower tropospheric levels lay over west Uttar Pradesh and neighbourhood on 11 and became less marked on 12
2.	Do	12 - 14	Northwest Madhya Pradesh and neighbourhood	Northwest	East Rajasthan and adjoining northwest Madhya Pradesh	Merged with the monsoon trough on 15. It was first observed as a cyclonic circulation extending upto mid tropospheric levels over north Bay of Bengal and adjoining coastal areas of West Bengal on 9. It moved inland and lay over coastal areas of north Odisha and adjoining Gangetic West Bengal on 10 and over Chhattisgarh and neighbourhood on 11. The associated cyclonic circulation extending upto mid tropospheric levels lay over north Rajasthan and neighbourhood from 15-17 and became less marked on 18
3.	Do	17 - 22	Northwest Bay of Bengal and neighbourhood	Northwest	South Uttar Pradesh and adjoining areas of northwest Madhya Pradesh and east Rajasthan	Less marked on 23. It was first observed as a cyclonic circulation extending upto mid tropospheric levels over northwest Bay of Bengal and adjoining coastal areas of north Odisha and West Bengal from 14-16. The associated cyclonic circulation extending upto mid tropospheric levels lay over Haryana and neighbourhood on 23 and merged with the cyclonic circulation associated with the Heat Low on 24
4.	Do	25 - 27	North Bay of Bengal and neighbourhood	Northwest	Northeast Madhya Pradesh and adjoining areas of Chhattisgarh	Merged with the monsoon trough on 28. It moved inland on 26. It was first observed as a cyclonic circulation extending upto lower levels on 24. The associated cyclonic circulation extending upto mid tropospheric levels lay over east Madhya Pradesh and neighbourhood on 28 and merged with the monsoon trough on 29
5.	Do	30 - 31	West central & adjoining northwest Bay of Bengal off south Odisha-north Andhra Pradesh coasts	Do	West Madhya Pradesh and neighbourhood	It moved inland and lay over southeast Madhya Pradesh and adjoining Vidarbha and Chhattisgarh on 31st August. Merged with the monsoon trough on 1 September. It was first observed as a cyclonic circulation over west central and adjoining northwest Bay of Bengal on 29. Associated cyclonic circulation tilted southwestwards with height

TABLE 3 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**B**)	*Upper air cyclonic circulations*					
1.	Upto lower tropospheric levels	5 - 7	Northwest Rajasthan and neighbourhood	Stationary	*In Situ*	Merged with the heat low on 8
2.	Between 1.5 & 5.8 kms a.s.l.	20 - 21	Gujarat Region and neighbourhood	Do	Do	Less marked on 22
3.	Upto mid tropospheric levels	27 - 28	North Rajasthan and adjoining Haryana	Do	Do	Less marked on 29
4.	Between 2.1 & 5.8 kms a.s.l.	23 - 24	Southeast Arabian Sea and adjoining Lakshadweep area	Oscillatory	East central Arabian Sea off Goa-Karnataka coasts	It was embedded in an east-west shear zone. Both became less marked on 25
5.	Upto mid tropospheric levels	30 - 31	Haryana and neighbourhood	Northwest	Punjab and neighbourhood	Less marked on 1 September
(**C**)	*Western Disturbances and other eastward moving systems*					
(*i*)	*As upper air cyclonic circulations*					
1.	Upto mid tropospheric levels	15 - 19	North Pakistan and neighbourhood	Northeast	Northern parts of Jammu & Kashmir	Moved away on 20

of Tropical Depression and above) reported during Southern Hemisphere during June - September 2012.

4.3.2. *Mid-Latitude troughs*

The number of troughs in upper tropospheric westerlies affecting the Indian region which penetrated south of 30° N is 1 in July and 2 in September at 300 hPa level and 1 each in June & July and 3 in September at 500 hPa level.

4.3.3. *Troughs in mid & upper tropospheric westerly over the south Indian Ocean*

There were 13 troughs in upper air 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 2012. The month wise break-up is 3 each in June, August and September and 4 in July.

4.4.3. *Mascarene HIGH*

The mean position of Mascarene HIGH during June to September 2012 was 33.6° S / 65° E. The intensity of Mascarene HIGH was above normal by 2.25 hPa during the monsoon period June to September 2012. It was above normal by 1.0, 3.8, 0.9 and 3.3 hPa during the months of June, July, August and September 2012 respectively. (*Source* : ACMAD, NOAA)

Though the mean monthly values of intensity remained above normal, the position of Mascarene HIGH showed large oscillations and often found to be located much to the east/southeast of its normal position, thereby adversely affecting the strength of cross equatorial flow.

5. Semi-permanent systems

5.1. *Heat LOW*

The Heat LOW got established in its near normal position over Pakistan and neighbourhood around 7th June. It remained in the near normal position during June & July. It was to the north to northwest of its normal position on many days during August. The LOW started filling up from 24th August and became less marked from 13th September.

An analysis of the monthly composite patterns of surface air temperature and pressure contours (from the CPC-NOAA re-analysis) during each month, around the Heat LOW region normally centred near Lat. 28° N / Long. 68° E, close to Jacobabad in Pakistan (figures not re-produced here) revealed that the monthly mean position of the Heat LOW was located to the northeast of its normal position during the season. Over the Heat LOW region, the Sea Level Pressure anomalies indicate stronger than normal Heat LOW in July and normal in June, August and September. However, the surface temperature

TABLE 4

Details of low pressure systems for the month of September 2012

S. No.	System	Duration	Place of first location	Direction of movement	Final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**)	*Low pressure areas*					
1.	Well-marked low pressure area	3 - 10	West central and adjoining northwest Bay of Bengal off north Andhra Pradesh–south Odisha coasts	Northwest	Southeast Pakistan and adjoining southwest Rajasthan	It was first observed as a cyclonic circulation over west central and adjoining northwest Bay of Bengal off north Andhra Pradesh–south Odisha coasts on 1 September. The low pressure area moved inland and lay as a well–marked low pressure area and lay over Odisha and adjoining Chhattisgarh on 4. It became low pressure area on 6 and lay over west Madhya Pradesh and neighbourhood. It became less marked on 11. The associated cyclonic circulation extended upto mid tropospheric levels tilting southwestwards with height. It lay over southeast Pakistan and neighbourhood from 11-15 and became less marked on 16
2.	Low pressure area	10 - 11	Chhattisgarh and adjoining Odisha	Do	Central parts of Madhya Pradesh and neighbourhood	It was first observed as a cyclonic circulation extending upto mid tropospheric levels over northwest Bay of Bengal and adjoining north Odisha-West Bengal coasts on 8. The low pressure area became less marked on 12. The associated cyclonic circulation lay over west Madhya Pradesh and neighbourhood on 12 and became less marked on 13
3.	Well marked low pressure area	27 Sep - 2 Oct	West central Bay of Bengal and neighbourhood	Westward	Telangana & neighbourhood	It was first observed as a cyclonic circulation over the same area on 25. The low pressure area became well marked on 27 evening. It moved inland and lay as a low pressure area over Telangana and neighbourhood on 2 October and became less marked on 3 October. The associated cyclonic circulation extended upto mid tropospheric levels lay over Vidarbha and neighbourhood 3 and became less marked on 4 October
(**B**)	*Upper air cyclonic circulations*					
1.	Upto mid tropospheric levels	1 - 5	Gujarat Region and neighbourhood	Quasi-Stationary	Saurashtra & Kutch and neighbourhood	Merged with the cyclonic circulation associated with the low pressure area over west Madhya Pradesh and neighbourhood on 6 evening
2.	Do	6 - 7	Tenasserim coast and neighbourhood	–	–	Less marked on 8
3.	Lower & mid tropospheric levels	13 - 19	Jharkhand and neighbourhood	Northwest	West Uttar Pradesh and neighbourhood	Less marked on 20
4.	Upto mid tropospheric levels	17 - 21	Northwest Bay of Bengal and adjoining coastal areas of Odisha	Do	Odisha and adjoining Jharkhand	Became less marked on 22 It lay as an embedded cyclonic circulation in the North-South trough on 20 & 21

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
5.	Between 2.1 & 4.5 kms a.s.l.	19 - 22	East central Arabian Sea and adjoining Maharashtra - Karnataka coasts	Stationary	*In situ*	Became unimportant on 23
6.	Upto mid tropospheric levels	28 Sep - 9 Oct	East central Arabian Sea off Maharashtra coast	Quasi-Stationary	East central Arabian Sea	Became unimportant on 10 October. A trough ran eastwards from the system to Tamil Nadu across Karnataka on 9
(**C**)	*Western disturbances and other eastward moving systems*					
(*i*)	*Western disturbances*					
1.	As an upper air cyclonic circulation (Upto 4.5 kms a.s.l.)	23 - 24	North Pakistan and adjoining Jammu & Kashmir	Northeast	Northern parts of Jammu & Kashmir	Moved away on 25
2	Do	26 - 28	North Pakistan and neighbourhood	Do	North Pakistan and adjoining Jammu & Kashmir	Moved away on 29
(*ii*)	*Troughs in westerlies*					
1.	Mid and upper troposphere	7 - 8	Along Long. 64° E, to the north of Lat. 30° N (at 5.8 kms a.s.l.)	Northeast	Long. 64° E, to the north of Lat. 35° N	Moved away on 9
2.	Do	17 - 18	Do (at 7.6 kms a.s.l.)	Do	Long. 68° E, to the north of Lat. 25° N	Became unimportant on 19
3.	Do	30 Sep - 3 Oct	Along Long. 66° E, to the north of Lat. 27° N (at 5.8 kms a.s.l.)	Do	Long. 74° E, to the north of Lat. 20° N	Moved away on 4 October
(*iii*)	*North-South troughs*					
1.	Lower level westerlies	20 - 25	Bihar to coastal Andhra Pradesh across Jharkhand and Odisha	Northeast	Northwest and west central Bay of Bengal	An embedded cyclonic circulation lay over north Bay of Bengal and neighbourhood on 25, which became less marked on 27 and the trough became less marked on 26

anomalies are not consistent with the centres of the Heat LOW.

5.2. *Axis of the monsoon trough*

A trough at mean sea level made a temporary appearance at its normal position on 6th June and became less marked on 8th June. It re-appeared at the mean sea level and extended from Uttarakhand/west Uttar Pradesh to north Bay of Bengal from 19th - 24th June. Then, the eastern end of the trough also shifted northwards and the trough remained close to the foothills of the Himalayas on 25th & 26th June. Subsequent to the southward shift of the eastern end, it was seen upto northwest/north Bay during 27th June - 3rd July. Then, the western end also shifted southwards and the trough was seen in its normal position from 4th - 10th July and also extended up to lower tropospheric levels.

With the South West monsoon covering the entire country, the heat trough established as the monsoon trough on 11th July. The eastern end of it then shifted northwards during 12th - 13th July and the western end lay close to the foot hills of Himalayas on 15th - 16th July. During 17th - 19th July, the trough lay close to the foot hills of Himalayas. With the formation of the low pressure area on 20th July over northwest Bay of Bengal, the trough regained its normal position and generally extended upto lower tropospheric levels during 20th July - 16th August. The trough exhibited wide north-south oscillations till 28th August and was confined to lower tropospheric levels. It then shifted southwards on 29th August and was active with two embedded low pressure areas (30th - 31st August and 3rd - 11th September). The trough remained to the south of its normal position till the second week of September. It also extended up to mid-tropospheric levels. However, the eastern end of the trough shifted to the north

of the normal position after the dissipation of the first low pressure area and the trough was confined to lower levels. With the formation of the second low pressure area, the eastern end was again seen to the south of normal position. Its characteristic southward tilt with height was seen from 3rd - 6th September.

Subsequent to the dissipation of the low pressure area, the trough regained its normal position and was seen only at mean sea level. It became less marked on 20th September.

5.3. *Tibetan anticyclone/HIGH*

The Tibetan Anticyclone (TA) got established to the south to southeast of its normal position at 300 & 200 hPa on 16th June. It was noticed all through the remaining period of the season.

An analysis of the monthly mean characteristics of this anticyclone using the CDC / NOAA data shows that the anticyclone remained to the south/southeast of normal position during June, near normal duirng July and September and slightly to the west of normal position duirng August. However, the intensity showed wide variations as noticed from the anomalous fields (Figures not shown).

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

STWJ started shifting northwards from the second week of June. Delhi reported 87 knots wind (at 335 hPa) on 7th June (1200 UTC). Subsequently the STWJ shifted to the north of the Himalayas. However, it made occasional re-appearances along the latitudes of Srinagar and Patiala during the first fortnight of July. Towards the end of the season, it once again shifted southwards as evidenced by the 70 knots westerly wind reported over Srinagar at 333 hPa on 15th September (0000 UTC).

5.5. *Tropical Easterly Jet (TEJ)*

TEJ got established over the southern tip of Peninsular India by 19th May with Kochi reporting easterlies of 60 kts around 100 hPa levels on 19th May. The wide latitudinal spread of the easterly jet speed winds was noticed during the whole of the season. A core wind speed of above 100 kts was noted over : Kochi on 6th, 15th & 16th July, Panjim on 6th July and Minicoy on 13th September.

Jet speed winds were also reported over Visakhapatnam, Bhubaneswar, Nagpur, Bhopal, Raipur, Ahmedabad and Kolkata on several days during the season.

6. Anomalous circulation

6.1. *Monthly wind anomalies during southwest Monsoon 2012*

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

6.1.1. *June wind anomaly features*

In the monthly anomaly winds, three anomalous cyclonic circulations were observed at 850 hPa level, one over the southeast Arabian sea & neighborhood, second over North Andaman sea adjoining South East Bay of Bengal extending upto 700 hPa level and third over Assam & Meghalaya & neighborhood. Anomalous anticyclonic circulations were observed at 850 hPa level over North East Arabian sea off Gujarat coast and at 700 hPa level over North West Bay off Gangetic West Bengal coast.

An anomalous cyclonic circulation was seen over the SW Bay of Bengal off Tamil Nadu coast at 850 hPa extending upto 700 hPa level. Another anomalous cyclonic circulation was observed at 700 hPa level over EC Arabian sea off Maharashtra coast. At 500 hPa level, anomalous cyclonic circulation was observed over Assam Meghalaya & neighborhood. A Ridge line at 200 hPa ran along 25° N.

During the week ending 6th June, three anomalous cyclonic circulations were observed at 850 hPa level, one over Chhattisgarh & neighborhood extending upto 700 hPa, second over Nagaland-Manipur-Mizoram-Tripura & neighborhood and third over North Andaman Sea. Anomalous anticyclonic circulation was observed over South East Arabian sea off Kerala coast at 850 hPa. An anomalous cyclonic circulation over West Madhya Pradesh and adjoining East Uttar Pradesh was observed at 700 hPa.

During the week ending 13th June, two anomalous cyclonic circulations were observed at 850 hPa, one over East Central Arabian sea off Maharashtra coast extending upto 700 hPa level and another over Arunachal Pradesh. An anomalous anticyclonic circulation was seen over Jharkhand and neighborhood at 700 hPa extending upto 500 hPa level.

During the week ending 20th June, anomalous cyclonic circulation was observed at 850 hPa level over Assam & Meghalaya extending upto 500 hPa level. Another anomalous cyclonic circulation was observed at 700 hPa level over Telangana and neighborhood

extending upto 500 hPa level. An anomalous anticyclonic circulation was seen over East Central Arabian Sea off Maharashtra coast at 850 hPa.

During the week ending 27th June, two anomalous cyclonic circulations were observed at 850 hPa level, one over Southwest Bay of Bengal off South Tamil Nadu coast and other over North Andaman sea extending upto 700 hPa. Also, anomalous cyclonic circulation was observed at 700 hPa level over East Central Arabian sea off Karnataka coast. An anomalous anticyclonic circulation was observed over West Central Bay of Bengal off South Andhra Pradesh coast at 500 hPa level.

6.1.2. *July wind anomaly features*

The monthly anomaly winds showed, two anomalous cyclonic circulations at 850 hPa level, one over Assam & Meghalaya and another over North West Bay off Gangetic West Bengal coast extending upto 700 hPa. An anomalous anticyclonic circulation was observed at 850 hPa over Gujarat & neighborhood extending upto 500 hPa levels.

An anomalous cyclonic circulation was observed at 700 hPa level over Odisha and neighborhood extending upto 500 hPa level.

During the week ending 4th July, three anomalous cyclonic circulations were observed at 850 hPa level extending upto 700 hPa level. One was seen over eastcentral Arabian Sea off Maharashtra coast, second over West Central Bay of Bengal and neighbourhood and third over Nagaland-Manipur-Mizoram-Tripura & neighborhood. An anomalous anticyclonic circulation was observed at 850 hPa over Rajasthan and neighborhood extending upto 700 hPa.

During the week ending 11th July, three anomalous cyclonic circulations were observed at 850 hPa level, one over west Uttar Pradesh & neighborhood extending upto 500 hPa level, second over Assam & Meghalaya and third over South West Bay of Bengal off south Tamil Nadu coast extending upto 700 hPa level.

During the week ending 18th July, anomalous cyclonic circulation was observed at 850 hPa level over South West Bay off south Tamil Nadu coast. Ridge line at 200 hPa level ran along Lat. 22° N. Anomalous anticyclonic circulations were seen over Gujarat & neighborhood at 850 hPa extending upto 300 hPa level and over North West Bay of Bengal off West Bengal coast at 850 hPa extending upto 500 hPa.

During the week ending 25th July, two anomalous cyclonic circulations were observed at 850 hPa level, one over North West and adjoining West Central Bay of Bengal and other over Assam & Meghalaya extending upto 700 hPa. Also, anomalous cyclonic circulation was observed over Jharkhand & neighborhood at 700 hPa level extending upto 500 hPa level. Two anomalous anticyclonic circulations were seen, one over Rajasthan & neighborhood at 700 hPa level extending upto 500 hPa level and other over Gangetic West Bengal & neighborhood at 500 hPa level.

During the week ending 1st August, three anomalous cyclonic circulations were observed at 850 hPa level, one over NW Bay of Bengal off West Bengal coast extending upto 500 hPa level, second over Arunachal Pradesh & neighborhood and third over East Uttar Pradesh & neighborhood. Also, anomalous cyclonic circulation was observed at 700 hPa over East Madhya Pradesh & neighbourhood extending upto 500 hPa level. Anomalous anticyclonic circulation was observed at 700 hPa over Rajasthan adjoining Gujarat extending upto 500 hPa. Ridge line at 200 hPa ran along 30°N.

6.1.3. *August wind anomaly features*

Monthly anomalous wind pattern showed, anomalous cyclonic circulation at 850 hPa level over west Uttar Pradesh & neighborhood extending upto 700 hPa. Two anomalous anticyclonic circulations were observed at 850 hPa, one over Gujarat & neighborhood and other over Gangetic West Bengal and neighborhood extending upto 700 hPa. The ridge line at 200 hPa ran along 30° N.

At 500 hPa level, anomalous cyclonic circulation was observed over South West and adjoining West Central Bay of Bengal.

During the week ending 8th August, two anomalous cyclonic circulations were observed at 850 hPa level extending upto 500 hPa level, one over West Central and adjoining North West Bay of Bengal and other over Nagaland-Manipur-Mizoram-Tripura & neighbourhood. An anomalous anticyclonic circulation was seen over the North West Arabian Sea off Gujarat coast at 850 hPa level.

During the week ending 15th August, two anomalous cyclonic circulations were observed at 850 hPa level, one over West Madhya Pradesh and adjoining East Rajasthan extending upto 500 hPa level and other over Assam & Meghalaya & neighbourhood at 850 hPa extending upto 500 hPa level.

During the week ending 22nd August, anomalous cyclonic circulation was observed at 700 hPa level over Chhattisgarh and adjoining Telangana extending upto 500 hPa level. An anomalous anticyclonic circulation was seen

over North Bay of Bengal and adjoining Gangetic West Bengal at 850 hPa extending upto 700 hPa.

During the week ending 29th August, anomalous cyclonic circulation was observed at 850 hPa level over East Rajasthan & neighbourhood extending upto 700 hPa level.

6.1.4. *September wind anomaly features*

The monthly anomaly winds showed, three anomalous cyclonic circulations at 850 hPa, one over North West Bay of Bengal off north Odisha coast, second over Assam & Meghalaya and third over West Rajasthan & neighborhood. An anomalous anticyclonic circulation was observed over Vidarbha and adjoining Telangana at 850 hPa extending upto 700 hPa.

During the week ending 5th September, three anomalous cyclonic circulations were observed at 850 hPa, one over North West Arabian Sea off Gujarat-Maharashtra coasts extending upto 700 hPa level, second over West Central Bay of Bengal off South Andhra Pradesh coast extending upto 700 hPa level and third over South East Bay of Bengal extending upto 700 hPa level.

During the week ending 12th September, two anomalous cyclonic circulations were observed at 850 hPa, one over Gujarat and adjoining West Rajasthan and second over north Odisha and neighborhood extending upto 500 hPa level.

During the week ending 19th September, anomalous cyclonic circulation was observed at 850 hPa level over Bihar & neighborhood. At 200 hPa level, ridge line ran along 26° N. In the week ending 26th Septtember, anomalous cyclonic circulation was observed at 850 hPa over West Rajasthan & neighborhood extending upto 700 hPa level. Anomalous anticyclonic circulation was observed at 850 hPa over Peninsular India extending upto 700 hPa.

During the week ending 3rd October, anomalous cyclonic circulation was observed at 850 hPa over South Andhra Pradesh coast and adjoining Telangana extending upto 500 hPa level. Ridge line ran along 23° N at 200 hPa level.

7. Significant temperature during the season

Severe heat wave/heat wave conditions prevailed over some parts of north, central and east coast of India during first three weeks of June and then it was confined to northern plains up to first fortnight of July. The highest maximum temperature of 48.6° C was recorded at Churu (West Rajasthan) on 2nd July 2012.

8. Disastrous weather events and damage during Monsoon months

8.1. *June*

According to media reports, *Heat wave, heavy rains*, intense convective rainfall, floods, Thunderstorm, Thunder Squall, lightning and landslides took a toll of 527 people (170 in West Bengal, 137 each in Assam and Jharkhand, 35 in Odisha, 23 in Gujarat, 9 in Bihar, 7 in Sikkim, 6 in Maharashtra and 1 each in Jammu & Kashmir, Chhattisgarh and Tripura).

Apart from the loss of life, around 9.35 lakh hectares of land was affected, power supply disrupted, trees uprooted, standing crops, houses were damaged and low lying areas flooded in Assam. Kaziranga National Park was flooded, which caused Loss of hundreds of animal life. In all 27 districts, more than 24 lakh people were affected in floods which occurred in two spells. There were floods in Arunachal Pradesh, Manipur and West Bengal too but no casualties were reported. More than 50,000 people were affected and hundreds of houses were damaged.

8.2. *July*

According to media reports, *heat wave*, *heavy rains*, floods, thunderstorm, lightning and landslides took a toll of 174 people (37 in West Bengal, 18 each in Mizoram and Bihar, 16 in Madhya Pradesh, 13 in Odisha, 11 each in Himachal Pradesh and Maharashtra, 9 in Andhra Pradesh, 7 each in Assam, Uttar Pradesh and Jharkhand, 5 in Gujarat, 4 in Tamil Nadu, 3 each in Jammu & Kashmir and Meghalaya, 2 each in Haryana and Rajasthan and 1 in Karnataka).

Incessant rain/*heavy rain* caused flooding in West Bengal, Assam, Manipur, Maharashtra, Chhattisgarh and Tamil Nadu. Around 80,000 people were affected in West Bengal. Inundation of low lying areas, hundreds of houses, standing crops, power supply and all communication systems were affected in flooded regions. In Tamil Nadu, strong winds and heavy rain damaged several houses (18 houses fully & 70 partially) and banana plantation worth Rs 2 lakh. Trees were also uprooted. An estimated loss of property worth 1 crore was reported.

8.3. *August*

Heavy rains, floods, thunderstorm, lightning and landslides took a toll of 263 lives (46 in Rajasthan, 38 in Uttarakhand, 28 in Jammu & Kashmir, 21 in Jharkhand, 20 in Madhya Pradesh, 19 in Kerala, 18 in West Bengal, 13 in Gujarat, 12 in Uttar Pradesh, 10 in Assam, 8 in Himachal Pradesh, 7 in Karnataka, 6 each in Bihar and

Chhattisgarh, 5 in Maharashtra, 2 each in Odisha, Mizoram, and Andhra Pradesh).

Heavy rain caused overflowing of Bhagirathi, Alaknanda, Yamuna and Ganga river in Uttarakhand; Chenab, Tawi, Ujhand and Basantar in Jammu & Kashmir and Saryu, Sharda and the Ghagra rivers in Uttar Pradesh. Several bridges were washed away and national highways blocked due to landslide. In Assam, overflowing of Brahmaputra and its tributaries affected 1 lakh people in 82 villages. In Madhya Pradesh 50,000 people were affected in floods. In Kerala heavy rain caused inundation of low lying areas and around 1500 houses were damaged.

8.4. *September*

According to media reports, *heavy rains*, floods, thunderstorm, lightning and landslides took a toll of 324 people (64 in Uttar Pradesh, 48 in Uttarakhand, 29 each in Gujarat and Maharashtra, 25 in Sikkim, 22 in Odisha, 21 in Assam, 18 in Bihar, 12 each in Himachal Pradesh and Andhra Pradesh, 11 in West Bengal, 9 each in Arunachal Pradesh and Rajasthan, 7 in Madhya Pradesh, 3 each in Jharkhand and Tamil Nadu and 1 each in Punjab and Jammu & Kashmir).

In Assam, Arunachal Pradesh, West Bengal, Gujarat, Bihar, Maharashtra and Madhya Pradesh incessant rain caused flooding. The rivers flowing above the danger level severely affected Assam, Arunachal Pradesh and West Bengal. Thirty one lakh people in Assam, 1.5 lakh in Arunachal Pradesh and 80,000 in West Bengal were affected. Submerging of low lying areas, damage to standing crops in more than 3 lakh hectares, house collapse, disruption in power supply, transport and communication systems were reported. In Uttarakhand massive landslide, triggered by cloudburst as reported by media, claimed 48 lives.

9. Severe floods experienced during southwest Monsoon 2012

During the southwest monsoon season 2012, many states *viz*., Arunachal Pradesh, Assam & Meghalaya, West Bengal, Bihar, Odisha, Uttar Pradesh, Uttarakhand, Jammu & Kashmir, Himachal Pradesh, Rajasthan, Madhya Pradesh, Gujarat, Maharashtra, Chhattisgarh, Karnataka and Kerala experienced flood/flash flood situations during various periods of the season. Incessant heavy rainfall associated with the low pressure systems as well as dis-organized convective activity in the form of scattered thunder showers were the major causes of flood.

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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.

Maximum/day temperatures

According to the revised criteria, since 1st March 2002, Heat Wave is declared only when the maximum temperature of a station reaches at least 40 °C for plains and at least 30 °C for Hilly regions.

Severe heat wave conditions	- Departure of maximum temperature from normal is +6 °C or more for the regions were the normal maximum temperature is more than 40 °C and +7 °C or more for regions were the normal maximum temperature is 40 °C or less.
Heat wave conditions	- Departure of maximum temperature from normal is + 4 °C to + 5 °C or more for the regions where the normal maximum temperature is more than 40 °C and departure of maximum temperature from normal is + 5 °C to + 6 °C for regions where the normal maximum temperature is 40 °C or less