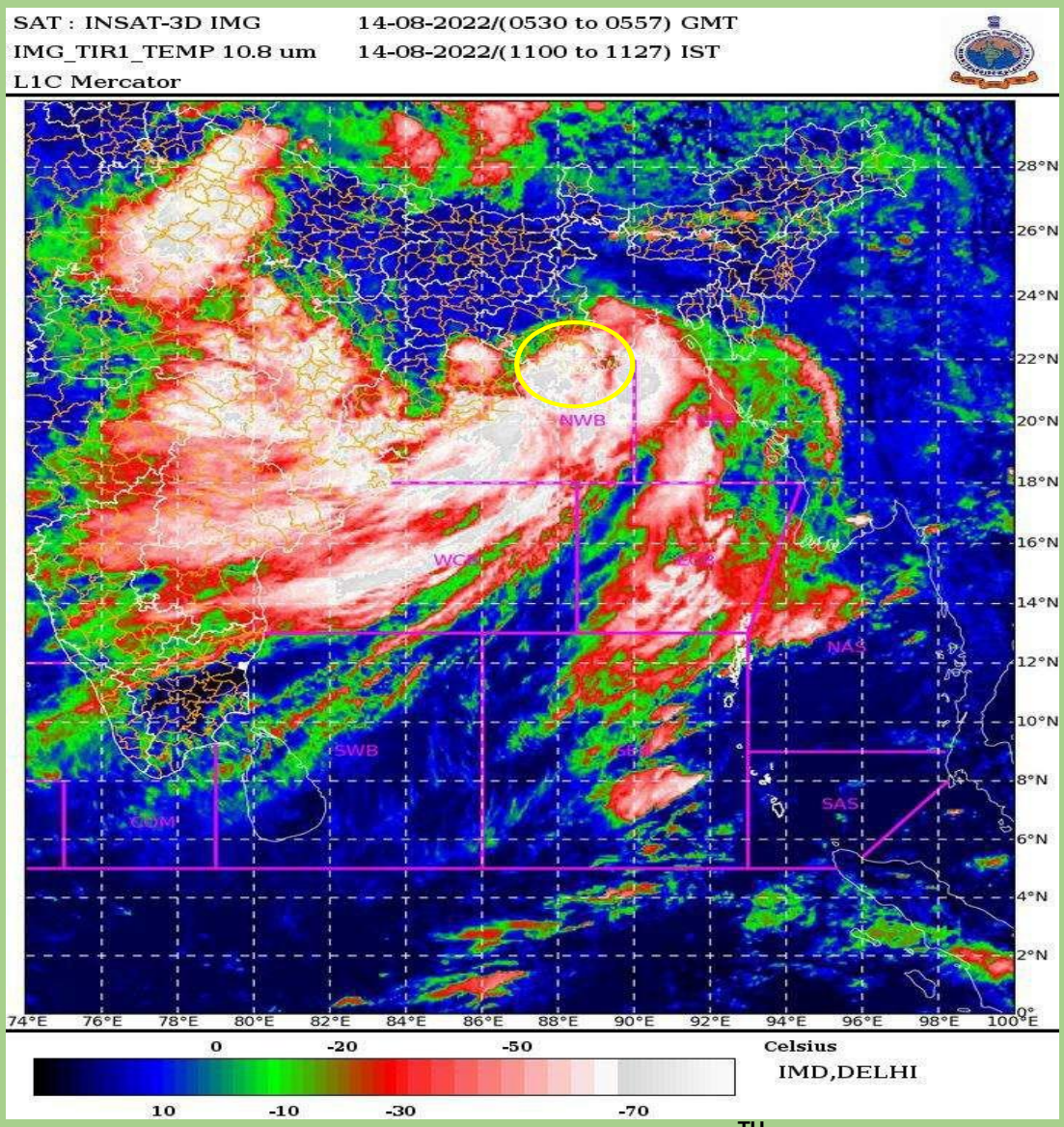
GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
INDIA METEOROLOGICAL DEPARTMENT

Depression over Bay of Bengal
(14th– 16th August 2022): A Report



INSAT-3D Satellite imagery at 0530 UTC of 14TH AUGUST, 2022
for Depression over northwest Bay of Bengal

Cyclone Warning Division
India Meteorological Department
New Delhi
August, 2022

Depression over Bay of Bengal (14th– 16th August, 2022)

1. Introduction

Under the influence of a cyclonic circulation in the middle and lower tropospheric levels over northeast Bay of Bengal and neighborhood, a low pressure area (LPA) formed over North Bay of Bengal in the morning (0830 hours IST) of 13th August,2022. The LPA lay as a well-marked low pressure area (WML) over northwest Bay of Bengal off North Odisha and West Bengal coasts at 1730 hours IST of 13th August, 2022.

The environmental conditions favoured the intensification of the WML into a depression which lay centred at 0830 hours IST of the 14th August, 2022 over northwest Bay of Bengal and adjoining coastal areas of West Bengal & North Odisha near latitude 21.7^{0}N and longitude 87.8^{0}E about 10 km southeast of Digha (West Bengal) and 90 km east-northeast of Balasore (Odisha). The depression moved west-northwestwards and crossed West Bengal & adjoining north Odisha coasts close to Digha between 1030 IST & 1130 IST of 14th August, 2022.

Moving west-northwestwards the system reached South Jharkhand & adjoining North Odisha at 1730 hours IST of 14th August, 2022 and over North Chhattisgarh and neighbourhood at 0530 hours IST of 15th August, 2022. The system reached over West Madhya Pradesh at 0530 hours IST of the 16th August, 2022 moving across north Chhattisgarh. The depression lay over East Rajasthan and adjoining West Madhya Pradesh at 0830 hours IST of 16th August, 2022 and moving further west-northwestwards weakened into a WML over central parts of Rajasthan at 1730 hours IST 16th August, 2022. Continuing to move west-northwestward, the WML moved across central Rajasthan and reached over west Rajasthan & adjoining southeast Pakistan at 0000 hours IST of 17th August, 2022

The track of the depression is presented in Fig. 1.

Fig.1: Observed track of depression over Bay of Bengal (14th-16th August, 2022)

Table1: Best track positions and other parameters of the depression over Bay of Bengal during 14th – 16th August, 2022

Date	Time(UTC)	Lat.	Long	C.I.No	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Category
14.08.22	**0300**	21.7	87.8	**1.5**	**994**	**25**	**4**	D
	Crossed West Bengal and adjoining north Odisha coast close to Digha during 0400 and 0500 UTC							
	0600	21.8	87.5	-	**994**	**25**	**4**	D
	1200	22.1	86.0	-	**994**	**25**	**4**	D
	1800	22.2	84.0	-	**994**	**25**	**4**	D
15.08.22	0000	22.4	82.8	-	**994**	**25**	**4**	D
	0300	22.6	82.0	-	**994**	**25**	**4**	D
	0600	22.8	81.1	-	**994**	**25**	**4**	D
	1200	23.3	79.8	-	**994**	**25**	**4**	D
	1800	23.6	79.0	-	**994**	**25**	**4**	D
16.08.22	0000	24.3	77.6	-	**994**	**25**	**4**	D
	0300	24.7	76.5	-	**994**	**25**	**4**	D
	0600	24.9	76.1	-	995	**20**	3	D
	1200	Weakened into a well-marked low pressure area over central parts of Rajasthan.						

Knots: kt, 1 kt = 1.85 kmph

2. Genesis, Intensification and movement

2.1 Genesis and intensification

A upper air cyclonic circulation lay over northeast Bay of Bengal and neighbourhood on 12th August. Under it's influence, a low pressure area formed over North Bay of Bengal at 0830 hours IST (1100 UTC) of 13th August, 2022. The LPA became well-marked low pressure area (WML) over northwest Bay of Bengal off North Odisha and West Bengal coasts at 1730 hours IST of 13th August, 2022.

The system was in favourable oceanic condtion with sea surface temperature of about 28-29°C over north Bay of Bengal. The low level positive vorticity was about $150x10^{-6}$ s^{-1} to the south of system centre. Low level convergence was about $30x10^{-5}$ s^{-1} over northwest BoB and upper level divergence with increasing trend was about $30x10^{-5}$ s^{-1} over the same region. Prominent westward outflow was seen in upper levels. Moderate vertical wind shear of about 05-10 knots was prevailing over the system area. Under these favourable environmental conditions, the well marked low pressure area concentrated into a depression over northwest Bay of Bengal and adjoining coastal areas of West Bengal & North Odisha and lay centered at 0830 hrs IST(0000 UTC) of 14th

August 2022, 2022 near latitude 21.7^{0}N and longitude 87.8^{0}E about 10 km southeast of Digha (West Bengal) and 90 km east-northeast of Balasore (Odisha).

2.2. Intensification and Movement:

At 1200 UTC of 14th August, the low-level vorticity was around 150 x10^{-6} s^{-1} to the southwest of system centre over coastal Odisha and is extending up to 200 hPa levels. Low level convergence decreased and was around 20 x10^{-5} s^{-1} to the southwest of system centre. Positive upper-level divergence was around 10x10^{-5} s^{-1} over system centre and along forecast track. Wind shear was low (05-15 knots) over system area and along the forecast track. The system maintained its intensity for about 48 hours due to favourable environmental conditions. The low-level vorticity with vertical extension up to 200 hPa level, low level convergence, positive upper-level divergence and low wind shear over the system area and along the forecast track delivered sustained support to the system till 0300 UTC of 16th August, 2022. As the system was found to be embedded within the monsoon trough, it nearly followed the path guided by the same. Moreover, the upper-level easterly winds also provided necessary steering for the system movement. Accordingly, the depression moved west-northwestward continually over the land after its genesis. The system although showed diurnal variation throughout its life period but moved very fast with a speed of more than 20 kmph. The depression weakened into a well-marked low pressure area over central parts of Rajasthan in the evening of 16th August as it experienced temporary decrease in moisture supply in the lower and mid tropospheric levels. But due to change in the wind circulation characteristics, the system over west Rajasthan received moisture feed from Arabian Sea and sustained further for 24 hours till it moved over adjoining Pakistan. Over Pakistan, it persisted for about five days with moisture supply from Arabian Sea and caused heavy to extremely heavy rainfall, especially over south Pakistan.

3. Monitoring of depression

First information about formation of depression over northwest BoB on 14th August was indicated in the extended range outlook issued by IMD on 4th August.

Accordingly, the cyclonic disturbance was monitored with the help of available satellite observations from INSAT 3D and 3DR and various polar orbiting satellites. The system was also observed by the DWRs at different stations while it was within the radar range. Various numerical weather prediction models developed by Ministry of Earth Sciences (moes) institutions and dynamical-statistical models were utilized to predict the genesis, track, landfall and intensity of the cyclone. A digitized forecasting system of IMD was utilized for analysis and comparison of various model guidance, decision making process and warning product generation.

3.1 Features observed through satellite

At 0300 UTC of 14th Aug, as per INSAT 3D imagery, intensity of the system was characterized as T1.5. Broken low and medium clouds with embedded intense to very intense convection lay over north Bay of Bengal, east Odisha and costal Gangetic West Bengal. Minimum cloud top temperature was -93^{0}C. At 1200 UTC of 14th Aug, as per INSAT 3D imagery, the cloud mass covered nearly entire north Bay of Bengal, Odisha,

Gangetic West Bengal, South Jharkhand and Chattisgarh. Minimum cloud top temperature was - 93^{0}C near very intense convection.

The imageries displayed that the clouds associated with the system moved west-northwestward and lay over Chhattisgarh and adjoining east Madhya Pradesh on 15th morning but minimum cloud top temperature increased to -85^{0}C (Fig.2). The cloud mass with very intense convection moved gradually west-northwestward across Chhattisgarh and east Madhya Pradesh to reach over west Madhya Pradesh and adjoining Uttar Pradesh and east Rajasthan in the morning of 16th Aug with a gradual increase in cloud top temperature (synonymous to the intensity of the system). But reaching over east Rajasthan the minimum Cloud top temperature again decreased to - 90^{0}C.

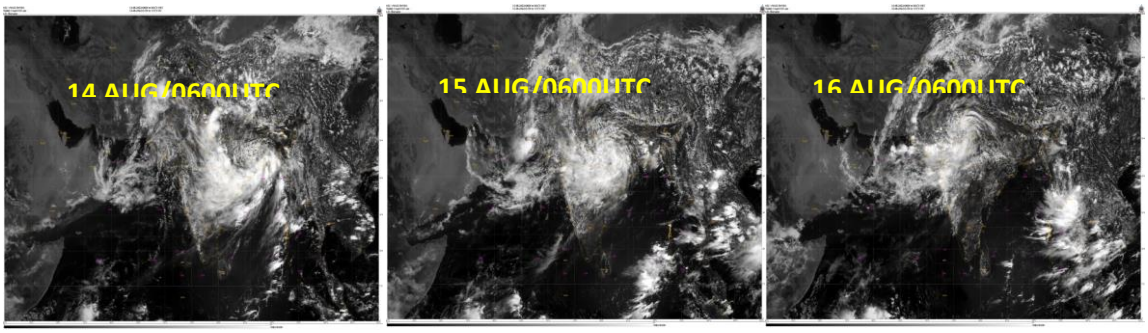


Fig.2a.INSAT-3D Visible imageries during life cycle of Depression (14-16 August, 2022)

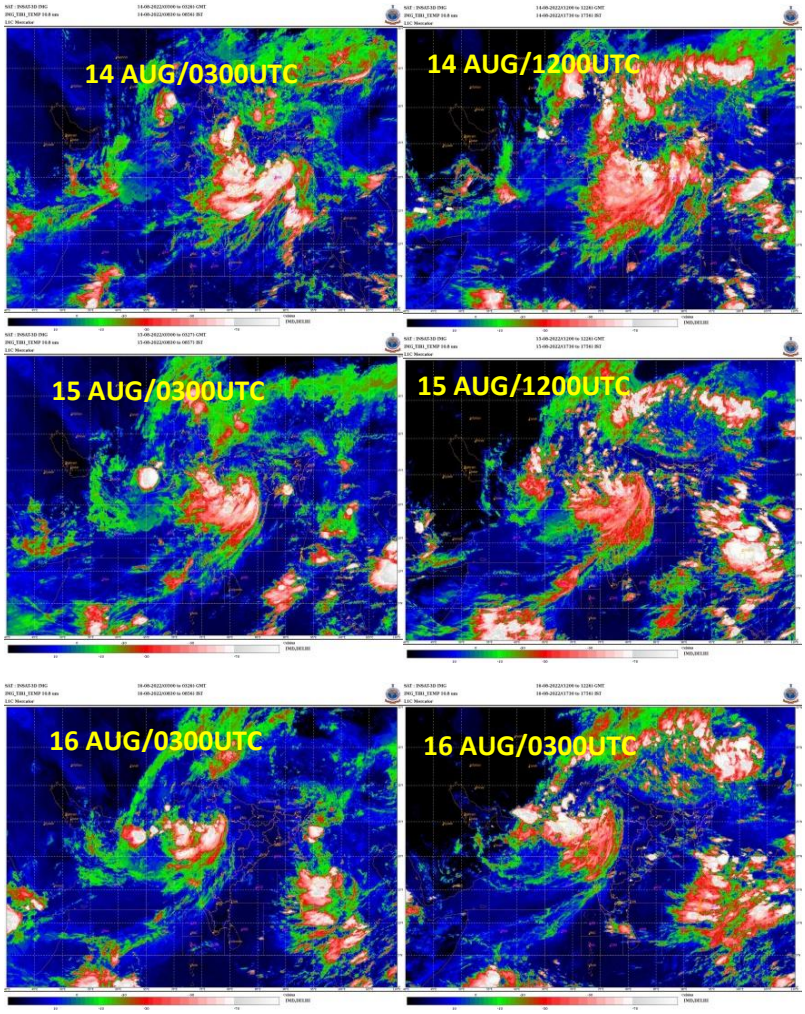


Fig.2 b. INSAT-3D NHC imageries during 14-16 August, 2022

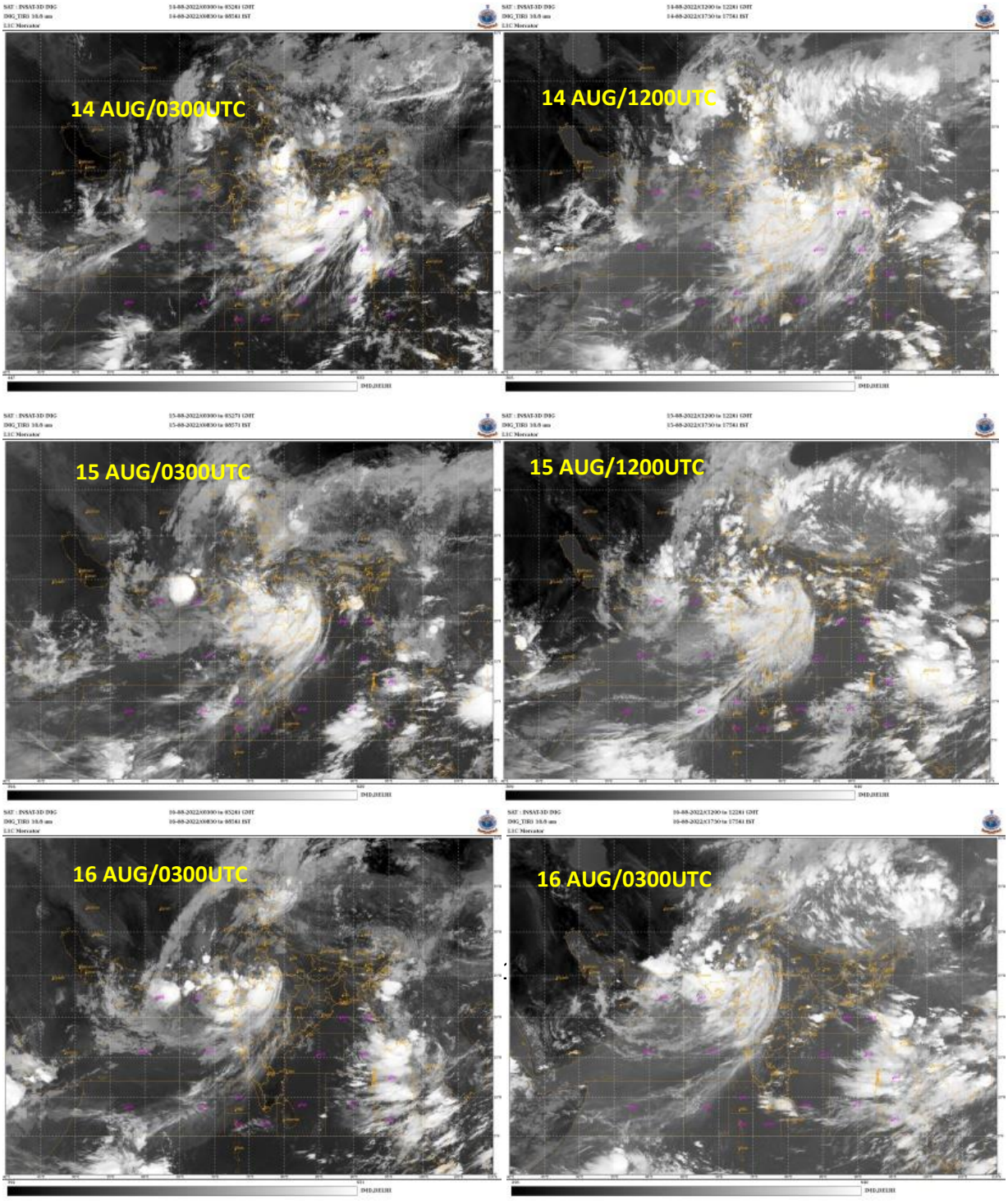


Fig.2 c.INSAT-3D IR imageries during 14-16 August, 2022

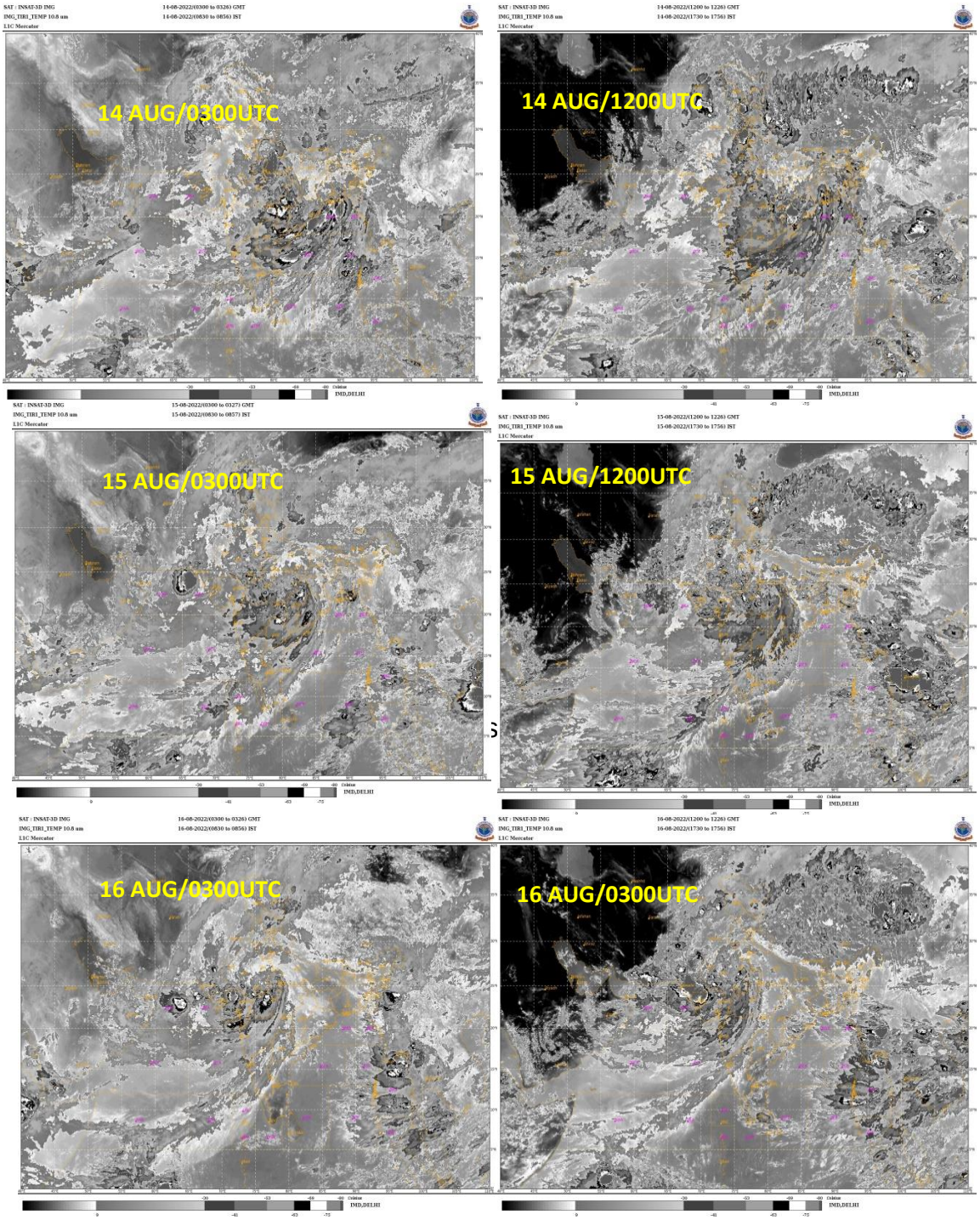


Fig.2 d.INSAT-3D BD imageries during 14-16 August, 2022

4. Dynamical features

IMD GFS analysis fields of mean sea level pressure (MSLP), 10m wind, winds at 850, 500 & 200 hPa level are presented in Fig. 3. The MSLP and 10m wind analysis based on 0000 UTC of 14th August indicated a depression over coastal West Bengal & north Odisha and adjoining northwest BoB. The vertical extension up to 500 hPa level was clearly seen with a little southwestward tilt with height. At upper tropospheric level, the easterlies were seen over the system area indicating west-northwestwards movement of the system. At 0000 UTC of 14th IMD GFS could pick up correctly the intensity and fairly the location of the system.

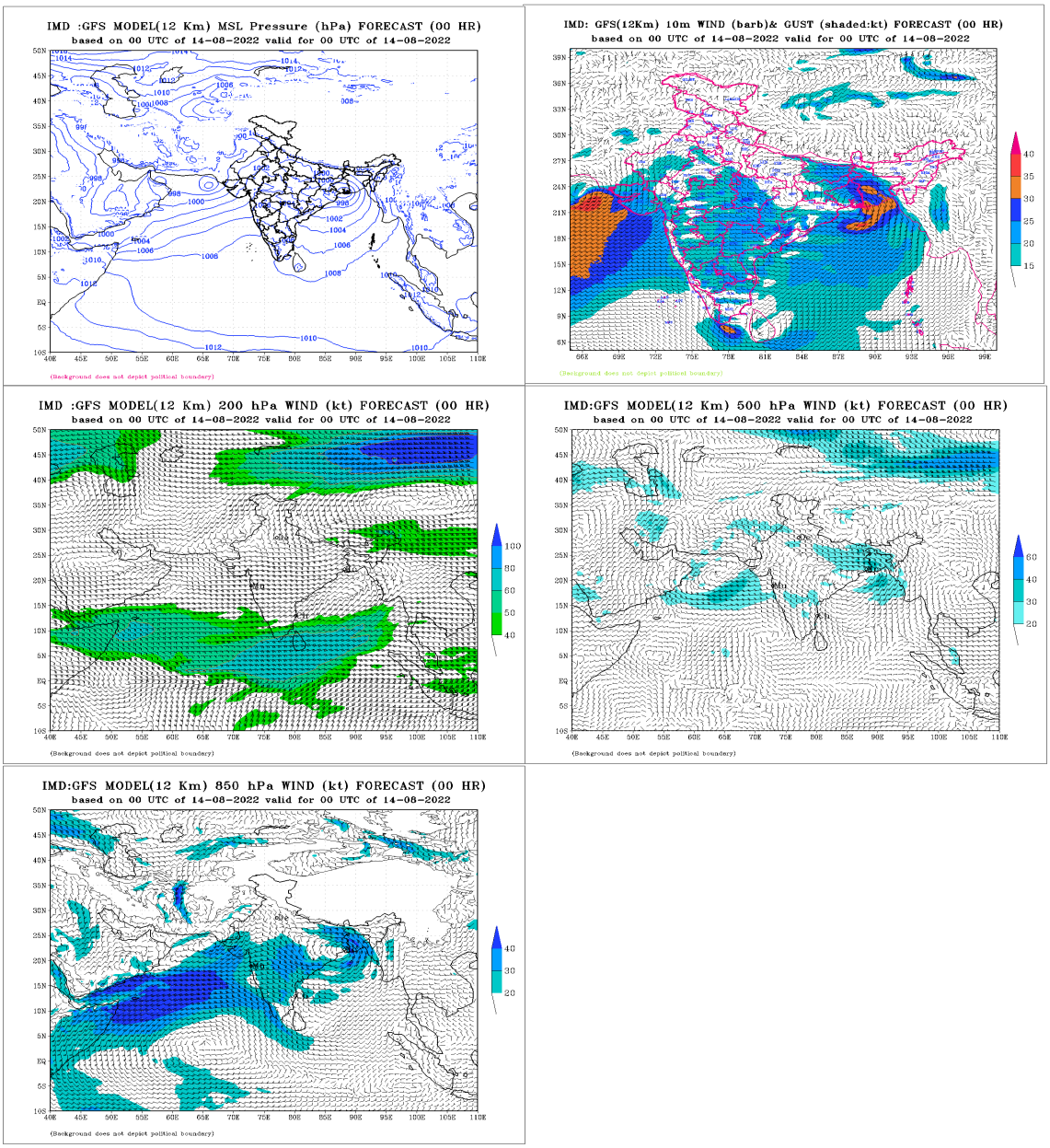


Fig.3 (a) IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 14th August 2022

The 10m wind analysis based on 0000 UTC of 15th August indicated a depression over north Chhattisgarh and adjoining east Madhya Pradesh with an obvious vertical extension up to 500 hPa level. The west-northwestwards movement of the system was established from the change in the location of the depression from 14th August location. Though broad scale features were correctly picked, but IMD GFS slightly under-estimated the intensity of the system.

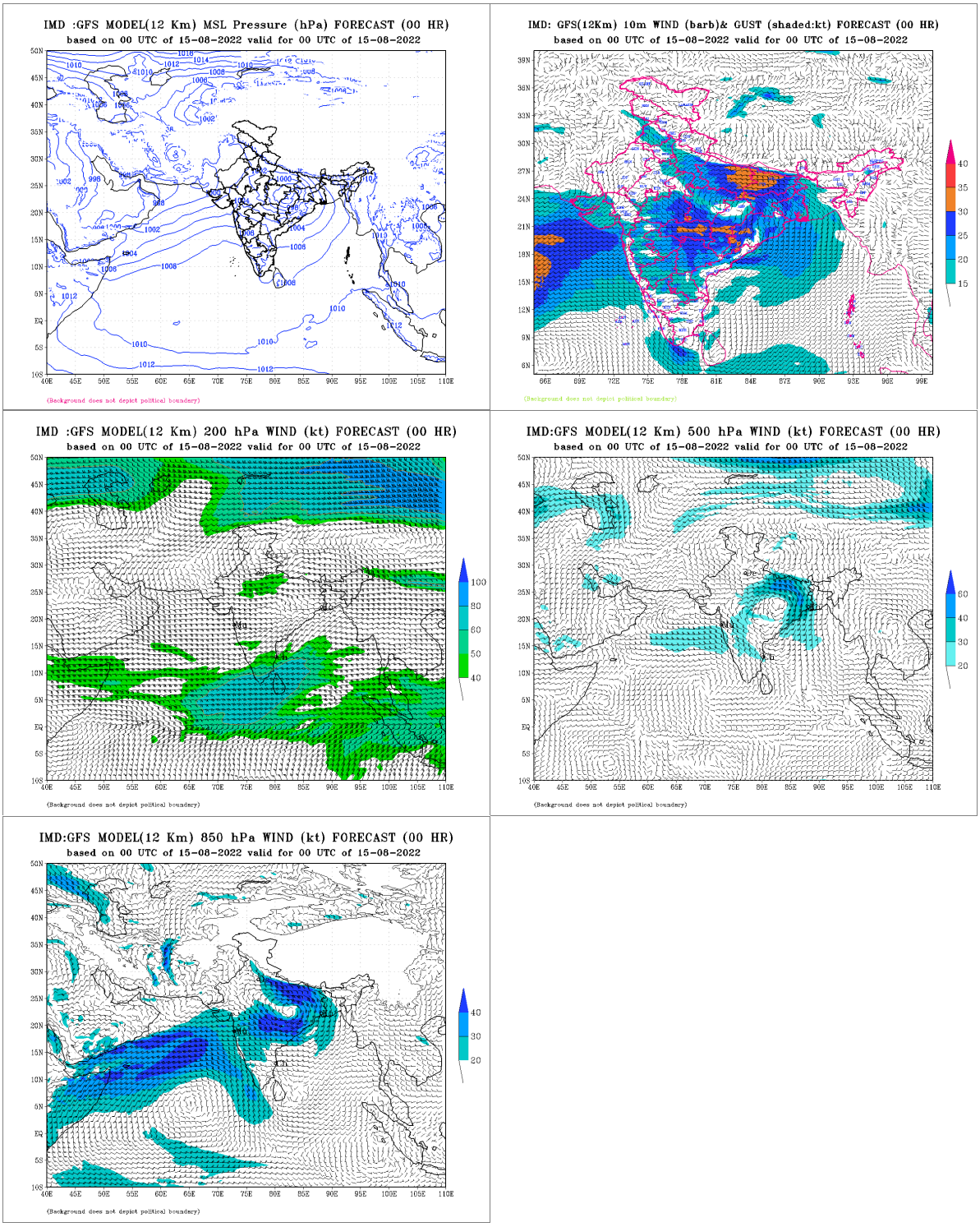


Fig.3 (b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 15th August 2022

The system over northwest Madhya Pradesh and adjoining east Rajasthan was visible from the isobaric pattern in MSLP chart and 10 m wind circulation characteristics. The vertical extension up to mid-tropospheric level (500 hPa) was also found in the model analysis charts. During this stage, the system intensity was under-estimated by the IMD GFS as the system lay as depression till afternoon of 16th August 2022.

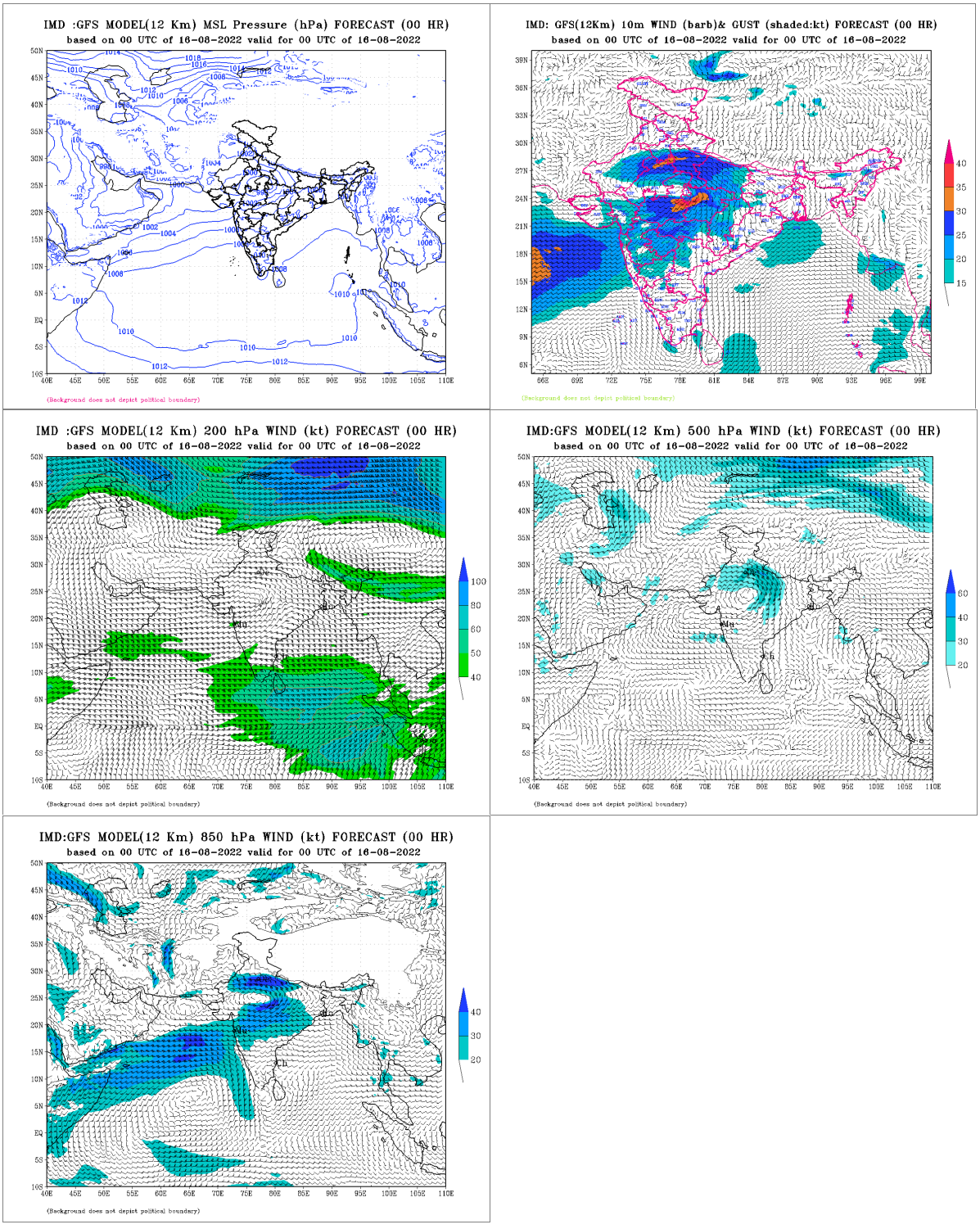


Fig.3 (c): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 16th August 2022

5. Realized Weather:

5.1. Realised rainfall

The daily rainfall distribution ending at 0300 UTC of each date during 13-19 August, 2022 based on merged gridded rainfall data of IMD/NCMRWF is shown in Fig.4(i). The spatial distributions of daily cumulative rainfall show the widespread rainfall zones associated with the depression in the successive days from 14th to 17th August. The maximum rainfall was confined at the southwestward sector of the system. The 7 days average rainfall show the clear swath of the rainfall due to the system starting from Odisha reaching up to southwest Rajasthan and adjoining Gujarat state which follow the track of the depression with higher rainfall areas south of the track.

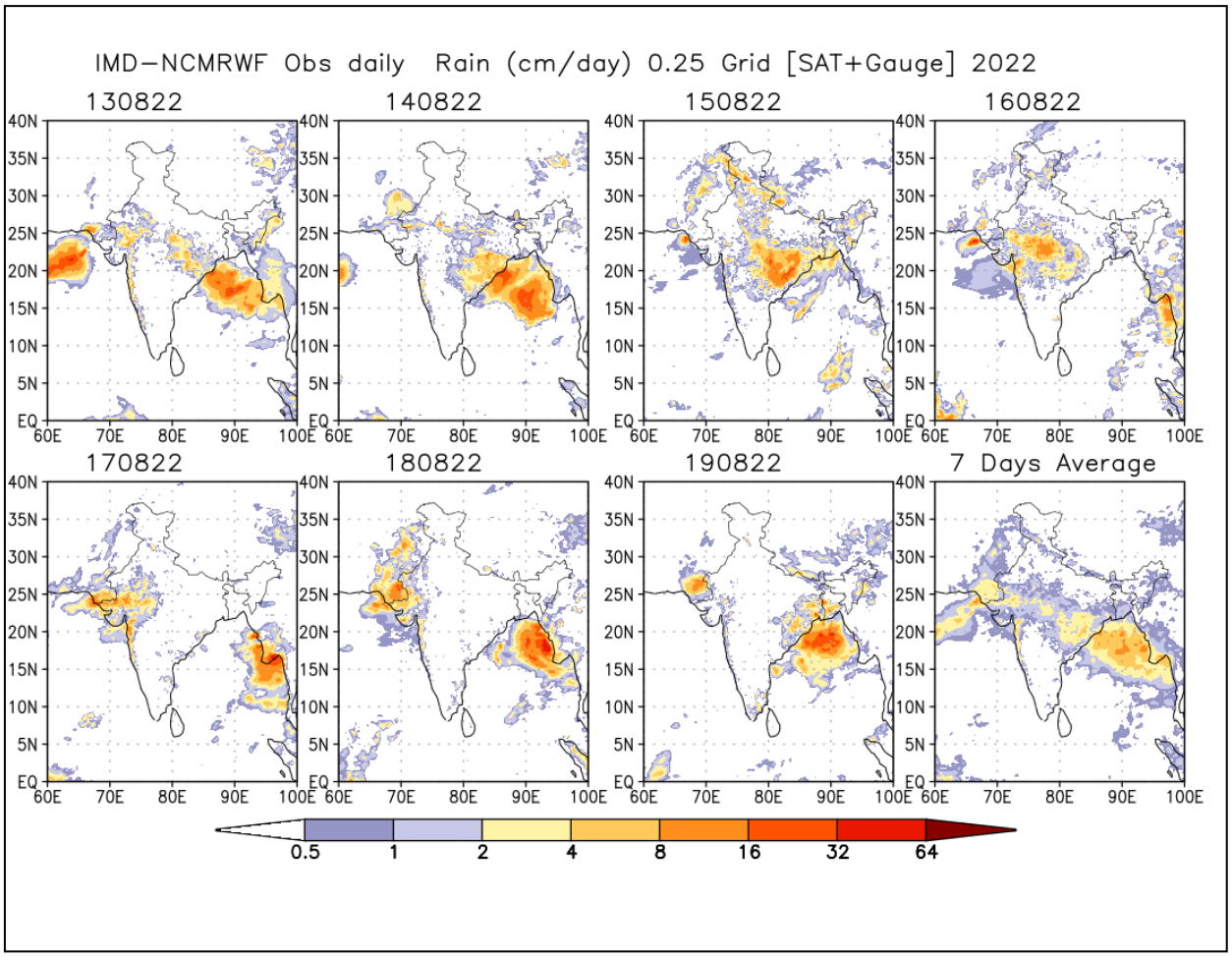


Fig. 4(i): IMD-NCMRWF GPM merged gauge 24 hr cumulative rainfall (cm) ending at 0830 IST of date during 13th Aug. – 19th Aug. and 7 days average rainfall (cm/day)

The 24 hours cumulative rainfall (≥ 7 cm) ending at 0300 UTC (0830 hours IST) of date during 14-16 August, 2022 is presented below in Fig 4(ii). The spatial distribution of station-wise heavy, very heavy and extremely heavy rainfalls along with the coverage of light to moderate rainfall associated with the system are clearly seen from all diagrams with the distribution of yellow, orange and red dots respectively. The occurrences of heavy to extremely heavy rainfall over various sub-divisions along the track of the

depression e.g., Odisha, Chhattisgarh, Madhya Pradesh, south Rajasthan and adjoining areas of Vidarbha and Maharashtra and Gujarat Region in successive days from 14th August to 17th August are also visible from all panels of the Fig 4(ii)

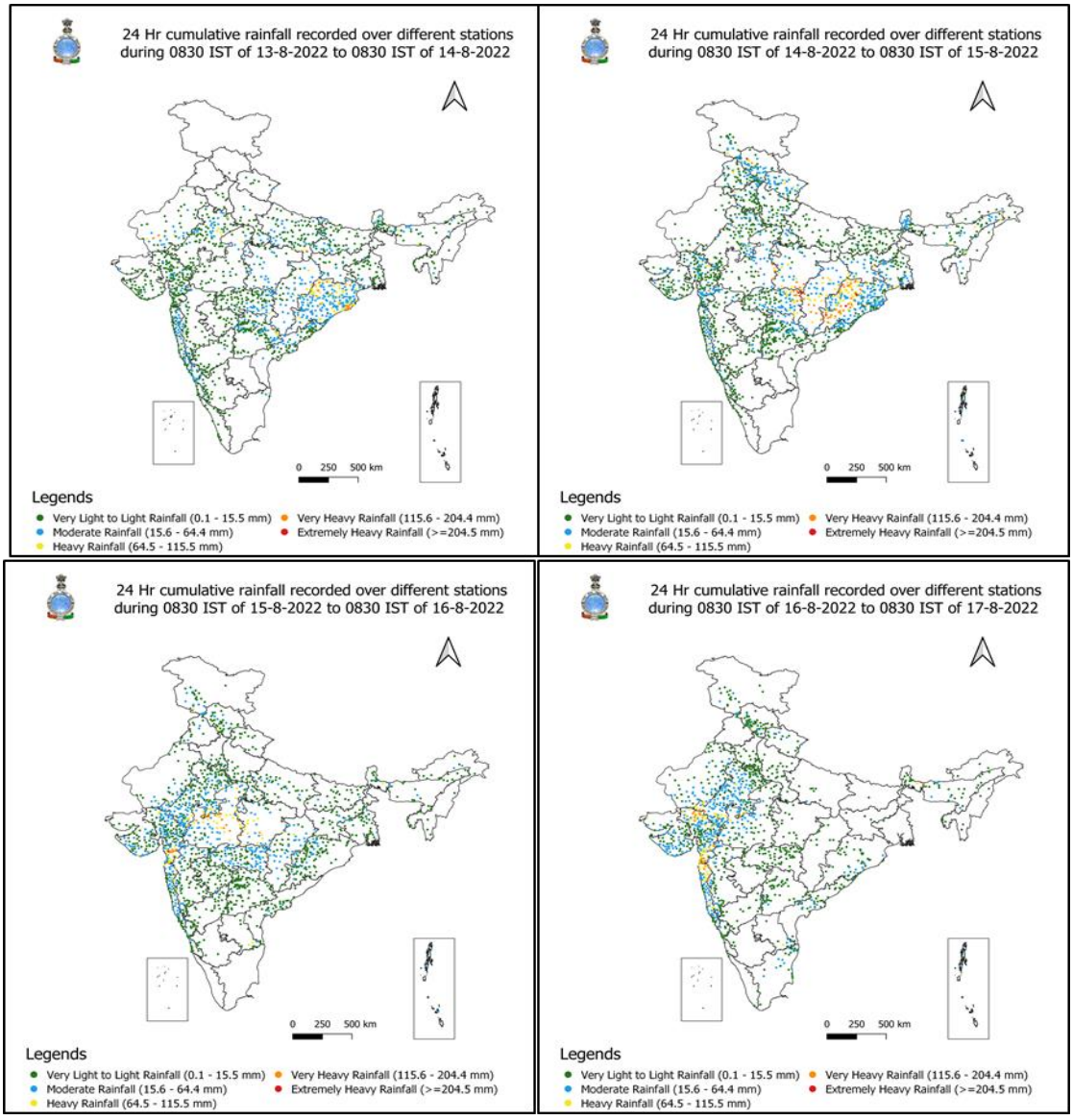


Fig. 4(ii): 24 hr cumulative rainfall distribution recorded over different stations of IMD during 14 August- 17 August, 2022

6. Damage due to the system

No damage was reported in association with this system.

7. Forecast performance:

- First information about likely formation of a cyclonic circulation over northwest Bay of Bengal and adjoining coastal areas of West Bengal & North Odisha was given in the extended range outlook issued on 04th August, 2022.

- The daily tropical weather outlook issued at 1130 hours IST of 10th August, 2022 indicated low probability (1-33%) of formation of depression over coastal West Bengal & adjoining North Odisha during 13th – 14th August, 2022.
- Actually, low pressure area/well marked low pressure area formed over northwest Bay of Bengal and adjoining coastal areas of West Bengal & North Odisha on morning and evening of 13th August respectively and depression formed over northwest Bay of Bengal and adjoining coastal areas of West Bengal & North Odisha at 0830 hours IST of the 14th August, 2022
- In the first bulletin issued on 14th August at 0830 hours IST, it was indicated that the depression would continue to move west-northwestwards thereafter.
- Thus, the track, initial movement intensification/weakening of the system were well predicted by IMD/RSMC New Delhi.

7.1 Rainfall forecast verification

The forecasts for heavy to extremely heavy rainfalls are verified with the 24 hours accumulated rainfall at various stations exceeding 7 cm. The table 2 describes the date-wise forecasts of rainfall of heavy to extremely rainfall issued at 0300 UTC of 13th to 16th August 2022.

Table 2: Verification of Heavy Rainfall Forecast

S.No.	Rainfall Forecast upto 0300 UTC	Realised 24 hrs heavy rainfall ending at 0830 IST of date
13/08 0300 UTC	**Odisha: H**eavy to extremely heavy rainfall at isolated places on 13th August and heavy to very heavy rainfall at a few places with extremely heavy rainfall at isolated places on 14th August. Isolated heavy rainfall over western Odisha on 15th**.** **Gangetic West Bengal:** Heavy rainfall at isolated places over coastal districts on 13th and 14th August. **Jharkhand:** Heavy rainfall at isolated places over South Jharkhand on 13th and 14th August. **Chattisgarh:** Heavy to very heavy rainfall at isolated places on 13th and 15th	**14.08.2022** **Odisha:-**Hemgiri-20, Astaranga & Rajgangpur-17 each, Sundargarh, Banki, Phiringia, Tangarpali, Dhankauda & Lephripara-16 each, Balikuda & Sambalpur-15 each, Gop-14, Tirtol, Naugaon, Alipingal, Binika, Burla & Nawana-13 each, Jagatsinghpur-12, Kakatpur, Kantapada & Niali-12 each, Mandira Dam, Biridi, Telkoi & Hirakud-11 each, R.Udaigiri, Banpur, Raghunathpur, Jagannath Prasad, Lakhanpur, Balisankara, Krishnaprasad & Kotpad-10 each, Puri, Deogaon (District: Jharsuguda), Paradeep Cwr, Kusumi, Tensa, Koraput, Joshipur, Jhumpura, Nh5 Gobindpur, Bargarh, Binjharpur, Bargaon, Harichandanpur, Banspal & Belpada-9 each, Kankadahad, Rajnagar, Dhenkanal Pto, Sukruli, Keonjhargarh, Jharsuguda, Phulbani, Narsinghpur, Bijepur, Raruana, Odagaon, Jujumura, Tikarpara, K Nuagaon & Kujanga-8 each, Kosagumda, Atabira, Ullunda,

	August and heavy to very heavy rainfall at a few places with extremely heavy rainfall at isolated places on 14th August. **East Madhya Pradesh:** Heavy to very heavy rainfall at a few places & extremely heavy rainfall at isolated places on 14th August and isolated heavy to very heavy rainfall on 15th August.	Ambabhona, Altuma, Chandrapur, Remuna, Nawarangpur, Bonth, Satyabadi, Garadapur, Sohela, Ghatagaon, Thakurmunda, Nuagada, Khordha Pto, Athgarh, Batli, Panposh, Joda, Similiguda, Kendrapara, Nawarangpur Pto, Hatadihi, Derabis, Tigiria, Jaleswar, Talcher, Kutra, Brahmagiri, Barpalli, Nimpara & Jharbandh-7 each **Jharkhand:-** Bano Simdega Kvk Aws-8 **Chhattisgarh:-** Seovrinarayan, Baloda Bazar &Pamgarh-15 each, Bilaigarh, Gidam, Pusaur, Kashdol, Sarangarh & Raigarh-9 each, Ambikapur, Mahasamund & Darbha-8 each, Bhatapara, Dhabhara, Bastanar, Pakhanjur, Bhairamgarh, Basana, Bastar & Pithora-7 each **East Madhya Pradesh:-** Hanumana-9, Niwas, Bijadandi & Jabalpur-Aws-7 each **West Madhya Pradesh:-** Shivpuri-21, Pohri-18, Karhal-16, Karera-9, Pathari-8, Sheopur-Aws-7
14/0800 UTC	**Odisha:** Heavy to very heavy rainfall at a few places with extremely heavy rainfall at isolated places on 14th August. Isolated heavy rainfall over western Odisha**.** **Gangetic West Bengal:** Heavy to very heavy rainfall at isolated places over coastal districts on 14th August. **Jharkhand:** Heavy to very heavy rainfall at isolated places over south Jharkhand and isolated heavy rainfall over north Jharkhand on 14th August **Chattisgarh:** Heavy to very heavy rainfall at a few places with extremely heavy rainfall at isolated places on 14th August and heavy to very heavy rainfall at isolated places on 15th August **East Madhya Pradesh:** Heavy to extremely heavy rainfall at isolated places on 14th and heavy to very heavy rainfall at isolated placed on 15th August.	**15.08. 2022** **Chhattisgarh:-** Bhanupratappur, Narayanpur & Makadi-19 each, Pakhanjur-18, Chhuria & Pusaur-17 each, Raigarh, Jagdalpur & Bastar-16 each, Bijapur, Antagarh & Darbha-15 each, Keshka, Kanker, Pharasgaon & Bakavand-14 each, Charama, Durgkondal, Mohla, Bastanar & Doundi-13 each, Dongargarh, Ambagarh Chowki, Dongargaon, Baderajpur, Kondagaon, Pali & Manpur-12 each, Lohandiguda & Dhamtari-11 each, Magarlod, Sarangarh, Kharsiya & Rajim-10 each, Tamnar, Tokapal, Katghora, Orcha, Dhabhara, Chhura, Dondilohara & Mahasamund-9 each, Balod, Baramkela, Malkharoda, Dantewara, Gurur & Bagbahara-8 each, Nerharpur, Bhairamgarh, Gariabund, Nagari, Kurud, Pithora, Katekalyan, Lailunga, Kusmi, Seovrinarayan, Korba, Bilaspur, Jaijaipur, Jashpurnagar, Kuakonda, Saraipali & Gundardehi-7 each **East Madhya Pradesh:-** Paraswada-20, Kirnapur-18, Malanjkhand-17, Lanji-16, Balaghat-Aws-14, Tamia & Waraseoni-13 each, Lalburra & Mandla-12 each, Baihar, Niwas, Birsa, Tirodi & Bichhia-11 each, Pushprajgarh- & Kesli-10 each, Bijadandi, Kurai, Nainpur,

	West Madhya Pradesh: Heavy to very heavy rainfall at isolated places on 14th and 16th and heavy to extremely heavy rainfall at isolated placed on 15th August**.**	Gadarwara & Raipura-9 each, Katangi, Amarpur, Jaisinagar, Rahatgarh, Narayanganj & Parasia-8 each, Sagar-Aws, Umreth, Gotegaon, Seoni, Deori, Mawai, Patera, Harrai & Junnardeo-7 each **West Madhya Pradesh:-** Pipariya-25, Pachmarhi-17, Begumganj-15, Sohagpur & Bareli-14 each, Udaipura-13, Bankhedi-12, Gairatgang-11, Badi-10, Salwani & Raghogarh-9 each, Pathari-8, Kumbhraj, Deori & Raisen-Aws-7 each **Vidarbha:-** Salekasa-24, Amgaon-22, Goregaon-19 & Deori-19 each, Sadakarjuni-17, Gondia-16 & Korchi-16 each, Arjuni Morgaon-14, Kurkheda, Tirora, Gondia Ap & Sakoli-12 each, Mohadi-11, Etapalli-10, Ahiri, Tumsar, Mulchera & Lakhani-9 each, Desaiganj, Mauda, Kuhi, Armori, Pombhurna, Ramtek & Bramhapuri-7 each. **Odisha:-** Th Rampur-37, Kotpad-29, K Nuagaon-23, Kalampur-22, Dabugan, Baliguda & Batagaon-21 each, Madanpur Rampur-20, Papadahandi & Mandira Dam-19 each, Rajgangpur, Lanjigarh, Jaipatna, Phiringia & Borigumma-18 each, Ambabhona, Ambadola, Kosagumda,Bhawanipatna, Narla, Gudvela, Nawarangpur, Bamra & Nawarangpur Pto-17 each, Chakapad & Jharsuguda-16 each, Kashipur, Nandahandi, Boudhgarh, Tikabali, Sohela, Tentulikhunti & Karlamunda-15 each, Junagarh, Kotagarh, Hemgiri, Dharmagarh & Kutra-14 each, Laikera, Belgaon, Jeypore, Jhorigam, Muniguda & Umarkote-13 each, Kirmira, Barkote, Athmalik, Lakhanpur, Raikia & Jamankira-12 each, Kuchinda, Naktideul, Kolabira, Deogarh, Rajkishorenagar, Deogaon (District: Jharsuguda), Kotraguda, Kolnara, Bargaon, Phulbani & Batli-11 each, Lephripara, Bargarh, Kalinga, G Udayagiri & Koksara-10 each, Gurundia, Deogaon (District: Bolangir), Rairakhol, Chandahandi, Daringibadi, Champua, Koraput, Kesinga, Tangarpali, Similiguda, Lathikata, Bissem-Cuttack & Burla-9 each, Jujumura, Atabira, Reamal, Hirakud, Raighar, Dhenkanal Pto, Balisankara, Titlagarh,
15/08 0300 UTC	**Chattisgarh:** Heavy rainfall at isolated places very likely on 15th August. **East Madhya Pradesh:** Heavy to very heavy rainfall at isolated places very likely on 15th August. **West Madhya Pradesh:** Heavy to very heavy rainfall with isolated extremely heavy falls on 15th and heavy to very heavy rainfall at isolated places on 16th August. **Vidarbha:** Heavy to very heavy rainfall at isolated places on 15th and heavy rainfall at isolated places on 16th August. **Odisha:** Heavy rainfall at isolated places very likely over western Odisha on 15th August.	
16/08 0300 UTC	**West Madhya Pradesh:** Heavy to very heavy rainfall at isolated places on 16th August. **East Rajasthan:** Heavy to extremely heavy rainfall at isolated places on 16th August and heavy rainfall at isolated places on 17th August. **West Rajasthan:** Heavy to extremely heavy rainfall at isolated places on 16th August and very heavy rainfall at isolated places on	

	17th August. **Gujarat Region:** Heavy to extremely heavy rainfall at isolated places on 16th August and heavy rainfall at isolated places on 17th August. **Saurashtra and Kutch:** Heavy to very heavy rainfall at isolated places on 16th & 17th August.	Nischintakoili & Rengali-8 each, Banaigarh, Gaisilet, Padampur, Bhograi, Sambalpur, Sundargarh, Binjharpur, Joda, Bolangir, Bijepur, Panposh, Lamataput, Kantamal, Rayagada Pto, Mathili, Jajpur Pto & Jaleswar-7 each **16. 08. 2022** **West Madhya Pradesh:-**Dhundhadaka-19, Shamshabad & Narsingarh-18 each, Gairatgang & Raisen-Aws-17 each, Begumganj-16, Sehore-Aws-15, Nateran, Pachmarhi, Vidisha, Barod & Pipariya-14 each, Khilchipur, Jaora, Badi, Bhopal Arera Hills, Navibagh Aet, Suvasara, Chachoda, Bareli, Ashoknagar-Aws & Kolar-13 each, Dolariya, Bairagarh Airport, Budhni, Susner, Pachore, Goharganj, Piploda & Shyampur-12 each, Udaipura, Kalapipal, Bhimpur, Jawad, Mandsaur-Aws, Ichhawar & Berasia-11 each, Sohagpur, Biaora, Deori, Aron, Sultanpur, Shahpur, Godadongri, Agar & Sarangpur-10 each, Sitamau, Shamgarh, Ganjbasoda, Gulabganj, Kayampur, Garoth, Shujalpur, Narmadapuram & Salwani-9 each, Nasrullahganj, Rehti, Bankhedi, Mungaoli, Bajna, Alot, Moman Badodiya, Gwalior & Sironj-8 each, Multai, Pathari, Lateri, Jharda, Chanderi, Itarsi, Rajgarh, Chicholi, Ashta-Aws, Babai (Makhan Nagar), Mahidpur, Karera, Tal, Sailana & Seoni Malwa-7 each **East Rajasthan:-**Bhungra Sr-18, Dug-17, Mounntabu Tehsil Sr-12, Pipalkhunt Sr &Asnawar Sr-10 each, Arnod Sr, Pira wa, Gangdhar Sr, Jagpura Sr & Garhi-9 each, Manohar Thana & Jhalarapatan Sr-8 each, Sheoganj-7, Khushalgarh, Ghatol, Jhalawar, Mandrayal Sr & Pratapgarh-7 each **West Rajasthan:-**Sayla Sr-8 **Gujarat Region:-**Palsana-22, Vyara-20, Ukai-18, Dolvan & Bardoli-17 each, Songadh-15, Mandvi & Mahuva-13 each, Valod-12, Navasari_Aws, Navsari, Khanvel, Madhbun & Umerpada-11 each, Dantiwada & Meghraj-10 each, Jalalpor, Surat_Kvk Aws, Dharampur, Daman_Arg, Surat City & Daman Fmo-9 each, Daman, Kaprada, Subir, Surat_Aws, Choryasi, Silvassa & Deesa-8 each,

		Dangs (Ahwa) & Vansda-7 each **Saurashtra & Kutch:-**Kodinar-8, Kandla New-7 **17. 08. 2022** **West Madhya Pradesh:-** Alot-16, Tal-14, Jaora-10, Piploda-9, Bajna-9, Barod-9, Zirapur-8 **East Rajasthan:-** Arnod Sr-17, Mounntabu Tehsil Sr-17, Dug-16, Kotda Sr-13, Abu Road Sr-13, Sabla Sr-12, Sheoganj-11, Pratapgarh-11, Pindwara-11, Chikali Sr-10, Gangdhar Sr-10, Aspur-10, Nithuwa Sr-9, Bakani Sr-8, Salumber-8, Phagi-8, Dhariabad-8, Jagpura Sr-7, Reodar Sr-7, Pirawa-7, Sarara-7 **West Rajasthan:-** Sumerpur Sr-10, Erinpura/Jawai Dam-8, Raniwada Sr-8, Jaswantpura-7 **Gujarat Region:-** Songadh-19, Khergam-16, Dantiwada-16, Vadgam-15, Poshina-15, Khanvel-15, Mahesana-14, Danta-14, Deodar-14, Siddhpur-14, Deesa-13, Dharampur-13, Satlasana-13, Daman-13, Madhbun-13, Nanipalson-13, Amirgadh-13, Kaprada-12, Umerpada-12, Dahegam-12, Chikhli-12, Vapi-12, Daman Fmo-12, Pardi-12, Idar-12, Becharaji-11, Vadali-11, Palanpur-11, Dhanera-11, Dolvan-11, Valsad-11, Kankrej-10, Silvassa-10, Valsad Kvk Aws-10, Navsari-10, Visnagar-9, Chhota Udepur-9, Dehgamarg-9, Dangs (Ahwa)-9, Unjha-9, Jalalpor-9, Kheralu-8, Dharoi Colony-8, Mandvi-8, Bhiloda-8, Kamrej-8, Mahuva-8, Chanasma-8, Wav-7, Lakhani-7, Bayadarg-7, Navasariaws-7, Palsana-7, Sagbara-7, Santrampur-7, Vijaynagar-7, Vansda-7, Umergam-7, Lunawada-7, Bayad-7, Ukai-7, Valod-7 **Saurashtra & Kutch:-** Dayaparaws-10, Sutrapada-8, Lakhpat-8

8. Warning Services

Bulletins issued by Cyclone Warning Division, New Delhi

- **Track & intensity forecast:** IMD continuously monitored, predicted and issued bulletins till the system weakened into a low pressure area.
- **Adverse weather warning bulletins:** The expected adverse weather like heavy rain and strong wind was issued with every six hourly update to central, state and

district level disaster management agencies including MHA NDRF, NDMA for all concerned states along the east coast of India including Odisha, West Bengal, Madhya Pradesh, Chattisgarh, Jharkhand and Rajasthan. The bulletins also contained the suggested action for disaster managers and general public in particular for fishermen. These bulletins were also issued to Defence including Indian Navy & Indian Air Force.

- **Warning graphics:** The adverse weather warnings related to heavy rain and gale/squally wind were also presented in graphics alongwith colour codes in the website.
- **Warning and advisory through social media:** Daily updates (every six hourly or whenever there was any significant change in intensity/track) were uploaded on face book and tweeter regularly during the life period of the system.
- **Warning and advisory for marine community:** Bulletins for maritime interest were issued by Area cyclone warning centres of IMD at Kolkata and Chennai, and Cyclone warning centres at Bhubaneswar and Visakhapatnam to ports, fishermen, coastal and high sea shipping community.
- **Fishermen Warning:** Regular warnings for fishermen were issued.
- **Diagnostic and prognostic features of Depression:** The prognostics and diagnostics of the systems were described in the RSMC bulletins and tropical cyclone advisory bulletins.

Statistics of bulletins issued by RSMC New Delhi in association with the depression over southwest BoB are given in **Table 3.**

Table 3: Bulletins issued by RSMC New Delhi

S.N	Bulletin type	No. of Bulletins	Issued to
1	National Bulletin	20	1. IMD's website, RSMC New Delhi website 2. FAX and e-mail to Control Room Ministry of Home Affairs & National Disaster Management Authority, Cabinet Secretariat, Minister of Science & Technology, Headquarter Integrated Defence Staff, Director General Doordarshan, All India Radio, National Disaster Response Force, Chief Secretary, Government of Tamil Nadu, Andhra Pradesh, Odisha, West Bengal and Andaman & Nicobar Islands, Madhya Pradesh, Chattisgarh and Jharkhand.
2	RSMC Bulletin	17	1. IMD's website 2. WMO/ESCAP member countries through GTS and E-mail.
3	GMDSS Bulletins	3	1. IMD website, RSMC New Delhi website 2. Transmitted through WMO Information System (WIS) to Joint WMO/IOC Technical Commission for Ocean and Marine Meteorology (JCOMM)
4	Warnings through SMS		SMS to disaster managers at national level and concerned states (every time when there was change in track, intensity and landfall characteristics) (i) 74216 to General Public by IMD Headquarters

5	Warnings through Social Media	Daily	Cyclone Warnings were uploaded on Social networking sites (Face book and Tweeter) since inception to weakening of system (every six hourly).
6	Press Release	1	Disaster Managers, Media persons by email and uploaded on website

9. Summary:

Under the influence of a cyclonic circulation in the mid and lower tropospheric levels over northeast Bay of Bengal and neighbourhood, a low pressure area formed over North Bay of Bengal in the morning of 13th August, 2022 which lay as a WML over northwest Bay of Bengal off North Odisha and West Bengal coasts in the evening of same day. The environmental conditions favoured the intensification of the WML into a depression over northwest Bay of Bengal and adjoining coastal areas of West Bengal & North Odisha at 0830 hours IST of the 14th August, 2022. Moving west-northwestwards the depression crossed West Bengal & adjoining north Odisha coasts close to Digha between 1030 IST & 1130 IST of 14th August, 2022. With west-northwestward movement, the system reached South Jharkhand & adjoining North Odisha at 1730 hours IST of 14th August, 2022 and over North Chhattisgarh and neighbourhood at 0530 hours IST of 15th August, 2022. Moving across north east Madhya Pradesh, the depression lay over East Rajasthan and adjoining West Madhya Pradesh at 0830 hours IST of 16th August, 2022 and moving further west-northwestwards weakened into a WML over central parts of Rajasthan at 1730 hours IST 16th August, 2022. Continuing to move west-northwestward, the WML moved across central Rajasthan and reached over southwest Rajasthan & adjoining southeast Pakistan at 2000 hours IST of 17th August, 2022.

Due to the formation of the depression active monsoon conditions prevailed over the country during the week. The widespread rainfall occurred over the areas along the track of the system. The heavy to extremely heavy rainfall episodes associated with the system were also observed at many stations of Odisha, Chhattisgarh, Madhya Pradesh, Vidarbha, Rajasthan and Gujarat state.

10. Acknowledgement:

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institutes including IIT Bhubaneswar, IIT Delhi and Space Application Centre, Indian Space Research Organisation (SAC-ISRO) for their valuable support. The support from various Divisions/Sections of IMD including Area Cyclone Warning Centre (ACWC) Chennai, Kolkata, Cyclone Warning Centre (CWC) Bhubaneswar, Visakhapatnam, Andaman & Nicobar Islands, Meteorological Centers at Bhopal, Raipur, Ranchi, Jaipur Madhya Pradesh, Chhattisgarh, Rajasthan and Jharkhand, Numerical Weather Prediction Division, Satellite and Radar Division, Surface & Upper air instruments Divisions, New Delhi, Information System and Services Division and Agromet Advisory Division at IMD is also duly acknowledged.