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Weather in India

MONSOON SEASON (June - September 2021)†

1. Introduction

The rainfall over the country as a whole during the monsoon season (June-September) 2021 was 99% of its long period average (LPA) thus categorized as *normal* monsoonrainfall. None of the low-pressure systems that formed during the monsoon season this year, intensified into a Depression during June to August, the first intense system of the season formed in the month of September as a Deep Depressionover northwest Bay of Bengal (12-15 September, 2021). Other than this system, 2 Cyclonic storms, 4 Well Marked Low Pressure systems and 9 Low Pressure systems formed in the monsoon months over the north Indian ocean. Southwest monsoon reached over the parts of Andaman Sea on 21 May (normal date 22 May). However, it set in over Kerala on 3 June, 2 days later than its normal date and covered the entire country on 13 July, with a delay of 5 days than its normaldate (8 July). A long hiatus of 22 days, from 20 June to 11 July during the advance of the monsoon was observed over northwest India. Typically, the monsoon current begins to withdraw around 17 September, with the retreat completed by 15 October. This year, the withdrawal began on 6 October and was over by 25 October with the commencement of the northeast monsoon rains on the same day. A negative Indian Ocean Dipole (IOD) was observed from May 2021, it remained moderately strong up until August 2021 and the negative IOD weakened and turned into neutral IOD conditions during September. Neutral El Nino Southern Oscillation (ENSO) conditions were recorded during May 2021 and continued up to July 2021, the cool ENSO started strengthening during August and weak La Nina conditions were established by September 2021. The Madden Julian oscillation (MJO) in June was over Phase 1 in the western hemisphere, it was in Phase 2 and Phase 3 over the Indian Ocean in the first fortnight of July but was weak. By second week of September it strengthened and was observed over Phase 2 which was advantageous for the Indian monsoon.

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

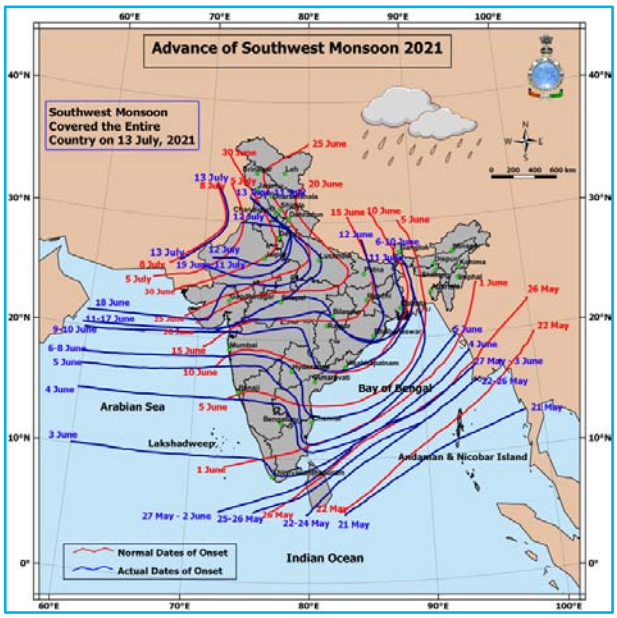

Fig. 1. Isochrones of advance of SW monsoon 2021

2. Various aspects of southwest Monsoon 2021

2.1. *Onset and advance*

Fig. 1 shows the isochrones for advance of monsoon over the country. Southwest monsoon advanced into some parts of southwest Bay of Bengal, most parts of southeast Bay of Bengal, south Andaman Sea and Nicobar Islands and some parts of north Andaman Sea, on the 21 May, 2021 in association with the strengthening and deepening of southwesterly winds over the region and widespread rainfall activity. It advanced into Kerala on 3 June with a delay of 2 days (normal date 1 June). The further advance of the monsoon current was swift and it covered most of the country outside parts of Rajasthan, Delhi, Uttar Pradesh, Haryana and Punjab by 19 June. Due to unfavorable conditions, alengthy hiatus in the progress of monsoon into parts of northwest India was experienced from 20 June to 11 July (22 days). The dry westerly winds were prevalent over northwest India at lower levels, MJO

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TABLE 1

Advance of southwest Monsoon 2021

S. No.	Date	Southwest monsoon advanced over	Northern limit of monsoon passed through
1.	21 May	Some parts of south Bay of Bengal, Nicobar Islands, entire south Andaman Sea and some parts of north Andaman Sea	5° N / 83° E, 10° N / 90° E, 12° N / 95° E and 13° N / 98° E
2.	22 May	Some more parts of southwest Bay of Bengal; most parts of southeast Bay of Bengal; some parts of eastcentral Bay of Bengal, entire Andaman Sea and Andaman & Nicobar Islands	5° N / 80° E, 10° N / 85° E, 13° N / 90° E and 16° N / 94.5° E
3.	25 May	Some parts of Maldives-Comorin area; some more parts of southwest and southeast Bay of Bengal today, the 25th May.	5° N / 75° E, 7° N / 80° E, 11° N / 85° E, 13° N / 90° E and 16° N / 94.5° E
4.	27 May	Some more parts of Maldives-Comorin area, southwest and eastcentral Bay of Bengal, most parts of southeast Bay of Bengal and some parts of westcentral Bay of Bengal	5° N / 72° E, 6° N / 75° E, 8° N / 80° E, 12° N / 85° E, 14° N / 90° E and 17° N / 94° E
5.	3 June	Some parts of south Arabian Sea, Lakshadweep area, south Kerala, south Tamil Nadu, remaining parts of Comorin - Maldives area and some more parts of southwest Bay of Bengal	At 10° N / Long. 60° E, Lat. 10° N / Long. 70° E, Kochi, Palayamkottai, Lat. 9° N/ Long. 80° E, 12° N / 85° E, 14° N / 90° E and 17° N / 94° E
6.	4 June	Remaining parts of south Arabian Sea, some parts of central Arabian Sea, remaining parts of Lakshadweep and Kerala, most parts of coastal and south interior Karnataka, some parts of north interior Karnataka and Andhra Pradesh, some more parts of Tamil Nadu, remaining parts of southwest Bay of Bengal, some parts of westcentral and some more parts of eastcentral Bay of Bengal	Lat. 14° N / Long. 60° E, Lat. 14.5° N / Long. 70° E, Karwar, Harapanahalli (Vijayanagaram district), Anantapur, Arogyavaram, Vellore, Nagapattinam, Lat. 12° N / Long. 83° E, 15° N / 89° E and 18.5° N / 94° E
7.	5 June	More parts of central Arabian Sea, entire coastal Karnataka, Goa, some parts of Maharashtra, most parts of north interior Karnataka, some parts of Telangana and Andhra Pradesh, more parts of Tamil Nadu, more parts of central Bay of Bengal and some parts of northeast Bay of Bengal	Lat. 17.0° N / Long. 60° E, Lat. 17.5° N / Long. 70° E, Harnai, Solapur, Raichur, Kurnool, Tirupati, Cuddalore, Lat. 11.5° N / Long. 81.5° E, 13° N / 85° E, 16° N / 89° E and 20° N / 93° E
8.	6 June	More parts of central Arabian Sea, some more parts of Maharashtra, entire Karnataka, some more parts of Telangana, entire Tamil Nadu, some more parts of Andhra Pradesh, more parts of central Bay of Bengal and northeast Bay of Bengal and thence entire north eastern states of India (Nagaland, Manipur, Mizoram, Tripura, Assam, Meghalaya and Arunachal Pradesh), most parts of Sub Himalayan West Bengal and Sikkim	Lat. 18.0° N / Long. 65° E, Lat. 18.5° N / Long. 70° E, Alibagh, Pune, Medak, Nalgonda, Rentachintala, Sriharikota, Lat. 14° N / Long. 85.0° E, Lat. 16° N / Long. 88° E, Lat. 20° N / Long. 90.5° E and Lat. 24.0° N / Long. 89.5° E and Baghdogra
9.	9 June	Entire central and some parts of north Arabian Sea, entire Konkan including Mumbai and most parts of interior Maharashtra, some parts of south Gujarat region, some more parts of Telangana and Andhra Pradesh, most parts of central Bay of Bengal and some more parts of north Bay of Bengal	Lat. 20.0° N / Long. 65° E, Lat. 20.5° N / Long. 70° E, Bulsar, Malegaon, Nagpur, Bhadrachalam, Tuni, Lat. 19° N / Long. 87.0° E, 22.5° N / 89.5° E, 24.0° N / 89.5° E and Bagdogra
10.	10 June	Some more parts of south Gujarat Region, remaining parts of Maharashtra, Telangana; Andhra Pradesh, some parts of south Madhya Pradesh, Chhattisgarh and south Odisha, remaining parts of central Bay of Bengal and most parts of north Bay of Bengal	Lat. 20.0° N / Long. 60° E, Lat. 20.5° N / Long. 70° E, Surat, Nandurbar, Betul, Mandla, Bilaspur, Bolangir, Puri, Lat. 22.5° N / Long. 89.5° E, Lat. 24.0° N / Long. 89.5° E and Baghdogra
11.	11 June	Some parts of north Arabian Sea, some more parts of south Gujarat, south Madhya Pradesh and Chhattisgarh, most parts of north Bay of Bengal and more parts of West Bengal	Lat. 20.5° N / Long. 60° E, Diu, Surat, Nandurbar, Raisen, Damoh, Umaria, Pendra Road, Bolangir, Puri, 21.0° N / 88.0° E, Canning, Krishnanagar, Malda and 26.5° N / 88.0° E
12.	12 June	Remaining parts of Northwest Bay of Bengal some more parts of Odisha, most parts of West Bengal and some parts of Jharkhand and Bihar.	Lat. 20.5° N / Long. 60° E, Diu, Surat, Nandurbar ,Raisen, Damoh, Umaria, Pendra Road, Bolangir, Bhubaneshwar, Baripada, Purulia, Dhanbad, Dharbhanga and Lat. 27° N / Long. 85.0° E
13.	13 June	Some more parts of Madhya Pradesh; entire Chhattisgarh, Odisha, West Bengal, Jharkhand and Bihar; most parts of East Uttar Pradesh; some parts of west Uttar Pradesh; entire Uttarakhand, Himachal Pradesh, Jammu-Kashmir and Ladakh, Gilgit, Baltistan and Muzaffarabad; some parts of north Haryana, Chandigarh and north Punjab	Lat. 20.5° N / Long. 60° E, Diu, Surat, Nandurbar, Bhopal, Nowgong, Hamirpur, Barabanki, Bareilly, Saharanpur, Ambala and Amritsar

TABLE 1 (*Contd*.)

S. No.	Date	Southwest monsoon advanced over	Northern limit of monsoon passed through
14.	18 June	Some more parts of north Arabian Sea, most parts of Gujarat region, some parts Saurashtra, southeast Rajasthan and some more parts of Madhya Pradesh and Uttar Pradesh	Lat. 21.5° N / Long. 60° E, Junagarh, Deesa, Guna, Kanpur, Meerut, Ambala and Amritsar
15.	19 June	Remaining parts of north Arabian Sea, Saurashtra, Gujarat Region, Madhya Pradesh, entire Kutch, some more parts of Rajasthan and west Uttar Pradesh	Lat. 26° N / Long. 70° E, Barmer, Bhilwara, Dholpur, Aligarh, Meerut, Ambala and Amritsar
16.	12 July	Most parts of Rajasthan and Punjab, some more parts of Haryana and west Uttar Pradesh	Jaisalmer, Nagaur, Bharatpur, Aligarh, Karnal and Ganganagar
17.	13 July	Remaining parts of the country including Delhi, remaining parts of Uttar Pradesh, Punjab, Haryana and Rajasthan. Thus, the Southwest Monsoon covered entire country on 13th July, against the normal date of 8thJuly	

TABLE 2

Withdrawal of southwest Monsoon 2021

S. No.	Date	Southwest monsoon withdrew from	Withdrawal line passed through
1.	6 October	From some parts of west Rajasthan and some parts of adjoining Gujarat	Lat. 28.5° N / Long. 72.5° E, Bikaner, Jodhpur, Jalore, Bhuj and Lat. 23° N / Long. 68° E
2.	8 October	Some more parts of Gujarat, most parts of Rajasthan, entire Punjab, Haryana, Chandigarh, Delhi, Jammu-Kashmir and Ladakh, Himachal Pradesh, Uttarakhand and some parts of Uttar Pradesh, Madhya Pradesh	Dwarka, Mehsana, Udaipur, Kota, Gwalior, Hardoi and Lat. 30° N / Long. 81° E
3.	9 October	Entire Uttar Pradesh, western parts of Bihar and Jharkhand, north Madhya Pradesh, north Chhattisgarh and some parts of Gujarat	Lat. 27.1° N / Long. 84.7° E, Motihari, Gaya, Daltonganj, Ambikapur, Mandla, Indore, Banswara, Gandhinagar, Rajkot and Porbandar
4.	11 October	From entire Jharkhand, Bihar; some more parts of Madhya Pradesh, Chhattisgarh; some parts of Maharashtra, Odisha and West Bengal	Lat. 26.7° N / Long. 87.9° E, Siliguri, Malda, Shantiniketan, Midnapore, Baripada, Bhawanipatna, Kanker, Chindwada, Indore, Gandhinagar, Rajkot and Porbandar
5.	12 October	From remaining parts of Gujarat, Madhya Pradesh; some more parts of Maharashtra, Chhattisgarh, Odisha and West Bengal; entire north Arabian Sea, Sikkim, Arunachal Pradesh, Assam, Meghalaya, Nagaland, Manipur and some parts of Telangana, Mizoram and Tripura	Lat. 27.0° N / Long. 92.0° E, Kohima, Silchar, Krishnanagar, Baripada, Malkangiri, Hanamkonda, Aurangabad, Silvasa, Lat. 20.0° N / Long. 65.0° E and Lat. 20.0° N / Long. 60.0° E.
6	14 October	From some more parts of Telangana; remaining parts of Marathwada, Madhya Maharashtra and Konkan; some parts of north interior Karnataka and most parts of central Arabian Sea	Lat. 27.0° N / Long. 92.0° E, Kohima, Silchar, Krishnanagar, Baripada, Malkangiri, Nalgonda, Bagalkote, Vengurla, Lat. 16.0° N / Long. 65.0° E and Lat. 16.0° N / Long. 60.0° E
8	23 October	From remaining parts of northeast India, West Bengal, Odisha; entire north Bay of Bengal and Goa; some parts of Andhra Pradesh; remaining parts of Telangana and some more parts of Karnataka and Central Arabian Sea	Lat. 18.5° N / Long. 94° E and Lat. 18.5° N / Long. 90° E, Kalingapatnam, Nandigama, Kurnool, Gadag, Majali, Lat. 15° N / Long. 65° E and Lat. 15° N / Long. 60° E
7	25 October	In view of significant reduction in rainfall activity over most parts of the country the Southwest Monsoon withdrew from the **entire country on 25th October, 2021**	

TABLE 3

Rainfall figures (mm) for each month and season as a whole (June-September 2021)

S. No.	Meteorological Sub-divisions	June			July			August			September			Season		
		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.	Andaman & Nicobar Islands	315.9	413.7	-24%	535.3	402.0	33%	506.5	409.0	24%	667.3	429.1	56%	2025.0	1653.8	22%
2.	Arunachal Pradesh	377.3	490.7	-23%	266.8	523.8	-49%	508.7	360.6	41%	141.2	351.5	-60%	1294.0	1726.6	-25%
3.	Assam & Meghalaya	452.5	496.9	-9%	346.3	557.7	-38%	417.4	404.3	3%	169.6	314.8	-46%	1385.8	1773.7	-22%
4.	Naga., Mani., Mizo. and Tri.	240.6	398.0	-40%	267.1	389.5	-31%	266.6	355.4	-25%	189.7	283.8	-33%	964.0	1426.7	-32%
5.	Sub-Himalayan West Bengal & Sikkim	469.9	483.3	-3%	491.3	625.9	-22%	618.5	480.7	29%	237.9	380.9	-38%	1817.5	1970.8	-8%
6.	Gangetic West Bengal	371.6	256.2	45%	420.2	334.7	26%	263.2	314.1	-16%	488.9	276.5	77%	1543.9	1181.5	31%
7.	Odisha	181.3	217.7	-17%	275.0	344.6	-20%	204.9	366.4	-44%	384.0	226.6	69%	1045.1	1155.3	-10%
8.	Jharkhand	266.8	199.9	33%	319.5	322.3	-1%	200.0	297.8	-33%	255.2	234.7	9%	1041.5	1054.7	-1%
9.	Bihar	354.3	167.7	111%	258.3	349.0	-26%	328.7	285.2	15%	103.0	215.3	-52%	1044.3	1017.2	3%
10.	East Uttar Pradesh	203.9	108.2	88%	203.6	281.2	-28%	260.3	263.8	-1%	199.9	186.2	7%	867.8	839.4	3%
11.	West Uttar Pradesh	73.8	76.0	-3%	226.3	243.9	-7%	146.0	256.7	-43%	127.6	144.7	-12%	573.7	721.3	-20%
12.	Uttaranchal	262.9	177.8	48%	371.6	407.7	-9%	307.6	397.7	-23%	214.0	193.7	10%	1156.1	1176.9	-2%
13.	Haryana, Chandigarh & Delhi	48.4	48.1	1%	255.5	156.8	63%	84.0	159.2	-47%	188.9	79.9	136%	576.7	444.0	30%
14.	Punjab	49.7	50.4	-1%	173.7	176.2	-1%	70.3	160.0	-56%	143.2	80.7	77%	436.8	467.3	-7%
15.	Himachal Pradesh	84.6	100.5	-16%	289.0	273.0	6%	146.0	262.3	-44%	171.3	127.7	34%	690.9	763.5	-10%
16.	Jammu & Kashmir and Ladakh	38.2	74.0	-48%	212.3	203.7	4%	74.1	185.4	-60%	76.9	102.9	-25%	401.6	566.0	-29%
17.	West Rajasthan	50.2	36.9	36%	80.7	101.7	-21%	38.3	88.0	-56%	148.3	38.7	283%	317.5	265.3	20%
18.	East Rajasthan	56.7	66.8	-15%	194.0	218.9	-11%	236.7	222.2	7%	209.3	95.0	120%	696.6	602.9	16%
19.	West Madhya Pradesh	138.1	105.9	30%	290.1	287.2	1%	309.0	303.8	2%	244.8	160.8	52%	981.8	857.7	14%
20.	East Madhya Pradesh	203.2	140.4	45%	267.4	342.4	-22%	206.3	366.2	-44%	214.8	199.4	8%	891.8	1048.4	-15%
21.	Gujarat region	137.2	138.6	-1%	189.8	340.1	-44%	83.7	295.3	-72%	378.1	148.9	154%	788.8	922.9	-15%
22.	Saurashtra & Kutch	68.5	94.0	-27%	116.4	195.6	-40%	18.3	141.0	-87%	423.4	76.6	453%	626.6	507.2	24%
23.	Konkan & Goa	962.5	689.7	40%	1433.7	1068.1	34%	394.5	759.0	-48%	768.0	358.5	114%	3558.7	2875.3	24%
24.	Madhya Maharashtra	189.3	157.0	21%	297.3	240.8	23%	129.1	197.1	-34%	257.0	156.3	64%	872.7	751.2	16%
25.	Marathawada	181.1	138.0	31%	243.7	179.1	36%	173.3	186.5	-7%	391.4	165.2	137%	989.5	668.8	48%
26.	Vidarbha	203.5	170.6	19%	293.3	307.1	-4%	174.8	306.6	-43%	296.8	158.8	87%	968.3	943.1	3%
27.	Chattisgarh	244.4	193.5	26%	331.7	375.5	-12%	221.5	364.2	-39%	310.2	208.9	48%	1107.7	1142.1	-3%
28.	Coastal Andhra Pradesh & Yanam	82.5	105.2	-22%	216.3	157.9	37%	169.0	162.1	4%	236.5	161.7	46%	704.3	586.9	20%
29.	Telangana	195.7	130.4	50%	365.7	232.7	57%	192.8	225.5	-15%	290.1	163.3	78%	1044.2	751.9	39%
30.	Rayalaseema	113.6	70.9	60%	183.4	92.6	98%	96.5	108.5	-11%	94.8	139.6	-32%	488.2	411.6	19%
31.	Tamil Nadu, Puducherry and Karaikal	62.3	51.7	21%	124.6	73.3	70%	88.9	92.8	-4%	117.6	118.3	-1%	393.3	336.1	17%
32.	Coastal Karnataka	764.3	866.7	-12%	1032.4	1116.3	-8%	495.8	806.3	-39%	508.5	305.8	66%	2800.9	3095.1	-10%
33.	North interior Karnataka	165.2	107.1	54%	192.6	123.5	56%	112.6	122.0	-8%	132.6	144.5	-8%	603.1	497.1	21%
34.	South interior Karnataka	165.9	144.1	15%	269.5	213.3	26%	150.9	178.0	-15%	115.3	146.4	-21%	701.6	681.8	3%
35.	Keralaand Mahe	408.3	643.0	-36%	577.4	720.1	-20%	416.3	426.7	-2%	317.2	259.5	22%	1719.1	2049.3	-16%
36.	Lakshadweep	160.0	330.3	-52%	156.5	294.0	-47%	319.5	223.2	43%	154.9	165.6	-6%	790.9	1013.1	-22%

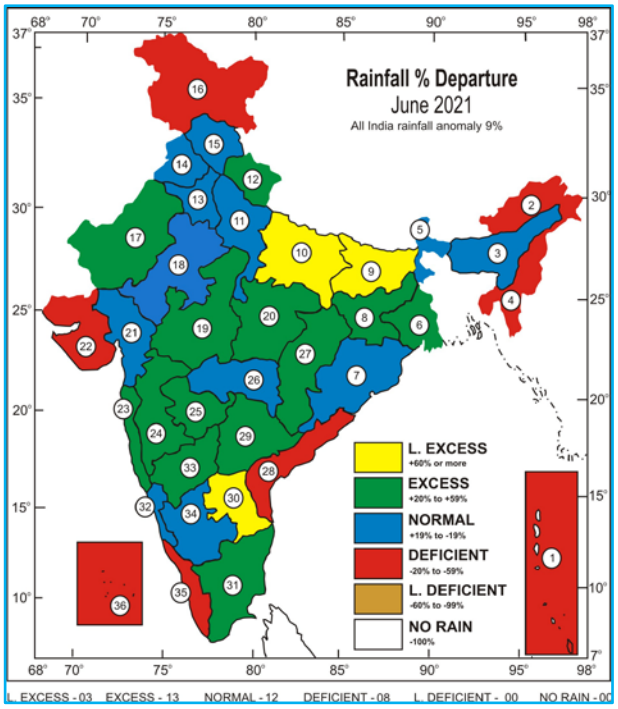

Fig. 2. Rainfall for the month of June 2021 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	-24	**7**	-17	**13**	1	**19**	30	**25**	31	**31**	21
2	-23	**8**	33	**14**	-1	**20**	45	**26**	19	**32**	-12
3	-9	**9**	111	**15**	-16	**21**	-21	**27**	26	**33**	54
4	-40	**10**	88	**16**	-48	**22**	-27	**28**	-22	**34**	15
5	-3	**11**	-3	**17**	36	**23**	40	**29**	50	**35**	-36
6	45	**12**	48	**18**	-15	**24**	21	**30**	60	**36**	-52

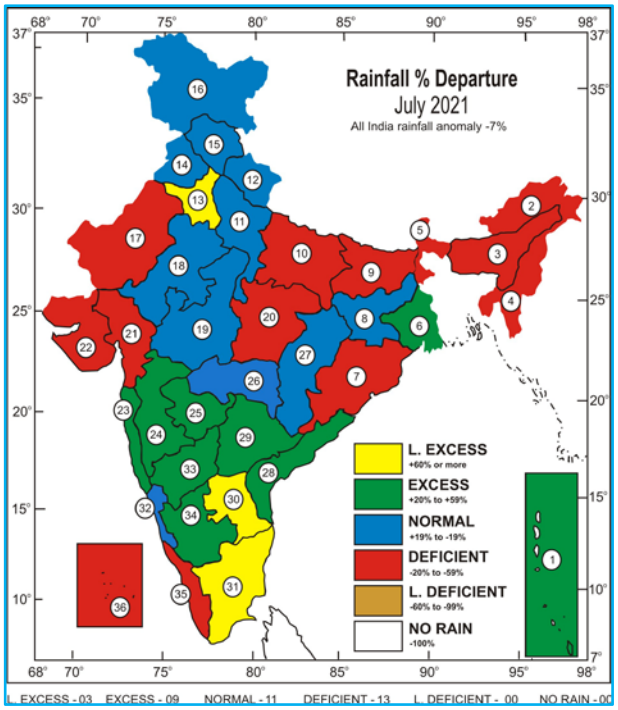

Fig. 3. Rainfall for the month of July 2021 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	33	**7**	-20	**13**	63	**19**	1	**25**	36	**31**	70
2	-49	**8**	-1	**14**	-1	**20**	-22	**26**	-4	**32**	-8
3	-38	**9**	-26	**15**	6	**21**	-44	**27**	-12	**33**	56
4	-31	**10**	-28	**16**	4	**22**	-40	**28**	37	**34**	26
5	-22	**11**	-7	**17**	-21	**23**	34	**29**	57	**35**	-20
6	26	**12**	-9	**18**	-11	**24**	23	**30**	98	**36**	-47

in June was in the western hemisphere, upto mid-July though over Indian ocean MJO was weak and absence of low-pressure systems over north Bay of Bengal, hindered the further progress of monsoon current. This delay in the arrival of monsoonand prevailing warm and dry westerlies led to heat wave conditions over north India. The formation of a low-pressure area over westcentral and adjoining northwest Bay of Bengal off north Andhra Pradesh - south Odisha coastscaused strengthening of the monsoon flow and the monsoon further advanced into most parts of Rajasthan, Punjab; some more parts of Haryana and west Uttar Pradesh on 12 July and it was on 13 July that monsoon covered the entire country against the normal date of 8 July.

2.2. *Monthly rainfall distribution*

Figs. 2-5 show the monthlyspatial distribution of rainfall. Table 3 gives the monthly and seasonal sub-divisional rainfall and percent departures. Though the seasonal rainfall was normal at 99% of LPA, it was marked by high contrasting month to month variation.The monthly rainfall of June was 109% of LPA rainfall while for both the chief monsoon months, July and August the respective monthly rainfall was less than normal at 93% of LPA and 76% of LPA, this led to the cumulative all India rainfall at the end of August to be 90% of LPA. At the seasons end, a month later it became 99% of LPA as the monthly September rainfall was a whopping 135% of LPA.

The monsoon current covered mostparts of the country earlier than normal, *i.e*., by 19 June, except some parts of northwest India. Aided by the formation and movement of two Low Pressure areas, cyclonic circulations/troughs in the lower tropospheric levels, movement of western disturbances and the influence of off-shore trough at mean sea level on most days, the monthly rainfall was more than normal (109% of LPA) in the month of June.

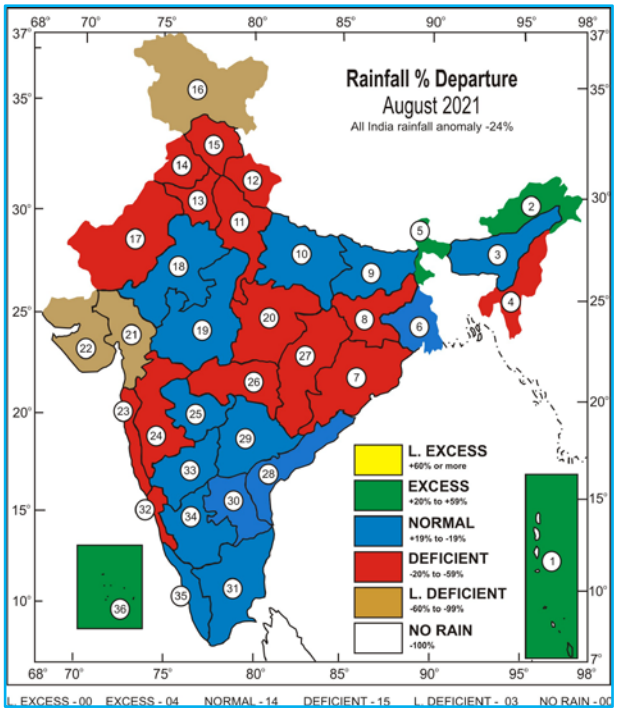

Fig. 4. Rainfall for the month of August 2021 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	24	**7**	-44	**13**	-47	**19**	2	**25**	-7	**31**	-4
2	41	**8**	-33	**14**	-56	**20**	-44	**26**	-43	**32**	-39
3	3	**9**	15	**15**	-44	**21**	-72	**27**	-39	**33**	-8
4	-25	**10**	-1	**16**	-60	**22**	-87	**28**	4	**34**	-15
5	29	**11**	-43	**17**	-56	**23**	-48	**29**	-15	**35**	-2
6	-16	**12**	-23	**18**	7	**24**	-34	**30**	-11	**36**	43

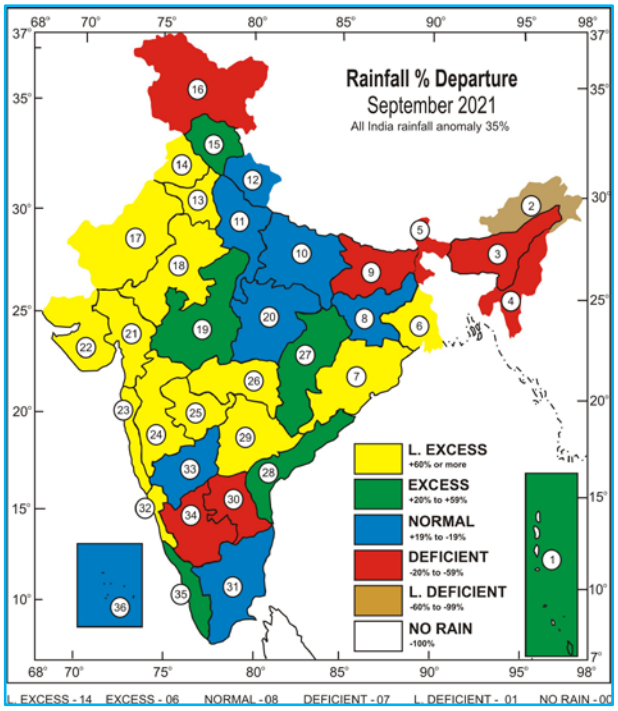

Fig. 5. Rainfall for the month of September 2021 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	56	**7**	69	**13**	136	**19**	52	**25**	137	**31**	-1
2	-60	**8**	9	**14**	77	**20**	8	**26**	87	**32**	66
3	-46	**9**	-52	**15**	34	**21**	154	**27**	48	**33**	-8
4	-33	**10**	7	**16**	-25	**22**	453	**28**	46	**34**	-21
5	-38	**11**	-12	**17**	283	**23**	114	**29**	78	**35**	22
6	77	**12**	10	**18**	120	**24**	64	**30**	-32	**36**	-6

In July, the rainfall over the country though categorized as *normal* at 93% of LPA was less than *normal*. The monthly rainfall over homogenous region ofsouth peninsular region (127% of LPA) was above normal while east and northeast India region (74% of LPA) recorded below normal precipitation. Five Low Pressure areas formed during the month, three formed over Bay of Bengal (out of which two became well marked low), one Low Pressure area formed over Arabian Sea and one over land.

Some of the stations received record 24-hour rainfall. A list of stations is given below with their previous record and date.

S. No.	*Station name*	*Previous record (mm)*	*Date of record (July)*	*Year of record*	*New record (mm)*	*Date (in July 2021)*
1.	Karnal	242.0	15	1968	245.0	14
2.	Kolhapur	151.6	1	1953	181.0	24
3.	Mahabaleshwar	439.8	7	1977	594.4	23
4.	Satara	129.2	7	1977	172.3	24
5.	Cuddapah	116.8	12	1977	125.8	5
6.	Kanyakumari	57.0	18	1968	94.2	10
7.	Belgum	192.8	10	1943	207.8	23
8.	Belgum (Sambra) AP	142.9	2	1984	145.4	23
9.	Diamond Harbour	204.7	28	1982	217.7	30

Source : IMD Climate Diagnostics Bulletin of India July 2021

An off shore trough extending from Maharashtra coast to Kerala coast which persisted on a few days and strengthening of the monsoon flow due to the formation of the Low Pressure area over northwest Bay of Bengal and neighbourhood coast caused fairly widespread to

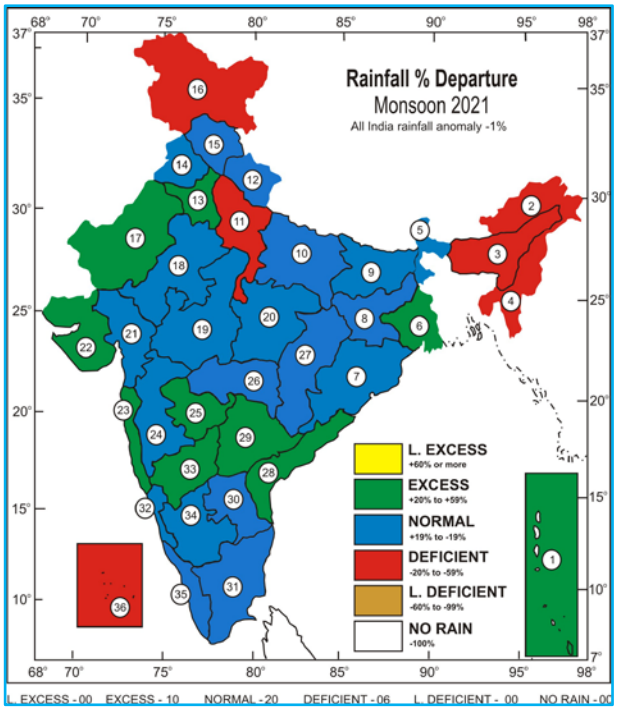

Fig. 6. Rainfall for the month of monsoon 2021 as percentage departure from normal. 36 sub-divisions are indicated by numbers on the map & bold letters in legend below. The rainfall anomaly values for these sub-divisions are indicated below :

1	22	**7**	-10	**13**	30	**19**	14	**25**	48	**31**	17
2	-25	**8**	-1	**14**	-7	**20**	-15	**26**	3	**32**	-10
3	-22	**9**	3	**15**	-10	**21**	-15	**27**	-3	**33**	21
4	-32	**10**	3	**16**	-29	**22**	24	**28**	20	**34**	3
5	-8	**11**	-20	**17**	20	**23**	24	**29**	39	**35**	-16
6	31	**12**	-2	**18**	16	**24**	16	**30**	19	**36**	-22

widespread rainfall/thunderstorm over the coastal, ghat areas and the adjacent interior parts of Maharashtra and Karnataka during the fourth week of August, along with heavy to very heavy/extremely heavy rainfall reported on a few days over these areas. Mahabaleshwar on 22, 23 and 24 July received 48, 59 and 32 cm of precipitation respectively, *i.e.*, a total of 139 cm in three days.

During the month of August, rainfall over the country as a whole was 76% of LPA, *i.e.*, a departure of −24% below LPA, the lowest August rainfall in the last 19 years, since 2002 and the 6th lowest rainfall from 1901. Eighteen sub divisions covering 54% of the country recorded *deficient/large deficient* rainfall in this month.Negative IOD, unfavorable MJO conditions, less west Pacific typhoon activity, monsoon trough located north of its normal position on most of the days, all these factorstogether culminated into lack of intense low-pressure systems like Depression and genesis of a fewer,

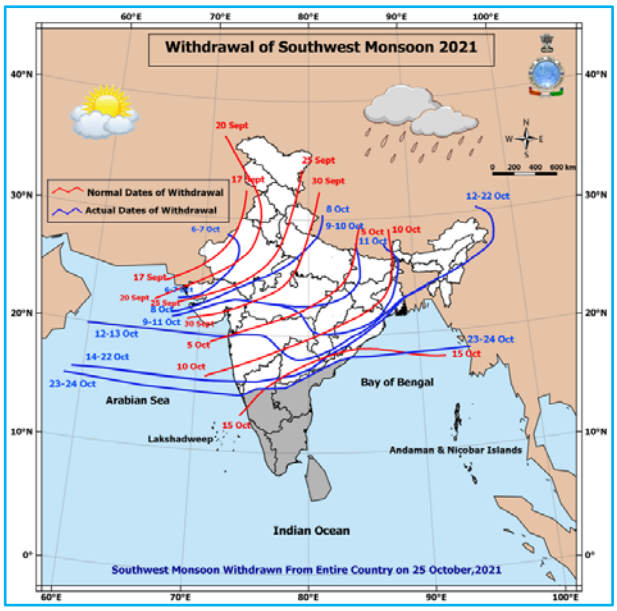

Fig. 7. Isochrones of withdrawal of SW monsoon 2021

faster dissipating low-pressure systems contributing to the rainfall deficit during the month of August generally over the country and particularly over northwest (69% of LPA) and central India (61% of LPA) homogenous regions. In contrast to this year, last year, 2020, August had received record-breaking rainfall throughout the country, especially in the central region (161% of LPA), this shows the large year to year variation in rainfall.

Some stations recorded highest one day rainfall in this month. A list of stations is given below with their previous record and date.

S. No.	*Station name*	*Previous record (mm)*	*Date of record (August)*	*Year of record*	*New record (mm)*	*Date (in August 2021)*
1.	Delhi (Ridge obsy)	127.4	2	2007	149.2	21
2.	Car Nicobar (IAF obsy)	73.2	16	2019	123.2	19
3.	Tinsukia	65.2	21	2006	72.0	13
4.	Aizawl	137.4	11	1943	161.7	3
5.	Sukinda	56.0	28	1974	57.0	13
6.	Bundi	155	15	2019	202.0	4
7.	Tanjavur observatory	115	14	2009	141.0	25
8.	Mahabalipuram observatory	4.2	2	1979	39.4	1
9.	Shivpuri	155.0	25	1991	470.0	3

Source : IMD Climate Diagnostics Bulletin of India August 2021

TABLE 4

Details of the weather systems during June 2021

S. No.	System	Duration	Place of initial location	Direction of movement	Place of final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**)	*Low Pressure Area*					
1.	Low Pressure area	11-15	Northwest Bay of Bengal, adjoining Odisha and Gangetic West Bengal coasts	Northwest	East Uttar Pradesh and adjoining Bihar	It formed under the influence of a cyclonic circulation over east central and adjoining northeast Bay of Bengal. The low became less marked on 16. The associated cyclonic circulation persisted over east Uttar Pradesh and neighbourhood on 17. It merged with the low pressure area that formed over southwest Bihar and adjoining southeast Uttar Pradesh
2.	Low Pressure area (land)	18-20	Southwest Bihar and adjoining southeast Uttar Pradesh	Do	Southeast Uttar Pradesh and neighbourhood	Initially it lay as a cyclonic circulation over Gangetic West Bengal and adjoining Bangladesh on 16. The cyclonic circulation became less marked on 29
(**B**)	*Western Disturbances / Eastward moving Systems*					
(*i*)	*Upper air cyclonic circulation*					
1.	Between 3.1 and 4.5 km above m.s.l.	4-5	Jammu and neighbourhood	East	Punjab and adjoining Haryana	Initially it lay as a trough in mid and upper tropospheric westerlies roughly along Long. 72° E to the north of Lat. 30° N on 3. It lay as a trough between 4.5 and 7.6 km above m.s.l. roughly along Long. 76° E to the north of Lat. 25° N on 6. It moved away east northeastwards on 7
2.	At 3.1 kms a.s.l.	25	West Afghanistan and neighbourhood	Stationary	*In situ*	Became less marked on 26
3.	At 3.1 km above m.s.l.	25	West Afghanistan and neighbourhood	Do	Do	Became less marked on 26
4.	At 5.8 km above m.s.l.	27-28	South Afghanistan and neighbourhood	Northeast	North Pakistan and neighbourhood	Moved away northeastward on 29
(*ii*)	*As a trough*					
1.	At 3.1 km above m.s.l.	4	Roughly along Long. 90° E to the north of Lat. 20° N	Stationary	*In situ*	Became less marked on 5
2.	Mid tropospheric westerlies	12	Roughly along Long. 75° E to the north of Lat. 30° N	East northeast		Moved away on 13
3.	Mid and upper tropospheric westerlies	23-26	Ran roughly along Long. 70° E to the north of Lat. 25° N	Northeast	Ran roughly along Long. 71°E to the north of Lat. 30°N	Initially it lay as a trough in mid and upper tropospheric westerlies roughly along Long. 64° E to the north of Lat. 28° N on 21st. It lay as cyclonic circulation over north Pakistan and adjoining Jammu - Kashmir and Ladakh on 22
4.	Mid and upper westerlies	29 Jun - 4 Jul	Roughly along Long. 60° E to the north of Lat. 30° N	East	Roughly along Long. 72° E to the north of Lat. 32° N	Moved away northeastwards on 5 July morning

TABLE 4 (*Contd*.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
(C)	*Other upper air cyclonic circulations*					
1.	Up to 1.5 km above m.s.l.	1-3	Central Pakistan and neighbourhood	Stationary	*In situ*	Became less marked on 4
2.	At 0.9 kms a.s.l.	2-3	South Chhattisgarh and neighbourhood	North	North Chhattisgarh and neighbourhood	Became less marked on 4
3.	Between 3.1 and 4.5 km above m.s.l.	2-5	Equatorial Indian Ocean and adjoining southeast Bay of Bengal	Northwest	Sri Lanka and adjoining Comorin area	Became less marked on 6
4.	At 0.9 kms a.s.l.	1	Northwest Madhya Pradesh and neighbourhood	Stationary	*In situ*	Became less marked on 2
5.	Between 3.1 and 7.6 km above m.s.l. tilting southwestward with height	21-23	Northwest and adjoining northeast Arabian Sea	Do	Do	Became less marked on 24
6.	Upto 1.5 kms a.s.l.	17	South Pakistan and neighbourhood	Do	Do	Became less marked on 20
7.	At 0.9 km above m.s.l.	17-19	South Haryana and neighbourhood	Northwest	Southeast Madhya Pradesh and neighbourhood	Became less marked on 21
8.	Between 3.1 km and 5.8 km above m.s.l.	18-19	South Bangladesh and neighbourhood	North	Bangladesh and neighbourhood	Became less marked on 20
9.	Between 3.1 and 4.5 km	19	Southeast Rajasthan and adjoining west Madhya Pradesh	Stationary	*In situ*	Became less marked on 20
10.	Between 3.1 and 5.8 km above m.s.l.	20	South Gujarat and neighbourhood tilting southwestward with height	Do	Do	Became less marked on 21
11.	Between 5.8 and 7.6 km above m.s.l.	21-22	South Bangladesh and adjoining northeast Bay of Bengal	Do	Do	Became less marked on 23
12.	Up to 1.5 km above m.s.l.	24-26	Northeast Rajasthan and neighbourhood	Oscillatory	Northeast Rajasthan and neighbourhood	Became less marked on 27
13.	Between 3.1 and 5.8 km above m.s.l.	25-26	Southwest Rajasthan and neighbourhood	Stationary	*In situ*	Became less marked on 27
14.	Up to 1.5 km above m.s.l.	24-26	Northeast Rajasthan and neighbourhood	Oscillatory	Northeast Rajasthan and neighbourhood	Became less marked on 27
15.	At 1.5 km above m.s.l.	25-27	Pakistan and adjoining Punjab	Do	Northwest Rajasthan and adjoining Pakistan	Became less marked on 28
16.	Between 0.9 km and 2.1 km above m.s.l.	26-28	South Odisha and neighbourhood	Southwest	Telangana and neighbourhood	Became less marked on 29
17.	Between 2.1 km and 3.1 km above m.s.l.	26-27	South Gujarat region and neighbourhood	Stationary	*In situ*	Became less marked on 28
18.	Between 3.1 km & 5.8 km above m.s.l.	26 Jun - 2 Jul	Westcentral Arabian Sea off south Oman coast	Do	Do	Became less marked on 3 July

TABLE 4 (*Contd*.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
19.	At 0.9 km above m.s.l.	27-29	Northwest Madhya Pradesh and neighbourhood	East	East Rajasthan and neighbourhood	Became less marked on 30
20.	Between 5.8 km and 7.6 km above m.s.l.	28	Comorin area and adjoining Equatorial Indian Ocean on 28	Stationary	*In situ*	Became less marked on 29
21.	At 1.5 km a.s.l.	25 Jun - 9 Jul	Pakistan and adjoining Punjab	East	Central Pakistan and neighbourhood	merged with the heat low on 10 July
22.	Between 3.1 and 5.8 km above m.s.l.	30 Jun	Northeast Arabian Sea, adjoining Saurashtra and Kutch	Stationary	*In situ*	Became less marked on 1 July
(D)	*Other troughs / Wind Discontinuity*					
1.	Between 3.1 and 4.5 km above m.s.l.	1-2	From eastcentral Arabian Sea and neighbourhood to north Madhya Maharashtra	Stationary	From cyclonic circulation over east central Arabian Sea and neighbourhood to north Konkan	Became less marked on 3
2.	At 0.9 km above m.s.l.	2	From Sub Himalayan West Bengal to the cyclonic circulation over south Chhattisgarh and neighbourhood	Do	*In situ*	Became less marked on 3
3.	At m.s.l.	2-7	Off Karnataka-Kerala coasts	East	From north Maharashtra coast to north Kerala coast	Became less marked on 8
4.	Between 3.1 and 4.5 km	2	From cyclonic circulation over Equatorial Indian Ocean and adjoining southeast Bay of Bengal to Comorin area	Stationary	*In situ*	Became less marked on 3
5.	Upto 1.5 km a.s.l.	3	Telangana to south Tamil Nadu	Do	Do	Became less marked on 4
6.	Upto 0.9 km above m.s.l.	4-5	From the cyclonic circulation over east central Arabian Sea to south Tamil Nadu across Karnataka	Do	Do	Became less marked on 6
7.	From m.s. l. upto 0.9 km above m.s.l.	7-27	From east Uttar Pradesh to northeast Bay of Bengal	Oscillatory	From northwest Uttar Pradesh to northwest Bay of Bengal	Became less marked on 28
8.	At 5.8 km above m.s.l. on	14-16	From east central Arabian Sea to south Konkan	West	From central parts of south Arabian Sea to south Konkan	Became less marked on 17
9.	Between 3.1 and 5.8 km above m.s.l.	23-25	From cyclonic circulation over southwest Bihar and adjoining southeast Uttar Pradesh to south Chhattisgarh	East	From the cyclonic circulation over Jharkhand and neighbourhood to south Odisha	Became less marked on 26
10.	Between 3.1 and 4.5 km above m.s.l.	29	From east central Arabian Sea off north Maharashtra coast to south Kerala across coastal Karnataka	Stationary	*In situ*	Became less marked on 30
11.	At 0.9 km above m.s.l.	28	From east Rajasthan and neighbourhood to west Assam	Do	Do	Became less marked on 29

TABLE 4 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
12.	At 3.1 km above m.s.l.	28	North interior Karnataka to Saurashtra	Stationary	*In situ*	Became less marked on 29
13.	At mean sea level	29 Jun - 14 Jul	From east Uttar Pradesh to northeast Assam across Bihar and Sub Himalayan West Bengal	Oscillatory	From the cyclonic circulation associated with the low pressure area over coastal areas of Kutch and neighbourhood to northwest Rajasthan	Became less marked on 15 July
14.	At 0.9 km above m.s.l.	30 Jun - 4 Jul	From Vidarbha to south Tamil Nadu across Telangana and interior Tamil Nadu	Do	From interior Karnataka to Comorin sea across Tamil Nadu	Became less marked on 5 July
(**E**)	*East-West shear zone*					
1.	At 4.5 kms a.s.l.	1	Roughly along Lat. 8° N	Stationary	*In situ*	Became less marked on 2
2.	At 3.1 km a.s.l.	3	Southwest Arabian Sea to southeast Bay of Bengal across extreme southern peninsula along Lat. 8° N	Do	Do	Became less marked on 4
3.	Between 3.1 and 5.8 kms a.s.l.	9	South Odisha to south Gujarat	Do	Do	Became less marked on 10
4.	Between 5.8 and 7.6 km above m.s.l.	9	From sub Himalayan West Bengal to south Odisha	Do	Do	Became less marked on 10
5.	Between 3.1 and 5.8 km above m.s.l.	12-13	From the cyclonic circulation associated with low pressure area over NW Bay of Bengal to west central Arabian Sea	East	From the cyclonic circulation associated with low pressure area to east central Arabian Sea	Became less marked on 14

In September, the factors changed in favour of the monsoon, resulting in the monthly rainfall to be 135% of LPA over the country, making it the tenth highest rainfall since 1901, 20 sub-divisions or 55% of the area of the country covered, experienced either *excess/large excess* precipitation. The homogenous regions of South Peninsula (122% of LPA), Northwest (140% of LPA) and Central India (185% of LPA) received above normal rainfall while East & Northeast India rainfall was deficient at 75% of LPA. At a surplus departure of 85% of LPA, Central India recorded its fourth highest rainfall since 1901. The IOD and ENSO conditions became neutral in the beginning of September, the monsoon trough was active and south of its normal position on many days, the low-pressure systems followed west/northwestward track causing good rainfall activity, especially over central India and adjoining areas.

Some of the stations received record 24-hour rainfall. A list of stations is given with their previous record and date.

S. No.	*Station name*	*Previous record (mm)*	*Date of record*	*Year of record*	*New record (mm)*	*Date (in September 2021)*
1.	Nandyal	125.8	16	2019	126.5	1
2.	Visakhapatnam AP	161.2	20	2005	267.0	27
3.	Pendra Road	173	15	1987	183.2	15
4.	Canacona	135.4	14	2015	185.0	5
5.	Hansi	22.0	16	2011	130.0	4
6.	Nancowry	121.4	6	1964	162.2	28
7.	Angul	148.8	6	1939	201.6	14
8.	Bhubaneswar Aero	137.0	9	2005	199.9	13
9.	Phulbani	154.4	12	1968	181.6	14
10.	Puri	210.8	20	1934	342.5	13
11.	Tondi	78.5	23	1985	107.5	18
12.	Mahabalipuram	42.4	20	1979	56.0	6
13.	Azamgarh	225.0	14	1976	370.0	17
14.	Fursatganj	137.8	27	2019	186.3	16
15.	Daman	267.8	4	2012	327.8	1
16.	Bankura	208.0	1	1978	354.3	30

Source : IMD Climate Diagnostics Bulletin of India September 2021

TABLE 5

Details of the weather systems during July 2021

S. No.	System	Duration	Place of initial location	Direction of movement	Place of final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**) *Well marked low/low pressure area*						
1.	Low Pressure area	12-14	South Gujarat and adjoining northeast Arabian Sea	Northwest	Coastal areas of Kutch and neighbourhood	Became less marked on 15. The associated cyclonic circulation merged with the Monsoon Trough and east-west shear zone
2.	Low Pressure area	11-12	Westcentral and adjoining northwest Bay of Bengal off north Andhra Pradesh - south Odisha coasts	Oscillatory	Northwest Bay of Bengal off north Andhra Pradesh - south Odisha coasts	Initially it lay as a cyclonic circulation over coastal Odisha and neighbourhood. The low pressure area became less marked on 13. However, associated cyclonic circulationbecame less marked on 17
3.	Well marked low Pressure area	22-25	Northwest Bay of Bengal off north Odisha-West Bengal coasts	Northwest	Northwest Madhya Pradesh and neighbourhood	Initially it las as a cyclonic circulation over northwest Bay of Bengal and neighbourhood. The low pressure area became less marked on 26. Its associated cyclonic circulation became less marked on 28
4.	Well marked low Pressure area	27 Jul - 7 Aug	Northwest Bay of Bengal and neighbourhood,	Do	Northern parts of east Madhya Pradesh and neighbourhood	Under the influence of the cyclonic circulation over northwest Bay of Bengal and neighbourhood. The low pressure merged with the monsoon trough on 8 Aug. the associated cyclonic circulation became less marked on 14 August
5.	Low Pressure area (land)	30 Jul - 1 Aug	Southern parts of central Uttar Pradesh	West	Southern parts of Haryana and neighbourhood	Became less marked on 2 August
(**B**) *Western Disturbances /Eastward moving Systems* (*i*) *Upper air cyclonic circulation*						
1.	Up to 2.1 km above m.s.l.	10-11	North Pakistan and neighbourhood which extended	Stationary	*In situ*	Became less marked on 12
(*ii*) *Trough in Westerlies*						
1.	Mid & upper westerlies with its axis at 5.8 km above m.s.l.	5-8	Roughly along Long. 64° E to the north of Lat. 28° N	East	Roughly along Long. 74° E to the north of Lat. 30° N	It then lay as a cyclonic circulation over northeast Rajasthan and neighbourhood on 9 which became less marked on 10
2.	Mid and upper tropospheric westerlies with its axis at 5.8 km above m.s.l.	20-22	Roughly along Long. 64° E to the north of Lat. 30° N	Northeast	Long. 70° E to the north of Lat. 28° N	It moved away northeastwards on 23
3.	Mid tropospheric level with its axis at 5.8 km above m.s.l.	23-26	Along Long. 62° E to the north of Lat. 28° N	East	Along Long. 66° E to the north of Lat. 30° N	It moved away northeastwards on 27
(**C**) *Other upper air cyclonic circulations*						
1.	At 3.1 km a.s.l.	2	Northwest Madhya Pradesh and neighbourhood	Stationary	*In situ*	Became less marked on 3

TABLE 5 (*Contd*.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.	At 5.8 km a.s.l	2	Telangana and neighbourhood at 5.8 km above m.s.l. on 2	Stationary	*In situ*	Became less marked on 3
3.	Up to 0.9 km above m.s.l.	2	South coastal Tamil Nadu and neighbourhood	Do	Do	Became less marked on 3
4.	At 3.1 kms a.s.l	1	Central parts of north Rajasthan at 3.1 km above m.s.l on 1	Do	Do	Became less marked on 3
5.	Between 3.1 and 4.5 kms a.s.l.	2-5	Southwest Rajasthan and neighbourhood	Do	Southeast Rajasthan and neighbourhood	Became less marked on 6
6.	At 3.1 kms a.s.l.	3-4	Sri Lanka and neighbourhood at 3.1 km above m.s.l. on 3	Do	*In situ*	Became less marked on 5
7.	Between 3.1 and 4.5 km above m.s.l.	5	North interior Tamil Nadu and neighbourhood on 5	Do	Do	Became less marked on 6
8.	At 2.1 kms a.s.l.	5-6	Kutch and adjoining southwest Rajasthan	West	Northeast Arabian Sea and adjoining Gujarat coast	Became less marked on 7
9.	Upto 1.5 kms a.s.l.	5	North Odisha and adjoining Gangetic West Bengal	Stationary	*In situ*	Became less marked on 6
10.	Upto 0.9 kms a.s.l.	3	West Assam and neighbourhood	Do	Do	Became less marked on 4
11.	At1.5 kms a.s.l.	7	Comorin area and neighbourhood	Do	Do	Became less marked on 8
12.	At 0.9 kms a.s.l.	6-8	East Uttar Pradesh at 0.9 km above m.s.l.	Do	Do	Became less marked on 9
13.	Up to 1.5 km above m.s.l.	14	Central Assam and neighbourhood	Do	Do	Became less marked on 15
14.	At 1.5 km above m.s.l.	11	Central Rajasthan	Do	Do	Became less marked on 12
15.	Up to 4.5 km above m.s.l.	8-9	Northwest Bay of Bengal, adjoining coastal areas of Odisha and West Bengal	Northwest	Jharkhand and neighbourhood	Became less marked on 10
16.	At 3.1 km above m.s.l.	8	South Rajasthan and neighbourhood	Stationary	*In situ*	Became less marked on 9
17.	Upto 1.5 kms a.s.l	18	North Pakistan and neighbourhood	Do	Do	Became less marked on 21
18.	At 1.5 km above m.s.l.	17	Southwest Rajasthan and neighbourhood	Do	Do	Became less marked on 18
19.	At 3.6 km above m.s.l.	19-20	South Gujarat Region and neighbourhood	North	Southwest Rajasthan and neighbourhood	Became less marked on 21
20.	At 0.9 kms a.s.l.	18-19	Central Assam and neighbourhood	Stationary	*In situ*	Became less marked on 20
21.	Between 1.5 and 4.5 km above m.s.l.	17-18	South coastal Andhra Pradesh and neighbourhood	North	North coastal Andhra Pradesh and neighbourhood	Became less marked on 19

TABLE 5 (*Contd*.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
22.	Between 3.1 and 5.8 km above m.s.l.	19-21	Southwest Uttar Pradesh and neighbourhood	Oscillatory	East Uttar Pradesh and neighbourhood	Became less marked on 22
23.	At 0.9 kms a.s.l.	21	Central Assam and neighbourhood	Stationary	*In situ*	Became less marked on 22
24.	At 1.5 kms a.s.l.	20-21	South Bangladesh and neighbourhood	Northwest	West Bengal and adjoining Bangladesh	Became less marked on 22
25.	Between 1.5 and 3.1 km above m.s.l.	22	West Uttar Pradesh and neighbourhood on 22	Stationary	*In situ*	Became less marked on 23
26.	At 1.5 kms a.s.l.	22	North Pakistan and adjoining Jammu	Do	Do	Became less marked on 23.
27.	Between 3.1 & 4.5 kms a.s.l.	23	Southwest Rajasthan and neighbourhood	Do	Do	Became less marked on 24
28.	Up to 1.5 km above m.s.l.	25-29	Northwest Rajasthan and neighbourhood	East	Haryana and neighbourhood	Became less marked on 30
29.	Between 3.1 and 3.6 km above m.s.l.	27	Southeast Rajasthan and neighbourhood	-	-	It merged with the trough from the cyclonic circulation over north Pakistan and adjoining Punjab to south Gujarat on 28
30.	Between 1.5 and 4.5 km above m.s.l.	29	East Uttar Pradesh which extended on 29	Stationary	*In situ*	Became less marked on 30
(**D**)	*Other Troughs*					
1.	Between 1.5 and 3.1 km above m.s.l.	3-8	Northeast Bihar to south interior Odisha	Southeast	Cyclonic circulation over Bay of Bengal, adjoining coastal areas of Odisha and West Bengal to south coastal Andhra Pradesh	Became less marked on 9
2.	Up to 0.9 km above m.s.l.	6	From north interior Karnataka to south interior Tamil Nadu	Stationary	*In situ*	Became less marked on 7
3.	At 1.5 kms a.s.l.	5	From the cyclonic circulation over north Odisha and adjoining Gangetic West Bengal to north coastal Andhra Pradesh	Do	Do	Became less marked on 6
4.	Up to 2.1 km	6-8	From north Bihar to north coastal Andhra Pradesh across Jharkhand and interior Odisha	East	From the cyclonic circulation over Bay of Bengal, adjoining coastal areas of Odisha and West Bengal to south coastal Andhra Pradesh	Became less marked on 9
5.	At 3.1 km above m.s.l	7	Roughly along Long. 88° E to the north of Lat. 23° N on 7	Stationary	*In situ*	Became less marked on 8
6.	At 0.9 kms a.s.l.	14	From the cyclonic circulation associated with the low-pressure area over coastal areas of Kutch and neighbourhood to northwest Rajasthan	Do	Do	Became less marked on 15

TABLE 5 (*Contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
7.	At 0.9 km above m.s.l.	18	From central Madhya Pradesh to south Tamil Nadu across Vidarbha, Telangana and Rayalaseema	Stationary	*In situ*	Became less marked on 19
8.	Between 3.1 and 7.6 km above m.s.l.	25-26	Roughly along Lat. 25° N	Do	Do	Became less marked on 27
9.	Between 3.1 and 5.8 km above m.s.l.	24	From the cyclonic circulation associated with the low pressure area over Jharkhand and adjoining north Chhattisgarh to north Gujarat region across Madhya Pradesh	North	-	The trough merged with the east-west trough on 25
10.	At 3.1 kms a.s.l.	28	From cyclonic circulation over north Pakistan and adjoining Punjab to south Gujarat across west Rajasthan	Stationary	*In situ*	Became less marked on 29
(E)	*East-West Shear Zone*					
1.	Between 3.1 & 5.8 kms a.s.l.	18	Roughly along Lat. 17° N	North	Roughly along Lat. 18° N	Became less marked on 21
2.	Between 3.1 & 5.8 kms a.s.l.	9-16	Roughly at 20° N	Do	Roughly along Lat. 15° N	Became less marked on 17

Some stations recorded the highest maximum temperature and the lowest minimum temperature for the month. A list of stations is given below with their previous record and date.

S. No.	*Station name*	*Previous record (°C)*	*Date of record (September)*	*Year of record*	*New record (°C)*	*Date (in September 2021)*
1.	North Lakhimpur	38.5	20	2013	39.3	14
2.	Cooch Behar AP	37.7	7	2019	37.8	27
3.	Fatehpur	40.0	29	1970	42.0	4
4.	Pamban	36.9	29	2006	37.0	22

Source : IMD Climate Diagnostics Bulletin of India September 2021

S. No.	*Station name*	*Previous record (°C)*	*Date of record (September)*	*Year of record*	*New record (°C)*	*Date (in September 2021)*
1.	North Lakhimpur	18.3	24	2019	17.7	16

Source : IMD Climate Diagnostics Bulletin of India September 2021

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, 10 sub-divisions (25% area of the country) received *excess* rainfall, 20 *normal* (58% area of the country) and 6 sub-divisions *deficient* (17% area of the country) precipitation. No sub-divisions, recorded *large excess* or *large deficient* rainfall in the season. Seasonal rainfall over the homogenous regions of South Peninsula and Central India were more than normal at 111% of LPA and 104% of LPA while Northwest India and East & Northeast India were less than normal at 96% and 88% of their respective LPA.

2.4. *Withdrawal of southwest monsoon*

Fig. 7 shows the isochrones of withdrawal of southwestmonsoon 2021.

Southwest monsoon started withdrawing from some parts of west Rajasthan and adjoining Gujarat on 6, October, 2021 with a delay of 19 days from its normal

TABLE 6

Details of the weather systems during August 2021

S. No.	System	Duration	Place of initial location	Direction of movement	Place of final location	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(**A**)	*Well marked low/low pressure area*					
1.	Low pressure area	16-17	Westcentral and adjoining northwest Bay of Bengal off south Odisha - north Andhra Pradesh coasts	West	North Odisha, adjoining south Jharkhand and Gangetic West Bengal	It formed under the influence of the cyclonic circulation over west central Bay of Bengal off north Andhra Pradesh coast. The low pressure became less marked on 18 morning. The associated cyclonic circulation moved upto northwest Rajasthan and neighbourhood became less marked on 25
2.	Low pressure area	28-30	Northwest and adjoining westcentral Bay of Bengal off north Andhra Pradesh - south Odisha coasts	Do	Western parts of Vidarbha and neighbourhood	It formed under the influence of cyclonic circulation over northwest Bay of Bengal off West Bengal coast. The associated cyclonic circulation over northeast Arabian Sea off Kutch coast became less marked on 7
(**B**)	*Western Disturbances /Eastward moving Systems*					
(*i*)	*As a trough*					
1.	Mid &Upper tropospheric westerlies	2-5	Long. 64° E to the north of Lat. 28° N	East	Long. 72° E to the north of Lat. 30° N	Moved away northeastwards on 6
2.	Mid - tropospheric westerlies	7	Roughly along Long. 62° E to the north of Lat. 32° N	Northeast		Moved away north-eastwards on 8
3.	Upper tropospheric westerlies	8-15	Roughly along Long. 62° E to the north of Lat. 32° N	Do	Along Long. 74° E to the north of Lat. 32° N	Moved away north-eastwards on 16
4.	Upper tropospheric westerlies with its axis at 5.8 km above m.s.l.	22-25	Roughly along Long. 62° E to the north of Lat. 30° N	Do	Roughly along Long. 70° E to the north of Lat. 32° N	Moved away north eastwards on 26
5.	Do	25-29	Roughly along Long. 62° E to the north of Lat. 30° N	Stationary	*In situ*	Moved away north eastwards on 30
6.	Lower and middle tropospheric westerlies with its axis at 3.1 km above m.s.l.	30 Aug - 1 Sep	Roughly along Long. 62° E to the north of Lat. 28° N	East	Roughly along Long. 70° E to the north of Lat. 28° N	Moved away north eastwards on 2 September
(**C**)	*Other upper air cyclonic circulations*					
1.	Between 1.5 and 3.1 km above m.s.l.	2	Central Pakistan and neighbourhood	Stationary	*In situ*	Became less marked on 3
2.	Upto 1.5 kms a.s.l.	2-7	North Bangladesh and neighbourhood	West	West Bengal and adjoining Bangladesh	Became less marked on 8
3.	Between 2.1 and 3.1 km above m.s.l.	9-13	Southwest Rajasthan and neighbourhood	South	Gujarat and neighbourhood	Became less marked on 14
4.	Up to 1.5 km above m.s.l.	9	Central Pakistan and neighbourhood	Stationary	*In situ*	Became less marked on 10

TABLE 6 (*Contd*.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
5.	Up to 2.1 km above m.s.l.	12-14	North Pakistan and neighbourhood	Stationary	*In situ*	Became less marked on 15
6.	Upto 1.5 km a.s.l.	13-14	Interior Odisha and neighbourhood.	West	North Chhattisgarh and neighbourhood	Became less marked on 15
7.	Upper-tropospheric westerlies with its axis at 5.8 km above m.s.l.	16-21	Roughly along Long. 65° E to the north of Lat. 28° N	Stationary	*In situ*	Moved away east-north eastwards on 22
8.	At 1.5 kms a.s.l.	17-20	North Pakistan and neighbourhood	Do	Do	Became less marked on 21
9.	At 1.5 km a.m.s.l.	20	Northeast Rajasthan and neighbourhood	Do	Do	Became less marked on 21
10.	Upto 4.5 km a.s.l.	19-21	Vidarbha and adjoining south Chhattisgarh	West	Marathwada and adjoining Vidarbha	Became less marked on 22
11.	Between 1.5 km and 3.1 km above m.s.l.	21	off Tamil Nadu and adjoining Sri Lanka coasts	Stationary	*In situ*	Became less marked on 22
12.	Between 1.5 and 5.8 km above m.s.l.	22-24	Southwest Bay of Bengal off Sri Lanka coast which extended	West	Southwest Bay of Bengal off Tamil Nadu coast	Became less marked on 25
13.	At 1.5 km above m.s.l.	24-25	Central Pakistan and neighbourhood	Stationary	*In situ*	Became less marked on 26
14.	Up to 1.5 km above m.s.l.	26	Southeast Arabian Sea off north Kerala coast	Do	Do	Became less marked on 27
15.	At 3.1 km above m.s.l.	27	East Vidarbha and neighbourhood	Do	Do	Became less marked on 28
16.	At 1.5 km above m.s.l.	29	East Vidarbha and neighbourhood	East	-	Merged with the cyclonic circulation associated with the low pressure area over south Chhattisgarh and neighbourhood on 30
(**D**)	*North-South Trough/Other trough*					
1.	Upto 1.5 km above m.s.l.	11-12	From cyclonic circulation over Bihar to north coastal Andhra Pradesh across Jharkhand and interior Odisha	Oscillatory	From the cyclonic circulation over Bihar and adjoining east Uttar Pradesh to westcentral Bay of Bengal across Jharkhand and coastal Odisha	Merged with the north - south trough from the cyclonic circulation over interior Odisha and neighbourhood to north Tamil Nadu on 13
2.	Up to 1.5 km above m.s.l.	13-15	From the cyclonic circulation over interior Odisha and neighbourhood to north Tamil Nadu	Do	From Jharkhand to westcentral Bay of Bengal off south Odisha coast across Odisha	Became less marked on 16
3.	At 3.1 kms a.s.l.	17	From the cyclonic circulation associated with the low pressure area over coastal Odisha and adjoining northwest Bay of Bengal to north Tamil Nadu	West	From Vidarbha to coastal Tamil Nadu	Became less marked on 19

TABLE 6 (*Contd*.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
4.	Up to 1.5 km above m.s.l.	20-22	From the cyclonic circulation over Vidarbha to north coastal Tamil Nadu across Telangana and coastal Andhra Pradesh	Oscillatory	From the cyclonic circulation over northeast Rajasthan and neighbourhood to Telangana across west Madhya Pradesh and Vidarbha	Became less marked on 23
5.	At 3.1 km above m.s.l.	22-23	from Haryana to northeast Arabian Sea across east Rajasthan and Gujarat region	Do	From northwest Rajasthan to northeast Arabian Sea	Became less marked on 24
(E)	*East-West shear zone*					
1.	Between 3.1 and 4.5 km above m.s.l.	18	Roughly along Lat. 20° N	Stationary	*In situ*	Became less marked on 19
2.	At 0.9 km above m.s.l.	19	From northwest Rajasthan to the cyclonic circulation over south Bihar and neighbourhood across south Haryana and south Uttar Pradesh	Do	Do	Became less marked on 20
3.	Between 3.1 and 4.5 km above m.s.l.	19-20	From Jharkhand to south Gujarat across Chhattisgarh, cyclonic circulation over Vidarbha and adjoining south Chhattisgarh, north Maharashtra	-	From the cyclonic circulation over northeast Madhya Pradesh and neighbourhood to Gujarat across north Maharashtra	Became less marked on 21
4.	At 3.1 km above m.s.l.	21	From the cyclonic circulation over northeast Madhya Pradesh and neighbourhood to Gujarat across north Maharashtra	Stationary	*In situ*	Became less marked on 22
5.	At 5.8 km above m.s.l.	23-24	Roughly along Lat. 10° N at 5.8 km above m.s.l.	Do	*In situ*	Became less marked on 25
6.	Between 4.5 and 7.6 km above m.s.l.	27-31	Roughly along Lat. 13° N	-	Roughly along Lat. 15° N	Became less marked on 1 September

date *i.e.*, 17 September. It further withdrew from some more parts of Gujarat, most parts of Rajasthan, entire Punjab, Haryana, Chandigarh & Delhi, Jammu Kashmir & Ladakh, Himachal Pradesh, and Uttarakhand, and some parts of Madhya Pradesh and Uttar Pradesh on 8th October. The withdrawal of southwest monsoon during the consecutive week was rather rapid as it withdrew from almost the entire northeast (except Nagaland, Manipur, Mizoram & Tripura), central India, and most parts of north peninsular India, Arabian Sea and the Bay of Bengal and thus from major parts of the country by 14 October. After a halt of 8 days, the southwest monsoon withdrew from some more parts of India on 23 October. Continuing further withdrawal, southwest monsoon withdrew from

TABLE 7

Details of the weather systems during September 2021

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 "Gulab"	24-28	Eastcentral and adjoining northeast Bay of Bengal	West	North Telangana and adjoining south Chhattisgarh and Vidarbha	Initially it lay as a cyclonic circulation over Myanmar coast and adjoining Gulf of Martaban. Details are given in the article on 'Storms & Depressions over the north Indian Ocean-2021'
2.	Cyclonic Storm "Shaheen"	30 Sep - 4 Oct	Northeast Arabian Sea and adjoining Kutch	Do	north Oman and adjoining United Arab Emirates (UAE)	Intensified from the remnant well marked low of the Cyclonic Storm 'Gulab'. Details are given in the article on 'Storms & Depressions over the north Indian Ocean 2021'
(**B**) *Depression/Deep Depression*						
1.	Deep Depression	12-15 (0530 hrs)	Northwest Bay of Bengal and adjoining Odisha coast	Northwest	North Chhattisgarh & adjoining east Madhya Pradesh	It formed under the influence of a cyclonic circulation over eastcentral Bay of Bengal and neighbourhood. The low pressure became less marked on 20 evening. The associated cyclonic circulation became less marked on 28
(**C**) *Low Pressure*						
1.	Well marked Low pressure area	6-9 mor	Northwest and adjoining westcentral Bay of Bengal off south Odisha-north Andhra Pradesh coasts	Northwest	Central parts of west Madhya Pradesh and adjoining east Rajasthan	It formed under the influence of cyclonic circulation over eastcentral Bay of Bengal between 4.5 km and 5.8 km above m.s.l. it became less marked on 9, However, the associated cyclonic circulation extending up to 7.6 km above m.s.l. lay over central parts of west Madhya Pradesh and adjoining east Rajasthan tilting southwestward with height and became less marked on 10
2.	Low pressure area	10-13	East Rajasthan and neighbourhood	South	South Gujarat region and neighbourhood	Became less marked on14. However, the associated cyclonic circulation merged with the trough from northwest Arabian Sea to the cyclonic circulation associated with the well marked low pressure area over central parts of north Madhya Pradesh and neighbourhood on 16
3.	Do	20 eve - 22	Southern parts of Gangetic West Bengal and neighbourhood	Northwest	Southwest Jharkhand and adjoining north Chhattisgarh	The low-pressure area formed under the influence of the cyclonic circulation over Gangetic West Bengal and neighbourhood. The associated cyclonic circulation became less marked on 27
4.	Well Marked low pressure area	28 Sep - 4 Oct	Northwest Bay of Bengal and adjoining coastal areas of West Bengal	North	East Bihar and adjoining Sub Himalayan West Bengal and Sikkim	It formed under the influence of a cyclonic circulation over eastcentral and adjoining northeast Bay of Bengal off Myanmar coast. Became less marked on 14. The associated cyclonic circulation moved away on 8 October
(**D**) *Western Disturbances / Eastward moving Systems*						
(*i*) *Upper air cyclonic circulation*						
1.	At 5.8 km above m.s.l.	11-13	Roughly along Long. 64° E to the north of Lat. 32° N	East	Roughly along Long. 72° E to the north of Lat. 30° N	It moved away east-northeastwards on 14
(*ii*) *As a trough*						
1.	At 5.8 km above m.s.l.	2-3	Roughly along Long. 65° E to the north of Lat. 28° N	East	Along Long. 70° E to the north of Lat. 30° N on 4	It moved away east-north-eastwards on 4

TABLE 7 (*Contd*.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.	At 3.1 km a.s.l.	2-3	Roughly along Long. 87° E to the north of Lat. 27° N	East	Roughly along Long. 90° E to the north of Lat. 25° N	Became less marked on 4
3.	At 1.5 km a.s.l.	8	North Pakistan and neighbourhood	Stationary	*In situ*	Became less marked on 9
4.	At 3.1 km a.s.l.	21-22	From cyclonic circulation associated with the low pressure area over southern parts of Gangetic West Bengal and neighbourhood to Telangana	North	From cyclonic circulation associated with the low pressure area over southeast Jharkhand and neighbourhood to Telangana across interior Odisha	It became Less marked on 23
5.	Between 3.1 and 5.8 km above m.s.l.	20-23	Roughly along Long. 62° E to the north of 28° N	Northeast	Roughly along Long. 72° E to the north of Lat. 32° N	It moved away east north-eastwards on 24
6.	Up to 5.8 km above m.s.l.	27-29	From north Konkan to cyclonic circulation associated with Deep Depression over south Odisha and adjoining south Chhattisgarh	Oscillatory	From the cyclonic circulation associated with the well-marked low-pressure area over south Gujarat region and adjoining Gulf of Khambhat to the cyclonic circulation associated with the other well marked low pressure area	Became less marked on 30
7.	Between 3.1 and 5.8 km above m.s.l.	24-25	Roughly along Long. 62° E to the north of Lat. 30° N	Northeast	Roughly along Long. 70° E to the north of Lat. 32° N	Moved away east-northeast ward on 26
(E)	*Other upper air cyclonic circulations*					
1.	Between 1.5 and 3.1 km above m.s.l.	2-3	Westcentral and adjoining southwest Bay of Bengal off south Andhra Pradesh - north Tamil Nadu coasts	West	Coastal Andhra Pradesh and neighbourhood	Became Less marked on 4
2.	Between 2.1 and 3.6 km above m.s.l.	4-5	South Chhattisgarh and neighbourhood	Do	Marathwada and neighbourhood	It became Less marked on 6
3.	Between 1.5 and 3.1 km	2-3	Westcentral and adjoining southwest Bay of Bengal off south Andhra Pradesh - north Tamil Nadu coasts	Do	Coastal Andhra Pradesh and neighbourhood	Became less marked on 4
4.	Upto 2.1 kms a.s.l.	3-7	Northwest Rajasthan and neighbourhood	North	South Punjab and neighbourhood	Became less marked on 8
5.	At 0.9 km above m.s.l.	18	South Bangladesh	Stationary	*In situ*	It became Less marked on 19
6.	Between 1.5 & 3.1 kms a.s.l.	18-19	Westcentral Arabian Sea off Oman coast	Do	Do	It became Less marked on 20

TABLE 7 (*Contd*.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
7.	At 1.5 km above m.s.l.	19-21	North Tamil Nadu and neighbourhood	East	South coastal Tamil Nadu, neighbourhood	It became Less marked on 22
8.	Between 1.5 and 2.1 km above m.s.l.	24	South coastal Andhra Pradesh and neighbourhood	Stationary	*In situ*	It became Less marked on 25
9.	Between 3.1 and 4.5 km above m.s.l.	23	Telangana and neighbourhood	Do	Do	It became Less marked on 24
(*F*)	*North-South Trough/Other trough/trough in easterlies*					
1.	Between 1.5 & 5.8 km a.s.l.	1	From south Gujarat to south coastal Andhra Pradesh	Stationary	*In situ*	Became less marked on 2
2.	Up to 1.5 km above m.s.l (in easterlies)	1-2	From cyclonic circulation over south Gujarat Region and neighbourhood to northwest Uttar Pradesh across east	Northwest	From the cyclonic circulation over Saurashtra and neighbourhood to Haryana across central parts of Rajasthan	Became less marked on 3
3.	Between 3.1 & 5.8 km a.s.l.	9-15	From northeast Arabian Sea to north Odisha across south Gujarat, south Madhya Pradesh and north Chhattisgarh	Oscillatory	From the cyclonic circulation over south Gujarat region and neighbourhood to Gangetic West Bengal	Became less marked on 16
4.	Up to 3.1 km above m.s.l.	16-17	From northwest Arabian Sea to the cyclonic circulation associated with the well-markedlow pressure area over central parts of north Madhya Pradesh and neighbourhood	Do	From northwest Arabian Sea to the cyclonic circulation associated with the well-marked low pressure area over northwest Madhya Pradesh and adjoining southwest Uttar Pradesh	Became less marked on 18
5.	At 3.1 km above m.s.l.	20	From cyclonic circulation over east Rajasthan to northeast Arabian Sea across Gujarat	Stationary	*In situ*	Became less marked on 21
6.	Between 0.9 and 1.5 km above m.s.l.	18-20	From Telangana to south Tamil Nadu across Rayalaseema which extended on 18	West	From south interior Karnataka to Comorin area	Became less marked on 21
7.	Up to 3.1 km above m.s.l.	30 Sep	From southeast Bay of Bengal to south Andhra Pradesh coast	Oscillatory	From cyclonic circulation over central parts of south Bay of Bengal to Tamil Nadu coasts	Became less marked on 2 October

the entire country on 25 October and the northeast monsoon rains commenced on the same day over south peninsular India.

3. Chief synoptic features of southwest monsoon 2021

The synoptic disturbances which affected the Indian monsoon region during June, July, August and September are given in Tables 4 to 7, respectively.

In all 16 Low Pressure areas formed, 2 of which intensified into Cyclonic storms, *viz.*, Cyclonic storm, "GULAB" over Bay of Bengal during 24-28 September, 2021, Severe Cyclonic storm, "Shaheen" (30 September - 4 October, 2021) over northeast Arabian Sea adjoining Kutch which formed from the remnant of Cyclonic storm, "GULAB", 1 as a Deep Depression over northwest Bay of Bengal during 12-15 September and 4 into Well Marked Low pressure areas.

The first Low Pressure system of June formed over northwest Bay of Bengal and adjoining Odisha and Gangetic West Bengal coasts on 11 June and moved northwestwards towards East Uttar Pradesh and adjoining Bihar. Under the influence of this Low-Pressure area and its associated cyclonic circulation, tilting southwestward with height, fairly widespread to widespread rainfall / thunderstorms occurred over east India and adjoining areas of central India. Formation of this low-pressure area strengthened the westerlies and along with an off-shore trough caused widespread rainfall / thunderstorm activity along the west coast. Another low-pressure area formed over southwest Bihar and adjoining southeast Uttar Pradesh on 18 June, the Low Pressure and its remnant cyclonic circulation over northwest Bihar and adjoining East Uttar Pradesh triggered fairly widespread to widespread rainfall/thunderstorm activity over parts of east India and over parts of east Uttar Pradesh. Movement of western disturbances and cyclonic circulations in the lower tropospheric levels supported by moisture incursion into the area caused rainfall/thunderstorm over western Himalayan Region and adjoining areas of Northwest India.

In the month of July, 3 Low Pressure and 2 Well Marked Low Pressure systems influenced the weather, with one Low Pressure system forming over land over southern parts of central Uttar Pradesh.

Two Low Pressure systems formed over Bay of Bengal in second fortnight of August. Movement of western disturbances caused rainfall/thunderstorm over Western Himalayan region, northeast India and adjoining areas of east India.

A Well-Marked Low Pressure area over westcentral and adjoining northwest Bay of Bengal and north Andhra Pradesh - south Odisha coasts and its associated cyclonic circulation extending up to 7.6 km above m.s.l. tilting southwestwards with height, alignment of the monsoon trough to the south of its normal position caused fairly widespread to widespread rainfall/thunderstorm over parts of east, central, west India and over northern parts of peninsular India during the first week of September. The first Depression over the north Indian Ocean during the monsoon season this year was the Deep Depression over northwest Bay of Bengal during 12-15 September, 2021. It caused active to vigorous monsoon conditions leading to extremely heavy rainfall at a few places over Odisha, at isolated places over Chhattisgarh and over east Madhya Pradesh on 13 and 14 September. In conjunction with this system and aLow Pressure area over southwest Rajasthan and adjoining Gujarat, their associated cyclonic circulations extending up to mid tropospheric levels, alignment of the monsoon trough to the south of its normal position, an east-west trough between the cyclonic circulations associated with the low-pressure systems over the eastern and western parts of the country across central India led to low level convergence of wind and enhanced moisture incursion from the Bay of Bengal and caused extremely heavy rains at isolated places over Odishafor example rainfall amounts such as Astaranga and Kakatpur-53 cm each, Balikuda 44 cm on 13 September. Cyclonic storm, "Gulab" formed and developed over Bay of Bengal, during active phase of monsoon over Indian sub-continent, moving westwards it crossed north Andhra Pradesh and adjoining south Odisha coasts and gradually weakened into a Well Marked Low Pressure area over western parts of Vidarbha and neighbourhood around noon of 28 September. It caused extremely heavy rainfall over Andhra Pradesh and heavy to very rainfall over Odisha. Remnant of the Cyclonic storm, "Gulab" emerged into gulf of Kutch and concentrated into a Depression over northeast Arabian Sea & adjoining Kutch which intensified into a Deep Depression over northeast Arabian Sea off Gujarat coast and further intensified into a Cyclonic storm, "Shaheen" over northeast Arabian Sea and neighbourhood, it intensified into a Severe Cyclonic storm over northwest and adjoining northeast Arabian Sea. This cyclone moved away from Indian coast and had no impact along Indian coast, however, in its initial stages as a Depression/Deep Depression, it caused widespread rainfall along with heavy / very heavy rainfall over Saurashtra & Kutch.

The off-shore trough along different parts of the west coast persisted from 4-7 June, 9-23 June, 29-30 June, 14-26 July, 28-29 July, and 29, 19-21 August and 26-30 August.

TABLE 8

Representative amounts of rainfall in cm for June, July, August and September 2021 (21cm and above)

Date	Some representative amounts of rainfall in cm for June, July, August and September 2021 (21 cm and above)
1 Jun	Nil
2 Jun	Nil
3 Jun	Nil
4 Jun	Mulki 39
5 Jun	Nil
6 Jun	Nil
7 Jun	Nil
8 Jun	Nil
9 Jun	Nil
10 Jun	Santacruz and Thane 23 each
11 Jun	Nil
12 Jun	Nil
13 Jun	Nil
14 Jun	Ratnagiri 24
15 Jun	Chanpatia and Ramnagar 28 each, Dhaurahara 27
16 Jun	Dhaurahara 23, Bankura (CWC) and Shriwardhan 21 each
17 Jun	Hosanagar 32, Gaganbawada 28, Kottigehara 22, Avalanche, Wakwali ARG and Mahabaleshwar 21 each
18 Jun	Matheran 23, Upper Bhavani, Linganamakki HMS and Dahanu 22 each, Bhagamandala and Tbia IMD Part Time 21 each
19 Jun	Guhagarh 25
20 Jun	Nil
21 Jun	Nil
22 Jun	Nil
23 Jun	Marsaghai 23
24 Jun	Cherrapunji 21
25 Jun	Williamnagar 23
26 Jun	Nil
27 Jun	Nil
28 Jun	Mawsynram 33, Cherrapunji 32, Cherrapunji (rkm) 30, Haldwani 21
29 Jun	Cherrapunji 56, Cherrapunji (rkm) 55, Mawsynram 47
30 Jun	Bhaghmara 28, Chengmari/Diana and Buxaduar 25 each, Beki Mathungari, Cherrapunji (rkm), Mawsynram and Hasimara 23 each, Cherrapunji 22, Gaunaha 21
1 Jul	Nil
2 Jul	Nil
3 Jul	Nil
4 Jul	Cherrapunji (rkm) 31, Cherrapunji and Mawsynram 28 each
5 Jul	Nil
6 Jul	Nil
7 Jul	Nil
8 Jul	Nil

TABLE 8 (*Contd*.)

Date	Some representative amounts of rainfall in cm for June, July, August and September 2021 (21 cm and above)
9 Jul	Nil
10 Jul	Nil
11 Jul	Nil
12 Jul	Murud 35, Wakwali ARG 25, Dapoli ARG 23, Mhasla, Shriwardhan, Kankavli and Gaganbawada 21 each
13 Jul	Tala 24, Dharmsala and Mandangad 23 each, Palampur 21
14 Jul	Karnal and Karnal REV 25 each
15 Jul	Hosanagar and Chegunta 21 each
16 Jul	Malvan 30, Santacruz 25, Ratnagiri 22
17 Jul	Nil
18 Jul	Daman Fmo 32, Ratnagiri 26, Chanderdeepghat 25, Daman and Palghar ARG 24 each, Kadiri AP and Santacruz 23 each, Kadiri, Bhatkal and Tbia IMD Part Time 21 each
19 Jul	Ozharkheda - Fmo 33, Tbia IMD Part Time 29, Panvel ARG 28, Matheran and Murud 27 each, Dapoli ARG, Umergam and Kankavli 24 each, Palampur and Rameshwar ARG 23 each, Igatpuri 22, Lanja, Wakwali ARG, Kamrej, Mangaon, Vikramgad, Thane, Mokheda - Fmo and Tala 21 each
20 Jul	Kalyan 37, Bhiwandi 30, Ulhasnagar 29, Matheran 26, Ambernath 25, Sikandra Rao and Pataudi 24 each, Haldwani, Etah and Dapoli ARG 23 each, Sudhagad Pali 22
21 Jul	Nil.
22 Jul	Mahabaleshwar 48, Jawhar 43, Wada 42, Dhaurahara 37, Matheran 33, Karjat ARG 32, Peth and Lonavala ARG 31 each, Mokheda - Fmo 29, Gaganbawada and Poladpur 27 each, Ozharkheda - Fmo and Sangameshwar Devrukh 25 each, Igatpuri 24, Murbad, Dilawarpur, Harsul - Fmo, Vikramgad and Sironj 23 each, Trimbakshwar, Sarangapurnrl, Lanja and Sudhagad Pali 22 each, Shahapur, Boath, Mahad and Wakwali ARG 21 each
23 Jul	Mahabaleshwar 59, Radhanagari and Ajra 40 each, Wankdi 39, Londa 38, Gaganbawada 36, Kadra and Janmane 34 each, Poladpur and Patan 31 each, Asifabad 30, Lonavala ARG 29, Banavasi and Chandgad 28 each, Bhainsdehi, Panhala, Thalaguppa and Khanapur 27 each, Gadhinglaj 25, Anavatti and Siddapur 24 each, Sagar, Shahuwadi, Yellapur and Agarahara Konanduru 23 each, Vaibhavwadi 22, Sanguem, Sawantwadi, Velhe, Sohagpur, Belagavi PTO, Manchikere, Haliyal and Sarangapurnrl 21 each
24 Jul	Mahabaleshwar 32, Kagal 22, Susner, Pirawa and Panhala 21 each
25 Jul	Anuppur and Udhampur (IAF) 23 each
26 Jul	Kathiwada, Jaora and Mahidpur 26 each, Zirapur 22, Pachore and Marwar Junction 21 each
27 Jul	Forbesganj 28, Bamori 26, Raghogarh 23, Chabra 21
28 Jul	Kunda 24
29 Jul	Kharagpur (I.i.t) 26, Midnapore (CWC) and Midnapore 23 each, Durgachack 22, Mohanpur 21
30 Jul	Diamond Harbour and Uluberia 22 each
31 Jul	Shahabad 30, Karhal 24
1 Aug	Makrana SR 24, Hurda SR 21
2 Aug	Bairad 29, Shahabad 25, Prithvipur 21
3 Aug	Shivpuri 47, Pichhore 42, Pohri 38, Khaniyadana 33, Kolaras 32, Bamori and Karera 27 each, Shahabad and Sheopur 25 each, Bairad 23, Veerpur, Narwar and Talbehat 21 each
4 Aug	Patan 25, Ladpura SR 23, Karhal and Shahabad 21 each
5 Aug	Nil
6 Aug	Mercara 113
7 Aug	Bamori 21
8 Aug	Nil
9 Aug	Nil
10 Aug	Mawsynram 25, Cherrapunji (rkm) 23, Cherrapunji 22

TABLE 8 (*Contd*.)

Date	Some representative amounts of rainfall in cm for June, July, August and September 2021 (21 cm and above)
11 Aug	Nil
12 Aug	Mawsynram 27
13 Aug	Mawsynram 22
14 Aug	Mawsynram 49, Cherrapunji (rkm) 30, Buxaduar and Haldwani 23 each
15 Aug	Nil
16 Aug	Nil
17 Aug	Salbari 23
18 Aug	Nil
19 Aug	Nil
20 Aug	Nil
21 Aug	Nil
22 Aug	Nil
23 Aug	Cherrapunji (rkm) 33, Mawsynram 28, Cherrapunji 27
24 Aug	Mawsynram 23
25 Aug	Rishikesh 21
26 Aug	Mawsynram 33, Cherrapunji (rkm) 21
27 Aug	Nil
28 Aug	Nil
29 Aug	Nil
30 Aug	Nil
31 Aug	Dahanu 22, Daman ARG 21
1 Sep	Umergam 40, Daman 33, Daman Fmo 30, Daman ARG 29, Dahanu and Pataudi 21 each
2 Sep	Alipurduar (CWC) and Alipurduar PTO 21 each
3 Sep	Nil
4 Sep	Nil
5 Sep	Nil
6 Sep	Nil
7 Sep	Murud 47, Harnai IMD 37, Dapoli ARG 36, Nallabelly 26, Huzurabad 25, Kothagudem, Mogullapalle and Khanapur 23 each, Dharmaram 22, Chiplun, Jammikunta, Konaraopeta and Parkal 21 each
8 Sep	Sangameshwar Devrukh 29, Guhagarh 24, Dediapada 22
9 Sep	Sutrapada 25
10 Sep	Nil
11 Sep	Nil
12 Sep	Nil
13 Sep	Kakatpur and Astaranga 53 each, Balikuda 44, Kantapada 38, Niali 37, Alipingal 36, Puri 34, Satyabadi and Gop 33 each, Raghunathpur 32, Nimpara 30, Kendrapara 28, Kujanga and Marsaghai 27 each, Jagatsinghpur and Pipili 26 each, Tirtol 25, Brahmagiri 24, Chandikhol and Paradeep Cwr 22 each, Derabis 21
14 Sep	Lodhika 52, Visavadar 47, Kalavad 41, Talcher 39, Birmaharajpur 37, Tikarpara 35, Sonepur 28, Boudhgarh 26, Banarpal, Dhoraji and Patnagarh 25 each, Hindol, Paikmal and Targhadia AWS 24 each, Parjang and Kantamal 23 each, Barmul and Belpada 22 each, Junagadh, Bari, Jenapur, Phiringia, Gaisilet, Kotdasangani and Mahanga 21 each
15 Sep	Midnapore (CWC) and Kharagpur (I.i.t) 28 each, Kalaikunda (IAF) and Mohanpur 27 each, Midnapore 26, Amarkantak 24, Uluberia (state) 21

TABLE 8 (*Contd.*)

Date	Some representative amounts of rainfall in cm for June, July, August and September 2021 (21 cm and above)
16 Sep	Nil
17 Sep	Ayodhya and Azamgarh 37 each, Laharpur 28, Ramnagar 24, Tirwa 23, Tanda and Sirauli Gauspur Tehsil 21 each
18 Sep	Nil
19 Sep	Nil
20 Sep	Nil
21 Sep	Nil
22 Sep	Khanvel 21
23 Sep	Dhaurahara 21
24 Sep	Nil
25 Sep	Kunda 21
26 Sep	Nil
27 Sep	Visakhapatnam, Gajapathinagaram and Nellimarla 28 each, Visakhapatnam AP 27, Mentada 25, Pusapatirega 24
28 Sep	Jakranpalle 23, Dhar Palle and Navipet 21
29 Sep	Khanvel 37, Silvassa, Umerpada and Durgachack 22 each
30 Sep	Asansol 43, Luchipur 41, Bankura 35, Putki 31, Visavadar and Bokaro 29 each, Sikatia 28, Jamtara Fmo 24, Bankura (CWC) 23, Pupunki, Durgapur and Kharidwar 22 each, Maithon 21

4. Extra Indian features

4.1. *Cross Equatorial Flow during June-September, 2021*

4.1.1. *Over the Arabian Sea*

Month	5° N - 5° S					North of 5° N				
		Weeks					Weeks			
	Normal (in kts)	1	2	3	4	Normal (in kts)	1	2	3	4
Jun	10-12	+2	+2	+3	+2	15-20	N	-1	+6	+2
July	12-14	N	-1	+1	-1	20-25	-5	-6	-2	-5
Aug	12-14	N	N	+1	+1	20-25	-2	-7	-10	-10
Sep	08-10	+3	+2	+4	+4	05-10	+10	+7	+6	+8

The cross equatorial flow along the equatorial belt (equator to 5° N / 5° S) over Arabian Sea was:

(*i*) In June 2021, it was above normal in 1st, 2nd, 3rd and 4th weeks.

(*ii*) In July 2021, it was above normal in 3rd week while it was normal in 1st weekand it was below normal in 2nd and 4th weeks.

(*iii*) In August 2021, it was above normal in 3rd and 4th weeks while it was normal in 1st and 2nd weeks.

(*iv*) In September 2021, it was above normal in 1st, 2nd, 3rd and 4th weeks.

4.1.1.1. *The surface winds over Arabian Sea to the north of 5° N*

(*i*) In June 2021, it was above normal in 3rd and 4th week while it was normal in 1st week and it was below normal in 2nd week.

(*ii*) In July 2021, it was below normal in 1st, 2nd, 3rd and 4th weeks.

(*iii*) In August 2021, it was below normal in 1st, 2nd, 3rd and 4th weeks.

(*iv*) In September 2021, it was above normal in 1st, 2nd, 3rd and 4th weeks.

4.1.2. *Over the Bay of Bengal*

Month	5° N - 5° S					North of 5° N				
		Weeks					Weeks			
	Normal (in kts)	1	2	3	4	Normal (in kts)	1	2	3	4
Jun	08-10	+8	+5	+6	+7	10-15	-2	+1	N	N
July	08-10	+3	+2	+3	+4	10-15	+2	+1	+3	+2
Aug	08-10	+4	+2	+3	N	10-15	+2	+2	+4	+2
Sep	08-10	+1	+6	+1	+6	05-10	+6	+6	+3	+4

4.1.2.1. *The Cross Equatorial flow along the equatorial belt (equator to 5° N / 5° S) over Bay of Bengal*

(*i*) In June 2021, it was above normal in 1st, 2nd, 3rd and 4th weeks.

(*ii*) In July 2021, it was above normal in 1st, 2nd, 3rd and 4th weeks.

(*iii*) In August 2021, it was above normal in 1st, 2nd, 3rd while it was normal in 4th weeks.

(*iv*) In September 2021, it was above normal in 1st, 2nd, 3rd and 4th weeks.

4.1.2.2. *The surface winds over the Bay of Bengal to the north of 5° N were*

(*i*) In June 2021, it was above normal in, 2nd week. While it was normal in 3rd 4th weeks It was below normal in 1st week.

(*ii*) In July 2021, it was above normal in 1st, 2nd, 3rd and 4th weeks.

(*iii*) In August 2021, it was above normal in 1st, 2nd, 3rd and 4th week.

(*iv*) In September 2021, it was above normal in 1st, 2nd, 3rd and 4th week.

4.2. *Position of equatorial trough was*

June 2021 : South of its normal position by 2° - 6°, from 40° E to 69° E and from 75° E to 100° E in the first week. South of its normal position by 2° - 3° from 40° E to 68° E and North of its normal position by 1° - 3°, from 75° E to 110° E in the 2nd week. South of its normal position by 2° - 4° from 40° E to 110° E in the 3rd week. South of its normal position by 1° - 3° from 40° E to 110° E in the 4th week.

July 2021 : South of its normal position by 1° - 8°, from 40° E to 68° E and from 80° E to 110° E and it was near to normal 70° E to 80° E in the first week. South of its normal position by 1° - 4° from 80° E to 110° E and near to normal from 40° E to 75° E in the 2nd week. South of its normal position by 3° - 5° from 40° E to 65° E and 78° E to 110° E and above normal by 1° from 65° E to 75° E in the 3rd week. It was near to normal from 40° E to 110° E in the 4th week.

August 2021 : Above normal by 1° - 2° from 55° E to 80° E and South of its normal position by 1° from 92° E to 110° E in the first week. South of its normal position by 1° - 7° from 40° E to 73° E and 75° E to 110° E in the 2nd week. South of its normal position by 1° - 5° from 40° E to 100° in the 3rd week.It was near to normal from 40° E to 55° E and South of its normal position by 2° - 8° from 55° E to 110° E in the 4th week.

September 2021 : It was near to normal from 40° E to 75° E and South of its normal position by 2° - 6° from 80° E to 110° in first week; South of its normal position by 1° - 5° from 40° E to 110° E in the 2nd week. It was near to normal from 40° E to 70° E and South of its normal position by 1° - 4° from 70° E to 110° in the 3rd week; South of its normal position by 1° - 3° from 40° E to 110° in the 4th week.

4.3. *Low Pressure Systems during June to September, 2021 in Bay of Bengal*

Low Pressure Systems	Jun	Jul	Aug	Sep	Total
Low Pressure Area / WML	01	02	01	03	07
Depression	00	00	00	00	00
Deep Depression	00	00	00	01	01
Tropical Storm (T.S.)	00	00	00	02	02
Total	01	02	01	05	09

4.3.1. *Low Pressure Systems during June to September 2021 in Arabian Sea*

Low Pressure Systems	Jun	Jul	Aug	Sep	Total
Low Pressure Area / WML	00	01	00	01	02
Depression	00	00	00	00	00
Deep Depression	00	00	00	01	01
Tropical Storm (T.S.)	00	00	00	00	00
Total	00	01	00	02	03

4.3.2. *In the West Pacific Ocean/ South China Sea*

There were, in all, 17 Low Pressure systems (reaching the intensity of Tropical Depression and above) in the northwest Pacific Ocean / South China Sea during June - September 2021. The month wise break-up is given below:

Low Pressure Systems	Jun	Jul	Aug	Sep	Total
Tropical Depression (T.D.)	01	02	01	01	05
Tropical Storm (T.S.)	02	02	04	01	09
Typhoon/Super Typhoon	00	01	00	02	03
Total	03	05	05	04	17

4.3.3. *In South Indian Ocean*

No low-pressure system (TD, TS or Typhoon) was reported in Southern Hemisphere during June-September, 2021.

4.4. *Troughs in Westerlies affecting the Indian region to the south of 30° N and to the north 0f 30° S during June to September, 2021*

4.4.1. *The Upper air troughs in mid and upper tropospheric Westerly* : Indian region

The number of troughs in westerlies which moved across Indian region from west to east penetrated to the south of 30° N was as follows:

The month wise break-up is given below:

Atmospheric level	*June*	*July*	*August*	*September*	*Total*
500 hPa	06	02	02	04	14
300 hPa	04	03	04	04	15

(*Source* : INOSHAC/CONSTANT PRESSURE MAPS, USA)

4.4.2. *Upper Air Troughs in westerlies over South Indian Ocean, which penetrated to the north of latitude 30° S*

The troughs in upper air westerlies which moved across the south Indian Ocean from west to east, penetrated to the north of Lat. 30° S, in the Southern Hemisphere, during June to September, 2021.

The month wise break-up is as follows:

Atmospheric level	*June*	*July*	*August*	*September*	*Total*
500 hPa	04	04	05	04	17
300 hPa	05	06	05	04	20

(*Source* : Climatic Atlas of The Indian Ocean)

4.5. *Normal position of Mascarene HIGH (centered at 30° S / 50° E) and Australian High (centered at 30° S / 140° E) during June to September*

4.5.1. *Intensity of Mascarene High during June to September 2021 with its mean position at Lat. 32.6° S and Longitude 55.8° E*

Month	**Normal Pressure (hPa) (approx.)*	*Actual Pressure (hPa)*	*Departure from normal hPa (approx)*
June	1023.0	1027.5	+4.5
July	1025.5	1026.8	+1.3
August	1026.0	1026.8	+0.8
September	1023.5	1026.3	+2.8

(**Source* : ACMAD, NOAA)

The Mascarene High with its mean position at 32.6° S / 55.8° E was strengthened by 2.3 hPa during the monsoon period June to September 2021. It was above normal by 4.5, 1.3, 0.8, 2.8 hPa during the months of June, July, August and September, 2021 respectively.

4.6. *Intensity of Australian High during June to September, 2021 with its Mean position at Lat. 31.7° S and Long. 136.4° E*

Month	**Normal Pressure (hPa) (approx.)*	*Actual Pressure (hPa)*	*Departure from normal hPa (approx)*
June	1022.0	1028.4	+6.4
July	1022.0	1025.1	+3.1
August	1020.5	1028.0	+7.5
September	1018.0	1027.9	+9.9

(**Source* : NOAA)

The Australian High centered at 31.7° S / 136.4° E was strengthened by an average of about 6.2 hPa during the entire monsoon period of June to September 2021. It was above normal by 6.4, 3.1, 7.5 hPa & 9.9 hPa in the month of June, July, August and September 2021 respectively.

5. *Semi-permanent systems*

5.1. *Heat Low*

The lowest and the second lowest values of the Heat Low were:

Jun : 992 hPa (on 11, 12 and 16) and 994 hPa (on 10, 13 and 15)

Jul : 990 hPa (on 28) and 994 hPa (on 1, 2, 10, 22, 23, 26, 27 and 29)

Aug : 994 hPa (on 3) and 996 hPa (on 2, 12, 14, 15, 26 and 27)

Sep : 1000 hPa (5, 6, 8, 9 and 13) and 1002-4, 7, 10-12, 14, 16, 17 and 22)

5.2. *Monsoon Trough*

This year, shallow Heat trough was seen over the Indo-Gangetic plains in first week of June. With the southwest monsoon covering the entire country, it got established as the monsoon trough on 13th July. The eastern end of the trough was seen north of its normal position. The trough remained to the north of normal position for most of the days in August and south of normal on many days in the month of September.

The monsoon trough got disorganized and disappeared from the pressure and wind field from 28th September.

5.3. *Tibetan Anticyclone/High*

This year, the Tibetan anticyclone was seen to either south to-southeast of its normal position in the first fortnight of June. Then it was seen to the northeast of normal. Almost all through the month of July, it remained either to the northeast or southeast of normal positionand in the month of August, it remained to the north or east of normal.In September, it remained to South or southeast on most of the days. It then shifted south-eastwards thus becoming un-important.

5.4. *Tropical Easterly Jet (TEJ)*

The TEJ got established over the southern peninsular India by 5 June with Multiplatinum reporting easterlies of 63 knots at 81 hPa level. A wide latitudinal spread of the easterly jet speed winds was observed during July, August and September, while during June the stations over the Peninsular India only reported jet speed winds. The highest wind speed of 126 knots at 166 hPa was reported at Chennaion 2nd August.

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

Shifted northwards from the last week of May, New Delhi reported 67 knots wind (at 166 hPa) at 0000 UTC of 5 June. Subsequently, the core of STWJ shifted to the north of the Himalayas. It made occasional re-appearances along the latitude of New Delhi.It once again shifted southwards as evident by the 63 knots westerly wind reported over New Delhi at 142 hPa on 18 October (0000 UTC).

6. Other features

6.1. *Monthly wind anomalies during southwest monsoon 2021*

The circulation anomaly features at lower, middle and upper tropospheric levels, 850, 700, 500 and 200 hPa during the southwest monsoon season are discussed below:

6.1.1. *June wind anomaly features*

In the monthly wind pattern, two anomalous cyclonic circulations were seen, one over 850 hPa, over Rajasthan extending upto 500 hPa and second over West Bengalat 700 hPa extending upto 500 hPa. An anomalous ridge at 200 hPa extended along 29° N.

In the week ending 2 June, two anomalous cyclonic circulations were seenat 850 hPa one over east Madhya Pradesh extending upto 300 hPa and second over Odishaand neighbourhood extending upto 500 hPa. Another anomalous cyclonic circulation was seen at 300 hPa over Rajasthan. An anomalous ridge at 200 hPa extended along 30° N.

In the week ending 9 June, two anomalous cyclonic circulations were seen at 850 hPa, one over west Madhya Pradeshand neighbourhood extending upto 500 hPa and second over peninsular region.

In the week ending 16 June, two anomalous cyclonic circulations were seen at 850 hPa, one over east Uttar Pradesh extending upto 700 hPa and second over Odishaand neighbourhood extending upto 200 hPa.

In the week ending 23 June, one anomalous cyclonic circulation was seen at 850 hPa, over Bangladeshand neighbourhood extending upto 700 hPa. A ridge at 200 hPa extended along 27° N.

In the week ending 30 June, one anomalous cyclonic circulation was seen at 850 hPa, over Vidarbha and neighbourhood extending upto 700 hPa. Two cyclonic circulations were observed at 500 hPa one over west Rajasthan and the other over north Rajasthan. Three anomalous anticyclones were observed at 850 hPa one over Pakistan, second over northwest Madhya Pradesh and the third over head Bay of Bengal. A ridge at 200 hPa extended along 30° N.

6.1.2. *July wind anomaly features*

In the monthly wind pattern, three anomalous cyclonic circulations were seen at 850 hPa, one over west Rajasthan andadjoining Pakistan, second over north Madhya Pradesh, neighbourhood and third over north Tamil Nadu extending upto 500 hPa. A ridge at 200 hPa extended along 33° N.

In the week ending 7 July, three anomalous cyclonic circulations were seen at 850 hPa, one over west Rajasthan, second over Uttar Pradesh and third over Jharkhand, all three extending upto 700 hPa. A ridge at 200 hPa extended along 23° N.

In the week ending 14 July, an anomalous cyclonic circulation was seen at 500 hPa, over north Kerala extending upto 200 hPa. A ridge at 200 hPa extended along 28° N.

In the week ending 21 July, two anomalous cyclonic circulation were seen at 850 hPa, one over south Rajasthan and neighbourhood and second over coastal

Andhra Pradesh extending upto 700 hPa. A ridge at 200 hPa extended along 31° N.

In the week ending 28 July, three anomalous cyclonic circulations were seen at 850 hPa, one over west Rajasthan and neighbourhood extending upto 500 hPa, second over Uttar Pradesh and third over head Bay of Bengal extending upto 200 hPa, a ridge at 200 hPa extended along 30° N.

6.1.3. *August wind anomaly features*

In the monthly wind pattern, one anomalous cyclonic circulation was seen over Karnataka at 700 hPa, A ridge at 200 hPa extended along 27° N.

In the week ending 4 August, two anomalous cyclonic circulations were seen at 850 hPa, one over head Bay of Bengal and the second over east Rajasthan, both extending upto 500 hPa. A ridge at 200 hPa extended along 27° N.

In the week ending 11 August, three anomalous cyclonic circulations were seen at 850 hPa, one over west Rajasthan and neighbourhood, second over south Maharashtra, neighbourhood and third over coastal Tamil Nadu and neighbourhood.

In the week ending 18 August, an anomalous ridge at 200 hPa extended along 26° N.

In the week ending 25th August, one anomalous cyclonic circulationwas seen at 850 hPa over west Rajasthan and neighbourhood extending upto 500 hPa. A ridge at 200 hPa extended along 34° N.

In the week ending 1 September, one anomalous cyclonic circulation was seen at 850 hPa, over southeast Arabian Sea. A ridge at 200 hPa extended along 26° N.

6.1.4. *September wind anomaly features*

In the monthly wind pattern, three anomalous cyclonic circulations were seen at 850 hPa, one over Gujarat extending upto 500 hPa. Another over Vidarbha region of Maharashtra and the third anomalous cyclonic circulation over coastal Odisha and adjoining area extending upto 500 hPa. A ridge at 200 hPa extended along 31° N.

In the week ending 8 September, two anomalous cyclonic circulations were seen at 850 hPa, one over west Rajasthanand neighbourhood extending upto 700 hPa and second over Vidarbha extending upto 500 hPa. A ridge at 200 hPa extended along 30° N.

In the week ending 15 September, two anomalous cyclonic circulations were seen at 850 hPa, one over Head Bay of Bengal and the other over Arabian Sea adjoining north Konkan and Goa extending upto 500 hPa. A ridge at 200 hPa extended along 31° N.

In the week ending 22 September, two anomalous cyclonic circulations were seen at 850 hPa, one over north Madhya Pradesh and adjoining Rajasthan extending upto 500 hPa. The second cyclonic circulation seen over north Odisha and adjoining Jharkhand extending upto 500 hPa. A ridge at 200 hPa extended along 31° N.

In the week ending 29 September, two anomalous cyclonic circulations were seen at 850 hPa, one over Marathwada and second over Bay of Bengal adjoining Odisha, both extending upto 500 hPa. A ridge at 200 hPa extended along 31° N.

7. Disastrous weather events and damage during monsoon months

7.1. *June*

As per media reports, heavy rainfall accompanied by gusty winds lashed several parts of Maharashtra including the Marathwada region, Kolhapur and Sangli districts, which took a toll of 6 lives, damaging properties and uprooting trees. Panchganga river in Kolhapur, Maharashtra overflowed due to heavy rainfall in Kolhapur district and cut off several villages. 11 persons reportedly claimed dead and 17 others injured in Mumbai, when a building collapsed due to incessant rains. Heavy rain caused flooding in Koradi river in Buldhana district which affected hundreds of hectares of cropland in three talukas of the district. Also, due to heavy rains and floods, damage to crops, property including bridge reported from Bongaigaon, Dhemaji, Dibrugarh, Sivasagar districts of Assam during the month. Floods also caused damage to property in, Kupwara district of Jammu - Kashmir and Ladakh on 3 June, Beed, Yavatmal districts of Maharashtra on 9 June and east Champaran, Gopalganj, Saran, west Champaran districts of Bihar on 28 June.

Total 98 persons reportedly claimed dead due to lightning strikes during the month, of which, 40 persons killed from West Bengal in the first fortnight of the month.47 persons reportedly claimed dead from Bihar, 7 persons reportedly claimed dead from Maharashtra and 3 from Tamil Nadu and 1 from Baramulla district of Jammu - Kashmir& Ladakh. Hailstorms reported from Baramulla, Kupwara districts of Jammu - Kashmir & Ladakh in the first week, damaged rice fields, apple, cherry, pear and apricot orchards, while galewind uprootedseveral trees affecting the movement of traffic for several hours in Baramulla district of Jammu - Kashmir and Ladakh.

7.2. *July*

As per media reports, heavy monsoon rainfall in western India caused widespread damage and triggered flash floods and a series of landslides in Chembur and Vikhroli, the suburban neighbourhood of Mumbai, Maharashtra on July 18, killing at least thirty-two people and injuring several others after they were trapped under house debris. The heavy rain also triggered several landslides in Mahad in Raigad district of Maharashtra damaging 32 houses and killing at least 7 people and injuring many others. Nearly 6,000 passengers were stranded as train services on the Konkan Railway route in Maharashtra's Ratnagiri district were suspended. Roads had been closed across the region, including major roads such as the Pune-Bangalore NH-4 and the Mumbai-Goa highway. At least 209 people and 3,221 animalswere killed due to the floods and related incidents in Maharashtra, while a total of 4,34,185 people were evacuated to safer places. According to estimates, losses to public and private properties were over ₹4,000 crores. Electricity infrastructure worth ₹1,200 crores had been destroyed, while damage to roads and bridges was over ₹1,500 crores. Crops across 3,38,000 hecta res had been damaged in western Maharashtra.

7.3. *August*

As reported by media, lightning took toll of three persons in West Bengal's Birbhum district. Flooding due to heavy rains in Madhya Pradesh took toll of 24 persons in different rain related incidents, 1,225 villages in Shivpuri, Sheopur, Datia, Gwalior, Guna, Bhind and Morena districts in north Madhya Pradesh were affected by flooding due to heavy rains in the first week of August. Some villages in Sheopur district were completely submerged. Two bridges in Datia district collapsed due to floods.The telecommunication infrastructure in Morena district was completely destroyed, train services between Shivpuri and Gwalior were halted as the rail infrastructure was badly damaged. Twenty-one goats were struck dead by lightning in a pen at Gopalapuram near T. Kallupatti, Madurai, Tamil Nadu. Due to heavy rain in Bihar, floods in various districts were reported, 12 persons lost their lives in the second week of the month. Heavy rains resulted in floods in Uttar Pradesh which affected 1243 villages of 23 districts. 21 districts of Assam were affected by flood due to heavy rain in the last week of the month, killing two persons, affecting 3.63 lakhs people and destroying crops on 16,338 hectares of land. Seven persons were swept in flash flood in Telangana. Five women were killed after they were trapped in a debris due to flood caused by cloudburst in Jumma village, Uttarakhand. A woman, more than 200 livestock and several vehicles were washed away in the flash floods in Chalisgaon, Jalgaon district.

7.4. *September*

In this month, according to media reports,extremely heavy rains in Marathwada resulted in flooding in many rivers due to which crops over thousands of hectares submerged, 34 persons and more than 1930 livestock were killed in different rain related incidents and water reservoirs two each at Kannad (Aurangabad) and Ahmedpur (Latur) were damaged. Heavy rains caused flooding in Vidarbha in which six persons were drowned, also rains resulted in extensive water logging in Telangana submerging crops over hundreds of acres. Due to extremely heavy rain vast areas were inundated in coastal Odisha, two persons died as wall collapsed in Kendrapara district. Lightning strikes took toll of two persons working in a farm at Madurai, Tamil Nadu. 6 persons and a buffalo too were killed by lightning strikes in Maharashtra. Intense rain caused floods in parts of Hyderabad, roads were flooded, vehicles were washed away and water entered in homes and shops. Cyclonic storm, "Gulab" and its remnant over Andhra Pradesh, Telangana and Maharashtra took a toll of about 18 persons, as per media reports. Standing crops including rice, groundnut, banana, custard apple, lemon trees in more than 1 lakh acres in Vizianagaram and Srikakulam districts, Andhra Pradesh were damaged. Heavy rain caused damage to standing *kharif* crops, *viz*., onion, soybean, maize, cotton, groundnut etc. in north Maharashtra, Marathwada and Vidarbha. Lightning strike took toll of one person in Jalgaon, Madhya Maharashtra and one in Vidarbha, 5 persons died in different rain related incidents in Vidarbha. Heavy downpour in Aurangabad caused three landslides in the Kannada ghat area which disrupted the traffic on the nearby highway while some vehicles were buried under the debris

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Appendix

Definitions of the terms given in '*Italics*'

Rainfall

Very light	- 0.1 to 2.4 mm
Light	- 2.5 to 15.5 mm

Moderate	- 15.6 to 64.4 mm
Heavy	- 64.5 to 115.5 mm
Very heavy	- 115.6 to 204.4 mm
Extremely Heavy	- ≥204.5 mm

Monthly/seasonal rainfall distribution on sub-division scale

Large Excess	- percentage departure from normal rainfall is +60% or more
Excess	- percentage departure from normal rainfall is +20% to +59%
Normal	- percentage departure from normal rainfall is from +19 % to –19 %
Deficient	- percentage departure from normal rainfall is from –20 % to –59%
Large Deficient	- percentage departure from normal rainfall is from –60 % or less
No rain	- –100%

Rainfall distribution on All India scale

Below Normal	- percentage departure from normal rainfall is from <10 %
Normal	- percentage departure from normal rainfall is from +10 % to –10 %
Above Normal	- percentage departure from normal rainfall is from >10 %

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 cms along the west coast and 5 cms elsewhere in at least two stations in the sub-division