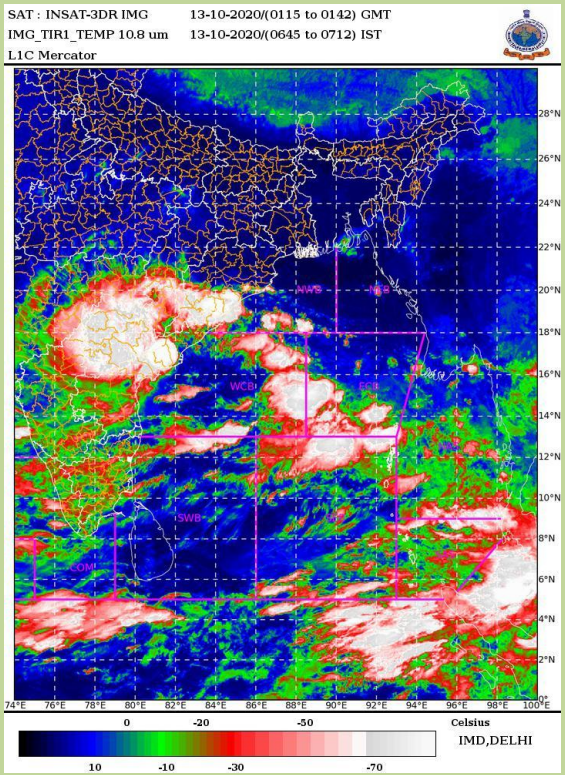
GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
INDIA METEOROLOGICAL DEPARTMENT

Deep Depression over the Bay of Bengal (11-14 October, 2020): A Report



INSAT-3D enhanced Colored IR imagery based on 0115 UTC of 13th October

Cyclone Warning Division

India Meteorological Department

New Delhi

October, 2020

Deep Depression over the Bay of Bengal
during 11-14 October, 2020

1. Introduction

- The Deep Depression originated from a low pressure area which developed over north Andaman Sea & neighbourhood in the early morning (0000 UTC) of 9th October 2020, it lay as a Well Marked Low Pressure Area over East Central Bay of Bengal and adjoining north Andaman Sea in the early morning of 10th October.
- It concentrated into a **Depression** over West Central Bay of Bengal in the early morning (0000 UTC) of 11th October.
- It intensified into **Deep Depression** in the forenoon (0600 UTC) of 12th October, 2020 and lay at a distance of about 250 km to the south-southeast of Vishakhapatnam.
- Moving west-northwestwards, it **crossed north Andhra Pradesh coast close to Kakinada (near Lat. 17.0°N & Long 82.4° E) between 0630 & 0730 hrs IST (0100 & 0200 UTC) of 13th October 2020, as a Deep Depression with a maximum sustained wind speed of 55-65 kmph gusting to 75 kmph**.
- Continuing to move west-northwestwards, it weakened into a **Depression** over Telengana in the forenoon (0600 UTC) of 13th October. It moved west-northwestwards as a Depression across Telangana and North Interior Karnataka to Maharashtra till evening of 14th October.
- It weakened into a Well Marked Low pressure area and lay centred over South Madhya Maharashtra and neighbourhood in the evening (1200 UTC) of 14th October 2020.
- It moved across Maharashtra and emerged as a well marked low pressure area over east-central Arabian Sea off Maharashtra coast on 16th morning. (Subsequently it re-intensified once again into a Depression over the Arabian Sea and moved away westwards during 17th – 19th October).
- The Deep Depression had impacts over Odisha, Andhra Pradesh, Telangana, Karnataka & Maharashtra in terms of heavy to extremely heavy rainfall and squally winds.

The salient features of the system were as follows:

(i) It had an initial west-northwestward followed by near westward moving track.
(ii) It had a life period of nearly 84 hours.
(iii) It had a track length of 1150 km.
(iv) Under the influence of this system and its remnant low pressure area, fairly widespread to widespread rainfall with heavy to very heavy and extremely heavy rainfall at isolated places occurred over Andhra Pradesh & south Odisha for a day, Telangana on 3 days and over Karnataka and Maharashtra on 2 days each.

IMD mobilised all its resources to track the system and regular warnings w.r.t. track, intensity, crossing point & time, associated severe weather and adverse impacts &

suggested actions were issued to concerned central and state disaster management agencies, print & electronic media and general public. Regular advisories were also issued to WMO/ESCAP Panel member countries. Its genesis, movement and associated adverse weather could be predicted with actionable accuracy by IMD.
The brief life history, associated weather and forecast performance of IMD/RSMC, New Delhi are presented in following sections.

2. Brief Life History:

The observed track of Deep Depression over west-central BoB is presented in Fig.1. The best track parameters of the system are presented in Table 1.

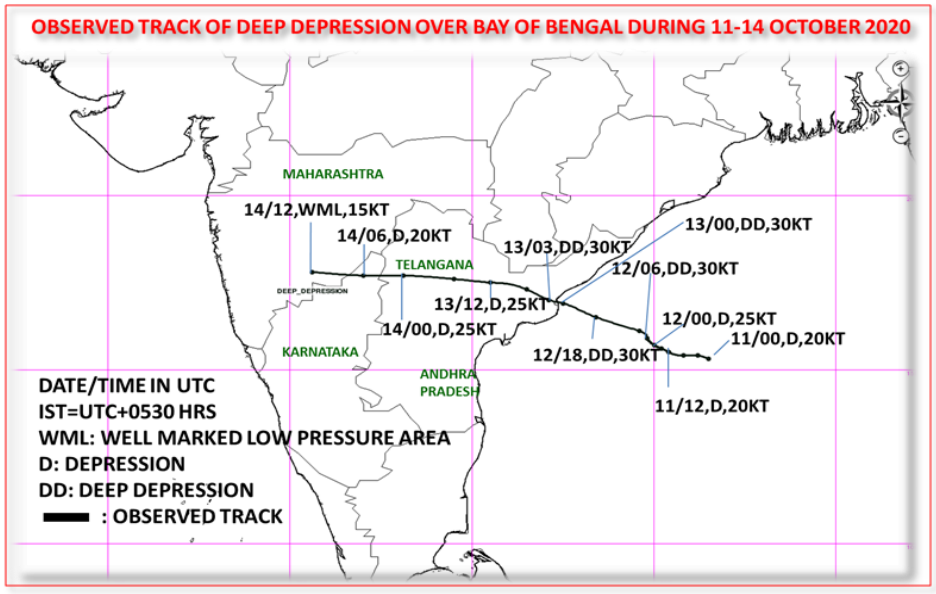


Fig.1. Observed track of deep depression over west-central Bay of Bengal (11-14 October, 2020)

Table 1: Best track positions and other parameters of the observed track of Deep Depression over west-central Bay of Bengal (11-14 October, 2020)

Date	Time (UTC)	Centre lat.^{0} N/ long.^{0} E		C.I. NO	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
11/10/2020	0000	15.3	86.5	1.5	999	20	3	**D**
	0300	15.4	86.2	1.5	998	25	4	D
	0600	15.4	85.8	1.5	998	25	4	D
	1200	15.5	85.4	1.5	998	25	4	D
	1800	15.6	85.2	1.5	998	25	4	D
12/10/2020	0000	15.7	85	1.5	998	25	4	D
	0300	15.7	85	2.0	997	30	5	**DD**

	0600	15.9	84.8	2.0	997	30	5	DD
	1200	16.1	84.6	2.0	997	30	5	DD
	1800	16.5	83.4	2.0	997	30	5	DD
13/10/2020	0000	16.9	82.5	-	997	30	5	DD
	crossed north Andhra Pradesh coast close to Kakinada (near Lat. 17.0°N & Long 82.4° E) between 0100 & 0200 UTC of 13th October 2020, as a Deep Depression							
	0300	17	82.1	-	996	30	6	DD
	0600	17.3	81.5	-	998	25	4	**D**
	1200	17.5	80.5	-	998	25	4	D
	1800	17.6	79.5	-	998	25	4	D
14/10/2020	0000	17.7	78.1	-	1000	20	3	D
	0300	17.7	77.5	-	1000	20	3	D
	0600	17.7	77.0	-	1000	20	3	D
	1200	Weakened into well marked low pressure area over south Madhya Maharashtra & neighbourhood						

Fig.2 depicts the hourly coastal observations recorded by the surface meteorological observatories located along Andhra Pradesh coast during 1600 UTC of 12th October to 0600 UTC of 13th October denoting the changes in wind direction and mean sea level pressure in association with the approach & crossing of the Deep Depression across Andhra Pradesh coast. Kakinada and Tuni reported the lowest mean sea level pressure of 995.2 hPa & 996.8 hPa respectively at 0100 UTC of 13th.The wind direction of Tuni had changed from northerly to southeasterly between 0100 & 0200 UTC, indicating that the system crossed close to Kakinada during this time period. Both the stations reported continuous rain as the present weather during the time of crossing.

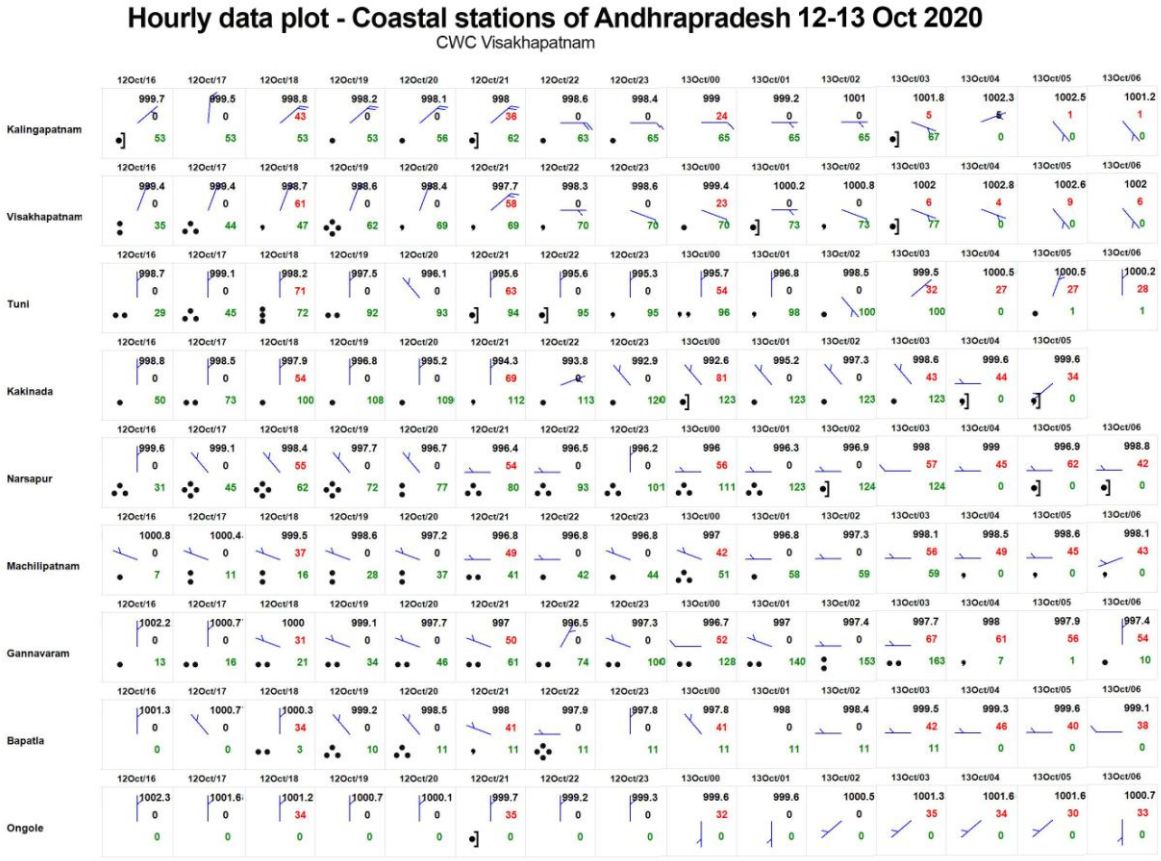


Fig.2. Hourly wind, mean Sea level & current weather observations recorded at the coastal surface meteorological observatories of coastal Andhra Pradesh during the passage of the Deep Depression over west-central Bay of Bengal (11-14 October, 2020)

3. Features observed through Satellites and Radar:

India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean and the development of the system was monitored since 01st October, about 8 days prior to the formation of low pressure area over north Andaman Sea & neighbourhood on 9th October. The **Deep Depression** was monitored with the help of available satellite observations from INSAT 3D and 3DR, SCAT SAT, polar orbiting satellites and available ships & buoy observations in the region. The system was also monitored by Doppler Weather RADARs (DWRs) Machilipatnam, Vishakhapatnam and Gopalpur. Various numerical weather prediction models run by Ministry of Earth Sciences (MoES) institutions, models run by other Global centres and dynamical-statistical models were utilized to predict the genesis, track, landfall and intensity of the Deep Depression. A digitized forecasting system of IMD was utilized for analysis and comparison of various models' guidance, decision making process and warning products generation. The heavy rainfall and wind warning at district and meteorological subdivision level along with expected impact, suggested actions and fishermen warnings were issued by IMD well in advance to all concerned states, media and stakeholders.

Typical satellite imageries are presented in Fig.3. From the system centre as evidenced by the SCATSAT derived near surface winds and the cloud organization based on the INSAT derived cloud imagery it may be noted that the clouds were sheared to the west of system centre.

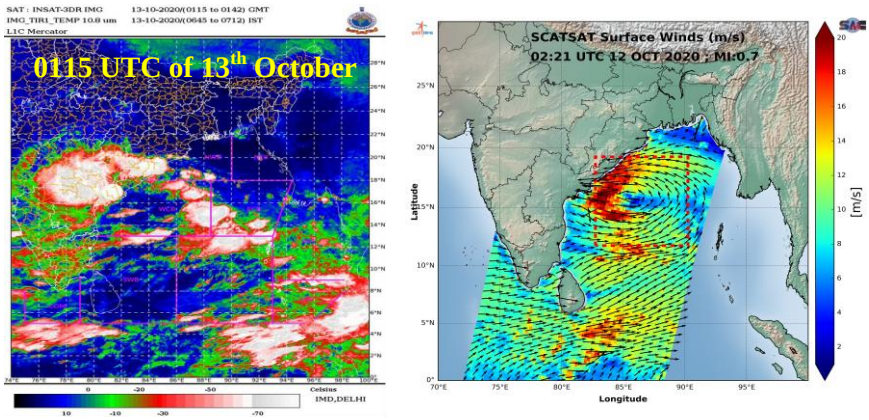


Fig. 3: Typical satellite imagery from INSAT-3D and SCATSAT

Fig.4 presents the ASCAT derived winds**, Fig.5,** the INSAT based cloud imageries and Fig.6 the SCATSAT winds. All through the system period, the convection was organized in a shear pattern and the minimum Cloud Top Temperature reported had been minus 93ºC, when the system was over the Sea.

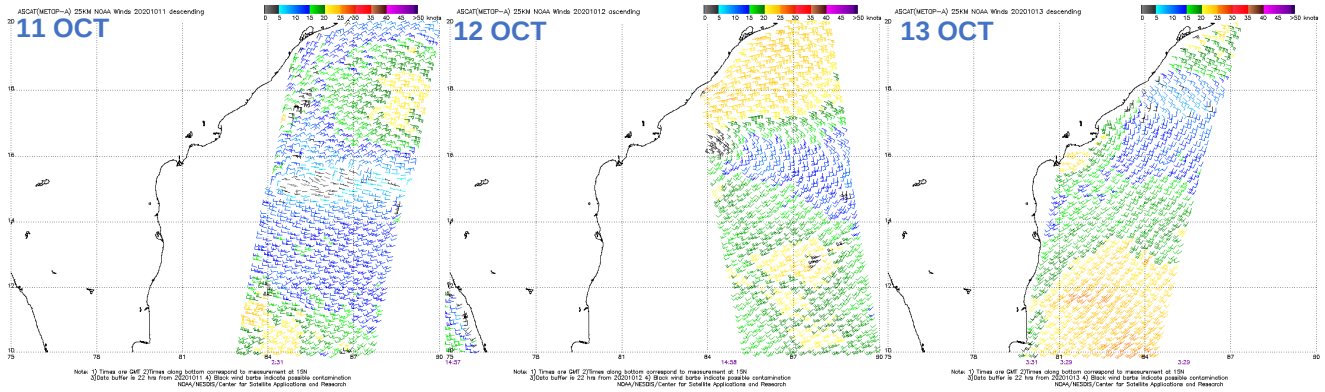


Fig. 4: ASCAT images during life cycle of Deep Depression (11-14 October, 2020)

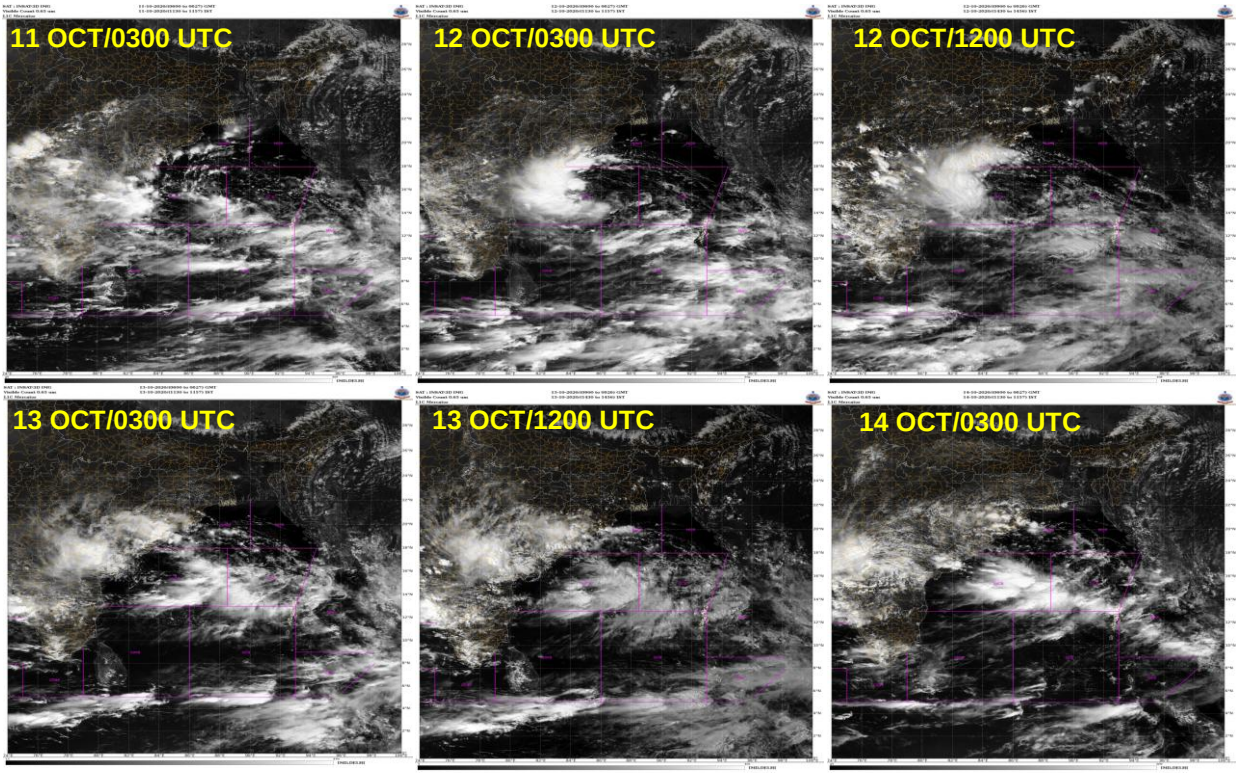


Fig. 5a: INSAT-3D IR imageries during life cycle of Deep Depression (11-14 October, 2020)

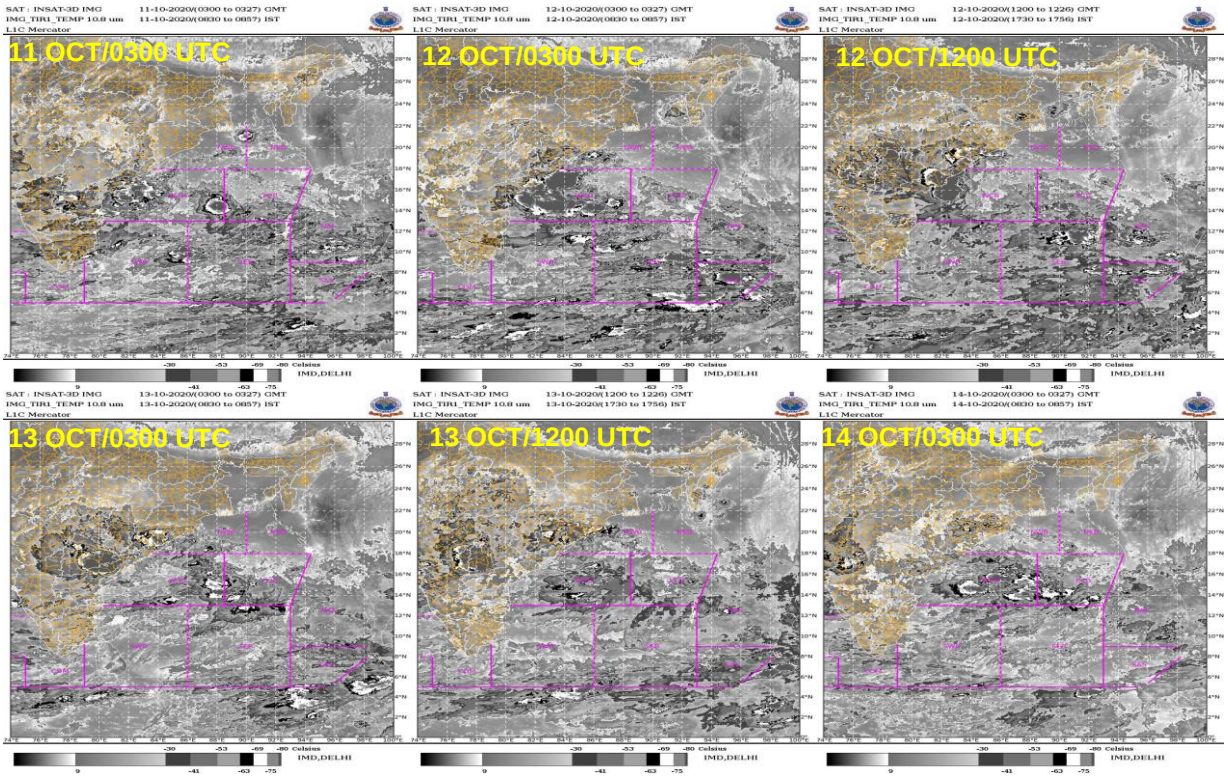


Fig. 5b: INSAT-3D cloud top brightness imageries during life cycle of Deep Depression (11-14 October, 2020)

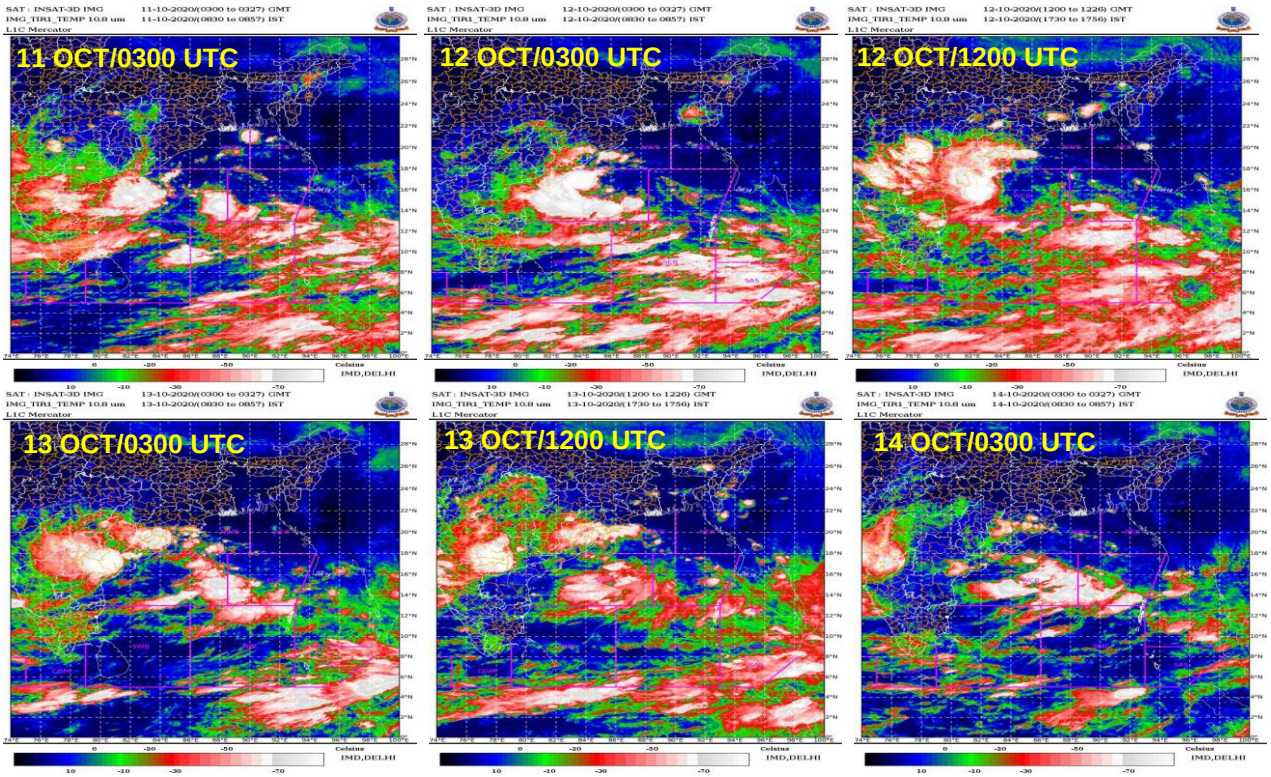


Fig. 5c: INSAT-3D enhanced colored imageries during life cycle of Deep Depression (11-14 October, 2020)

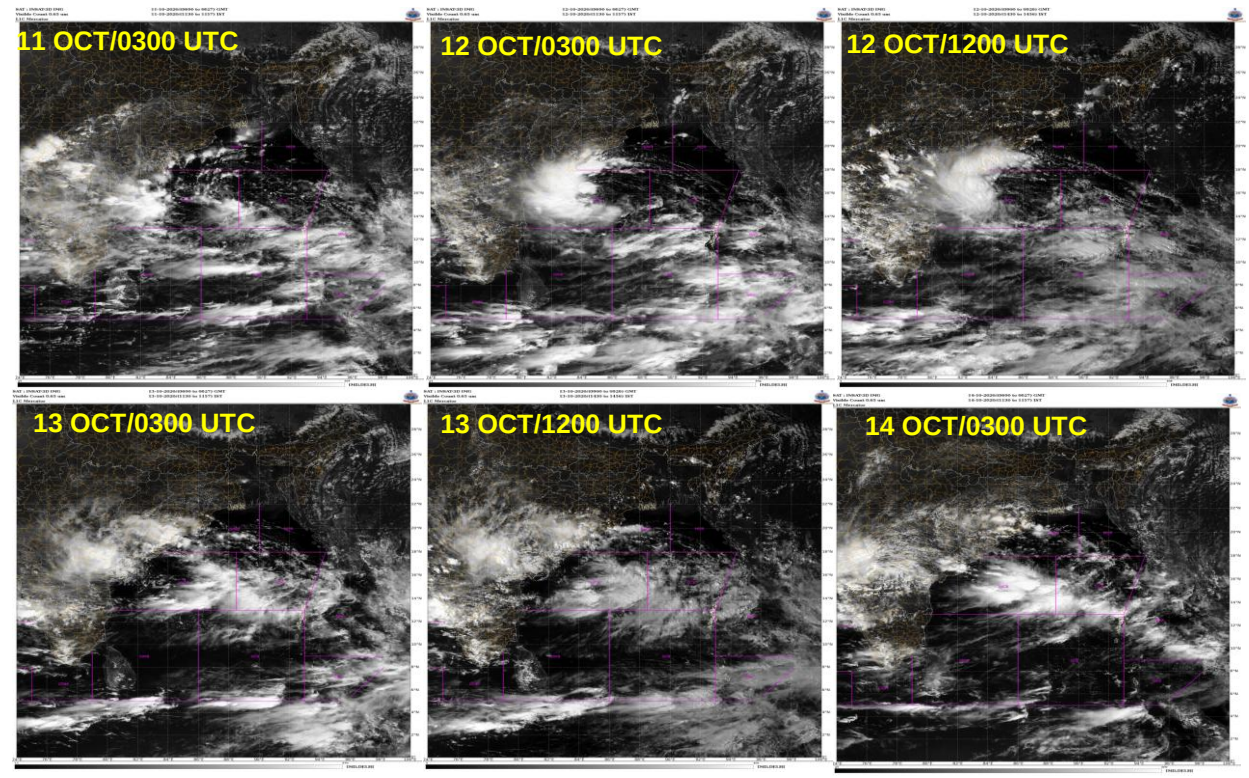


Fig. 5d: INSAT-3D visible imageries during life cycle of Deep Depression (11-14 October, 2020)

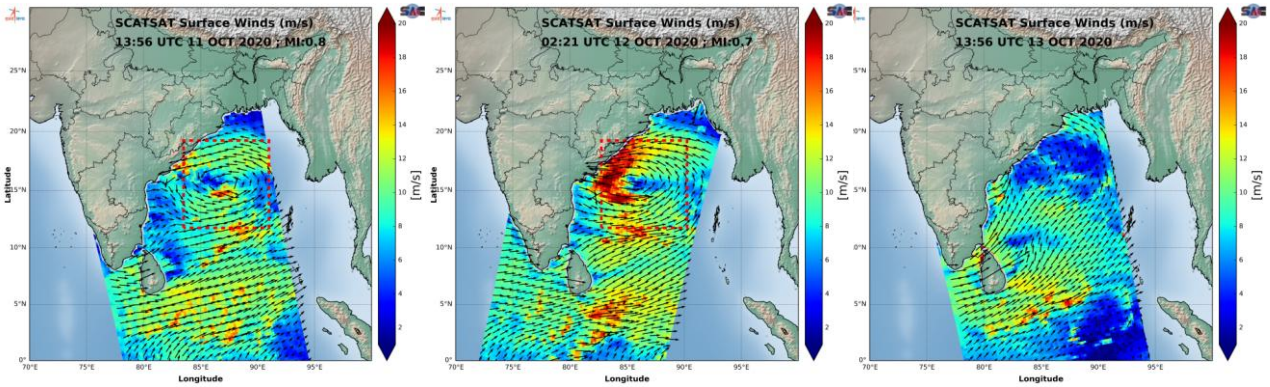


Fig. 6: SCAT SAT based sea surface winds during life cycle of Deep Depression (11-14 October, 2020)

Fig.7 shows the RADAR imageries from Doppler Weather RADARs **(a)** Visakhapatnam (b) Machilipatnam (c) Hyderabad and (d) Mumbai in association with the system.

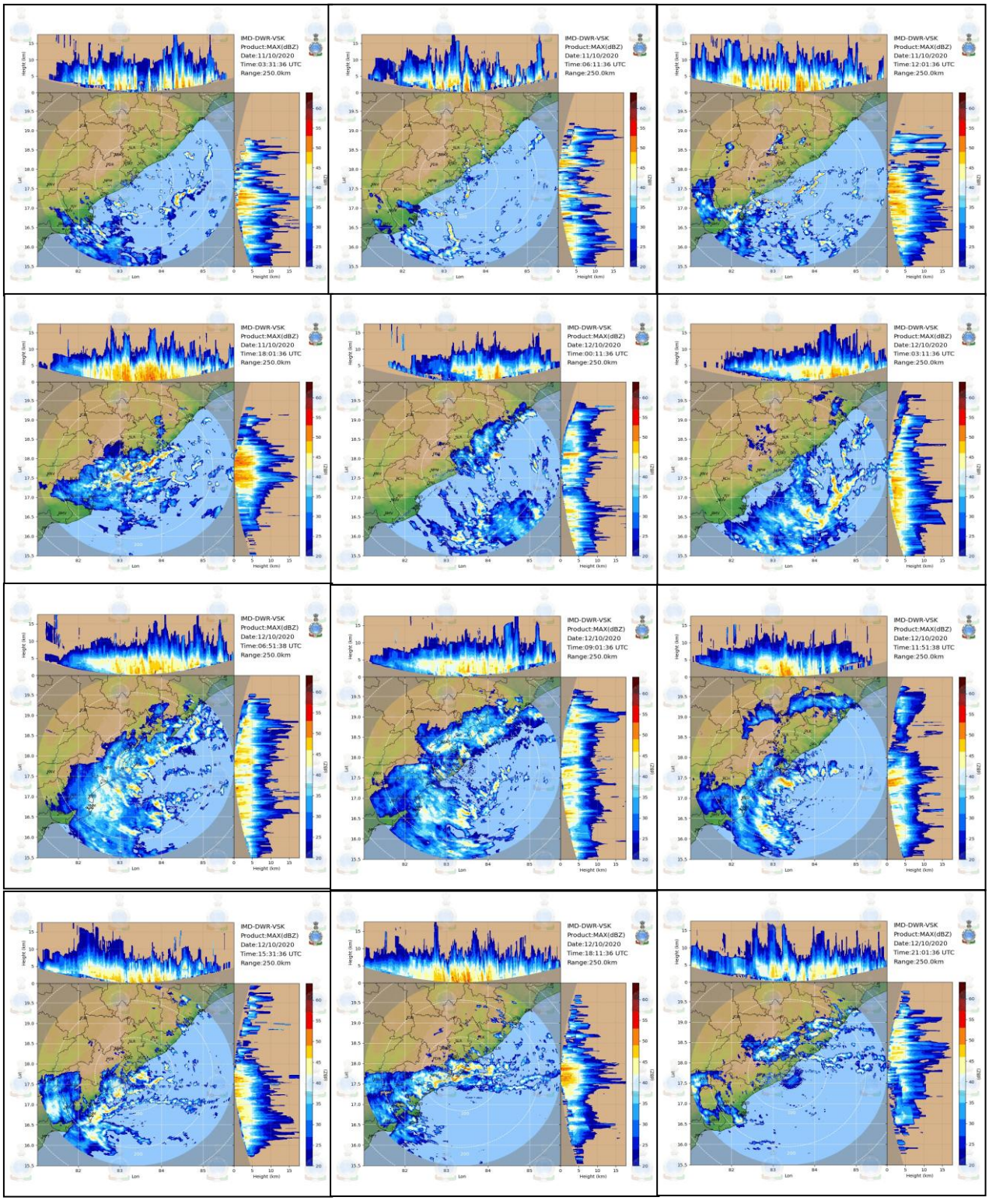


Fig 7a: Typical Max Z Radar imageries of DWR Visakhapatnam during 11-14 October, 2020

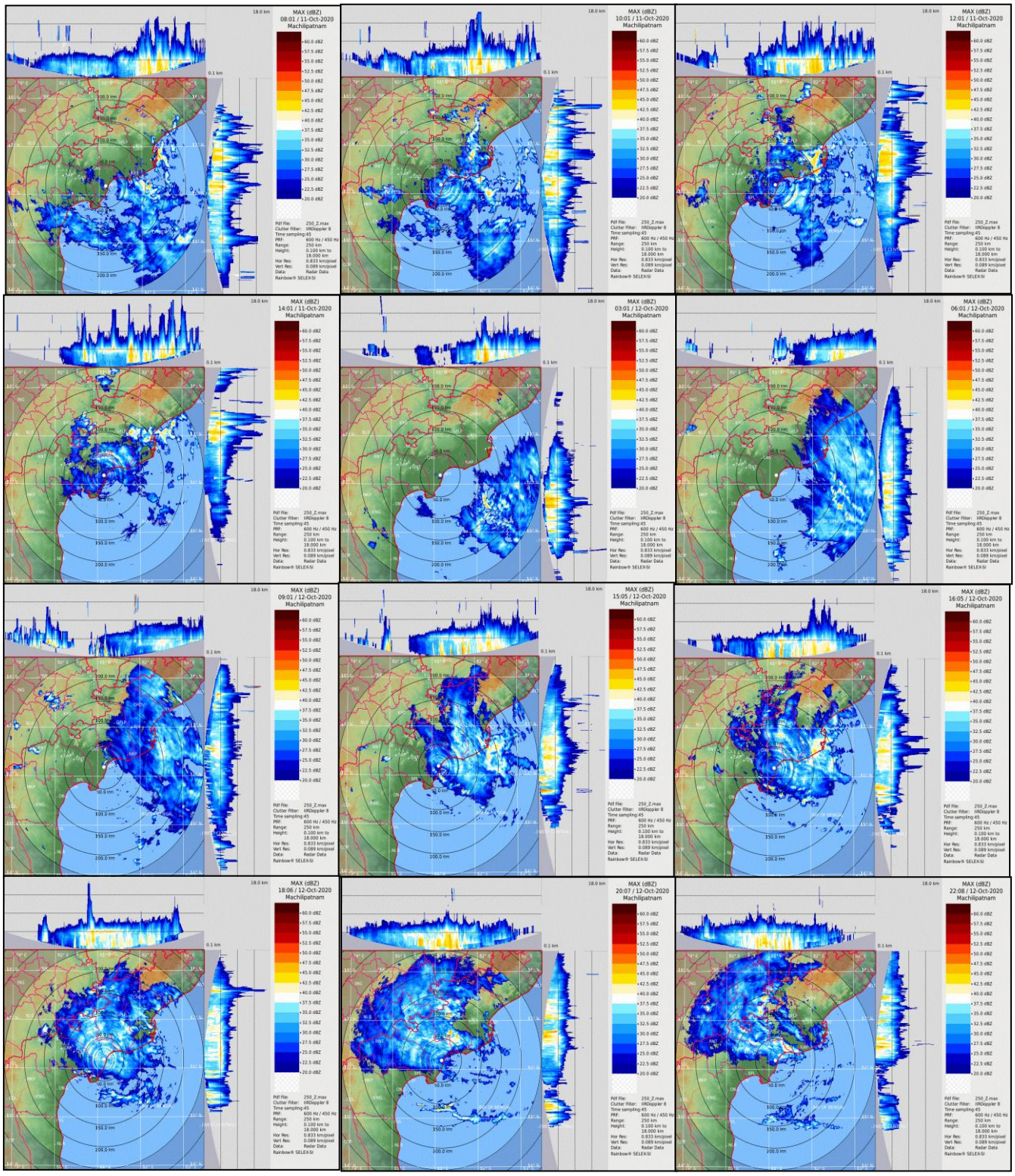


Fig 7b: Typical Max Z Radar imageries of DWR Machilipatnam during 11-14 October, 2020

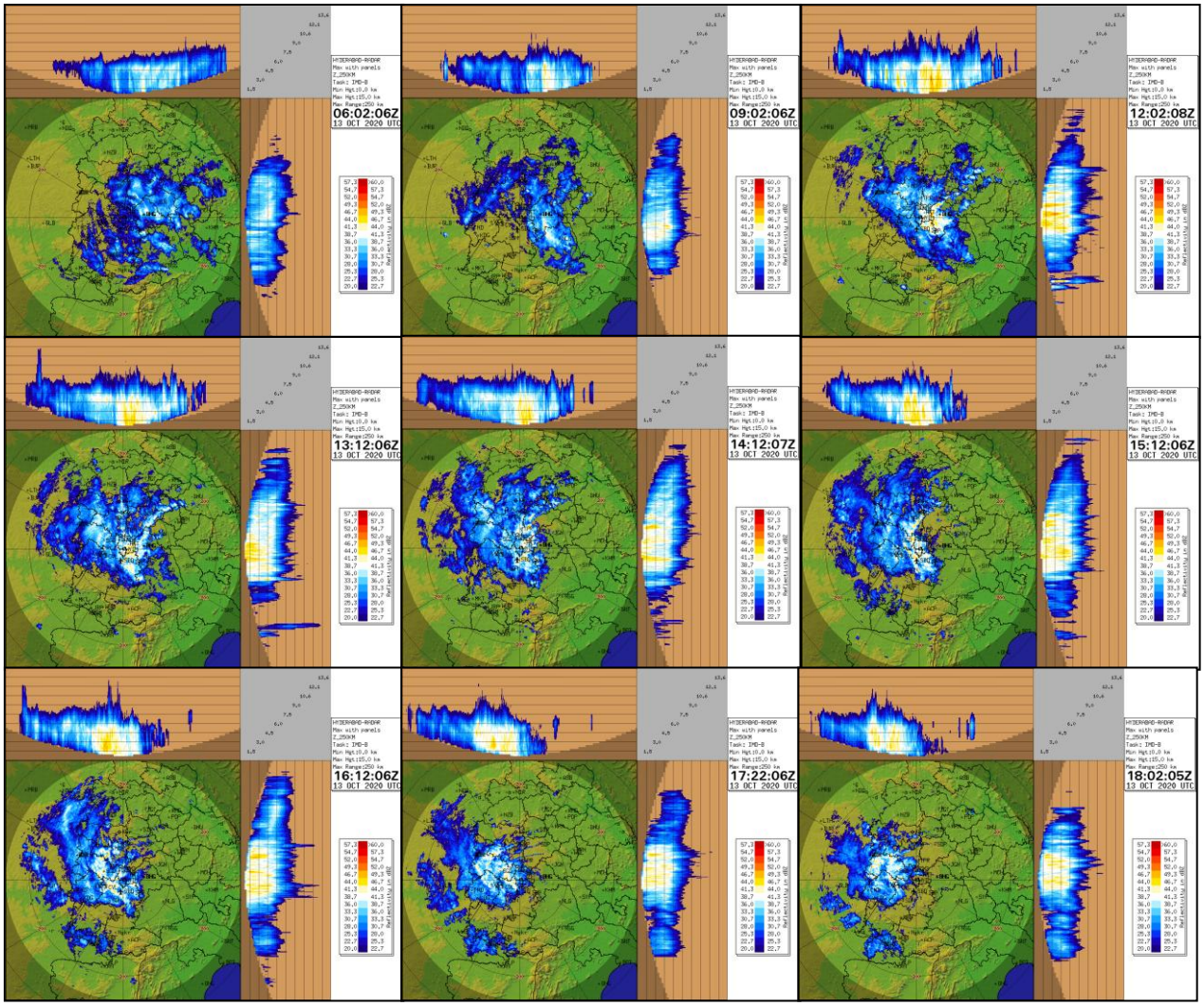


Fig 7c: Typical Max Z Radar imageries of DWR Hyderabad during 11-14 October, 2020

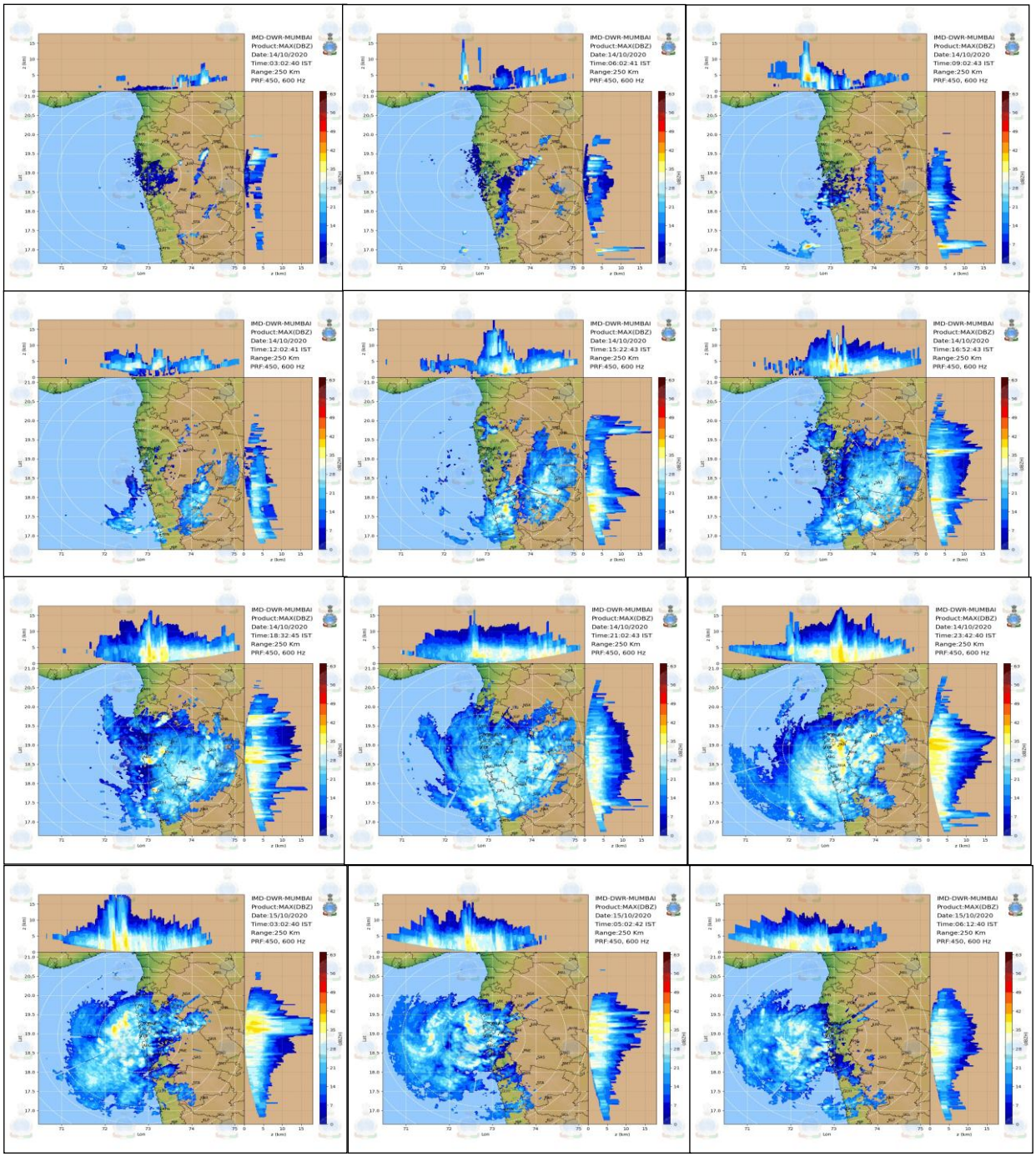


Fig 7d: Typical Max Z Radar imageries of DWR Mumbai during 11-14 October, 2020

4. Dynamical features

IMD GFS (T1534) analysis fields of mean sea level pressure (MSLP), winds at 10 m, 850, 500 and 200 hPa levels are presented in Fig.8 (a) – 8(d).

At 0000 UTC of 11th October, it indicated a Depression over central BoB. The circulation was seen extending upto 500 hPa level. Also another cyclonic circulation lay over south peninsular India to the west of this system and a trough in the wind field linked the two cyclonic vortices at 500 hPa. At 200 hPa level east-southeasterly winds prevailed over the system area and easterly flow to the west, indicating the likely direction of movement. Overall model simulated the system quite well.

At 0000 UTC of 12th October, it indicated a Deep Depression over west-central BoB. The circulation was seen extending upto 500 hPa level. The other cyclonic circulation over south peninsular India to the west of this system and the trough in the wind field linking the two cyclonic vortices at 500 hPa persisted. At 200 hPa level easterly winds prevailed over the system area indicating the likely direction of movement. The system intensity at 0000 UTC remained that of a Depression. However it intensified into a Deep Depression by 0300 UTC.

At 0000 UTC of 13th October, the model indicated the system as a Deep Depression over west-central BoB, close to north Andhra Pradesh coast. The circulation was seen extending upto 500 hPa level. The other cyclonic circulation over south peninsular India to the west of this system had merged with the trough in the wind field which extended westwards across south peninsula at 500 hPa. Easterly flow prevailed at 200 hPa level. The system as a Deep Depression lay very close to north Andhra Pradesh coast and was beginning the process of crossing coast at this time.

At 0000 UTC of 14th October, the model located the system as a Depression centered over Telangana and adjoining north interior Karnataka. The circulation was seen extending upto 500 hPa level. Easterly flow prevailed at 200 hPa level. The system after crossing north Andhra Pradesh coast had weakened into a Depression by 0600 UTC of 13th October. Further moving west-northwestwards it lay over North Interior Karnataka & adjoining areas of Maharashtra and Telangana as a Depression, at this point of time.

Hence IMD GFS provided reliable guidance in forecasting the intensity & movement of the system all through its life period.

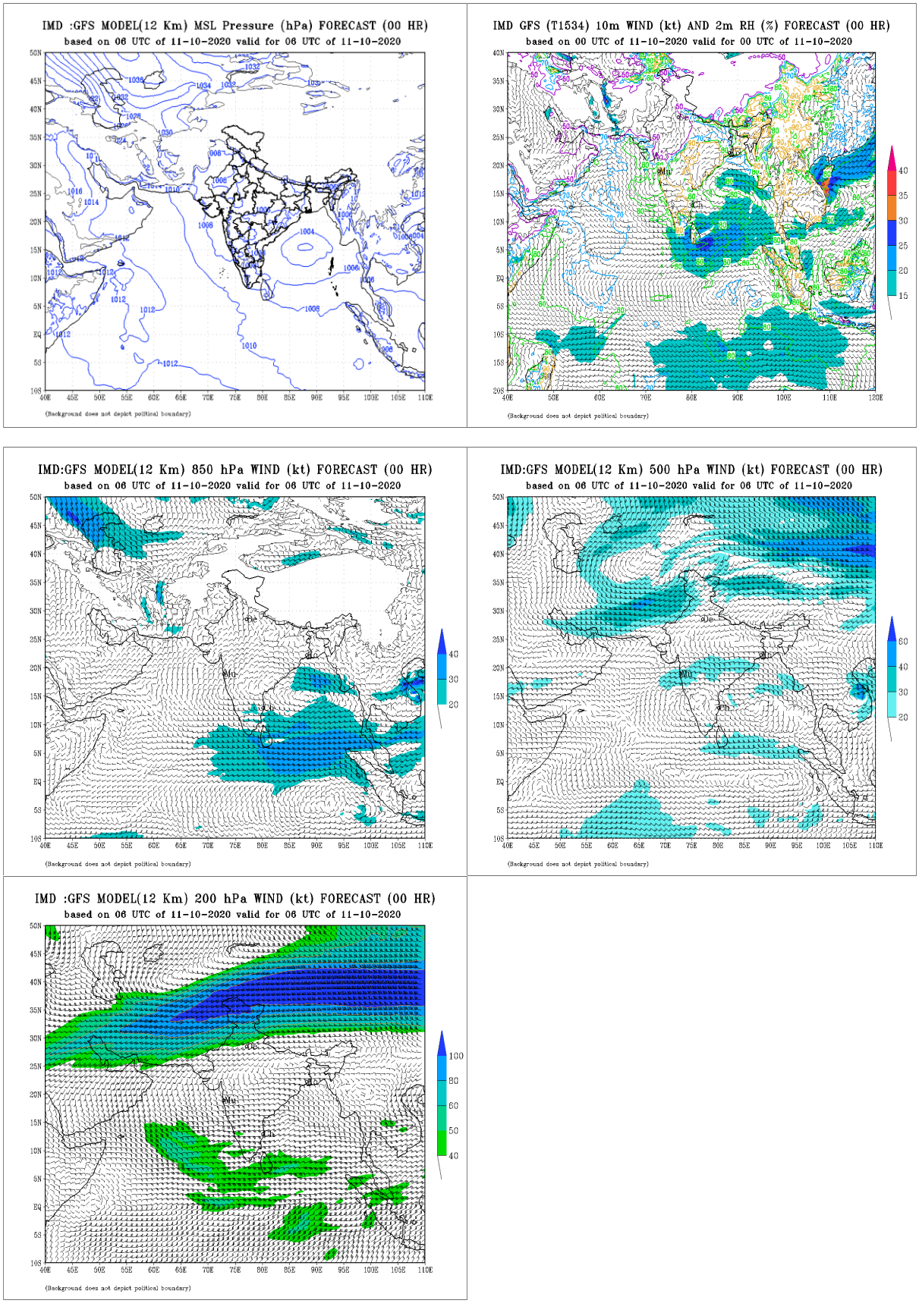


Fig.8 (a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 11th October 2020

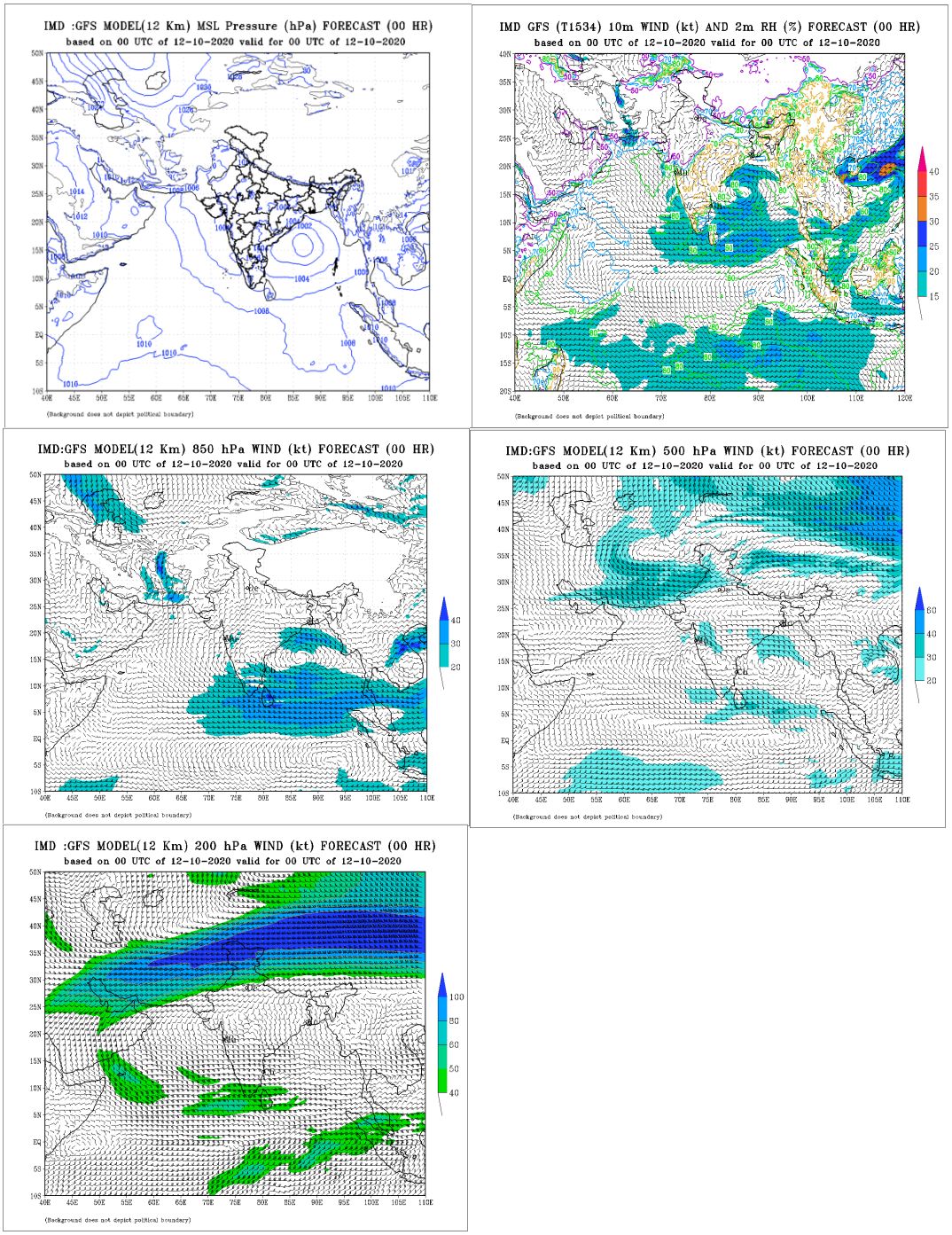


Fig.8 (b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 12th October 2020

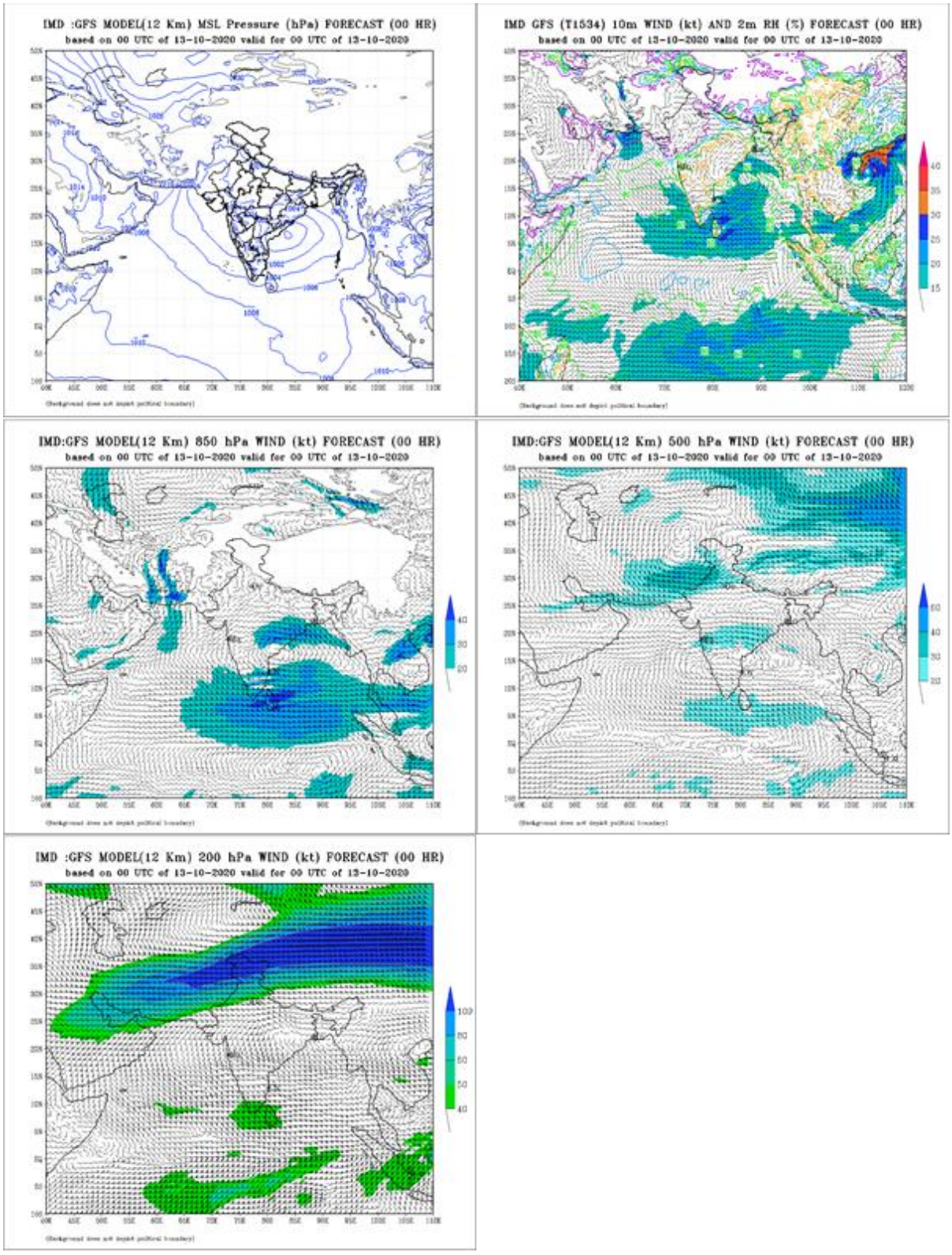


Fig.8 (c): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 13th October 2020

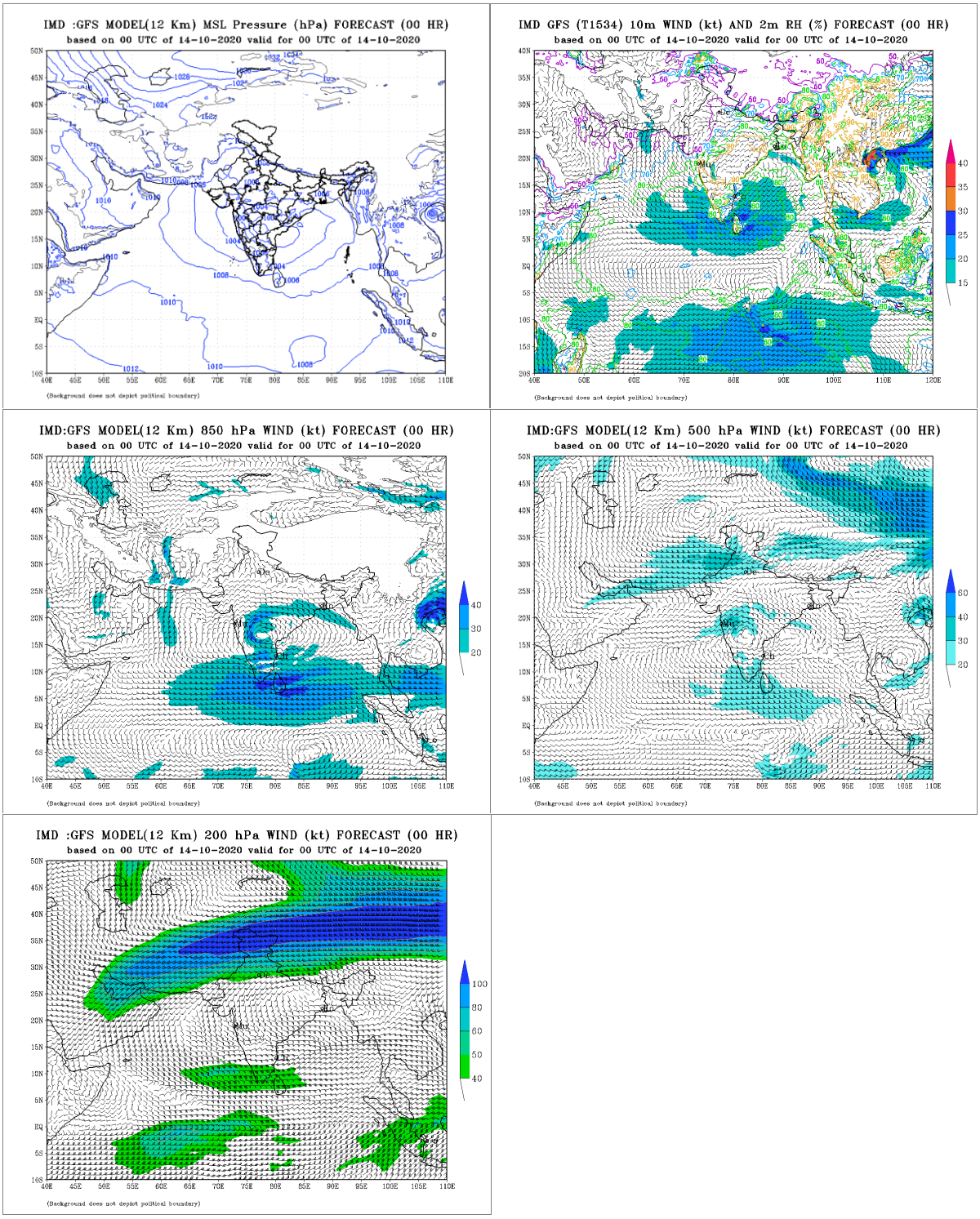


Fig.8 (d): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 14th October 2020

5. Realized Weather:

Under the influence of this system, light to moderate rainfall at many places with heavy to very heavy & extremely heavy rainfall at isolated places occurred over Odisha, Coastal Andhra Pradesh & Yanam, Telengana and Coastal Karnataka on one day each, Heavy to very heavy rainfall at isolated places over Telangana on three days; over North & South Interior Karnataka and Marathwada on two days each; over Madhya Maharashtra, Coastal Andhra Pradesh & Yanam, Rayalaseema and Coastal Karnataka on one day each.

The daily rainfall distribution ending at 0300 UTC of each date during 09-15 October, 2020 based on merged gridded rainfall data of IMD/NCMRWF is shown in Fig.9. It may be noted that the rainfall over the mainland had started even 2 days prior to the system crossing Andhra Pradesh coast owing to the sheared nature of the convection associated with the system.

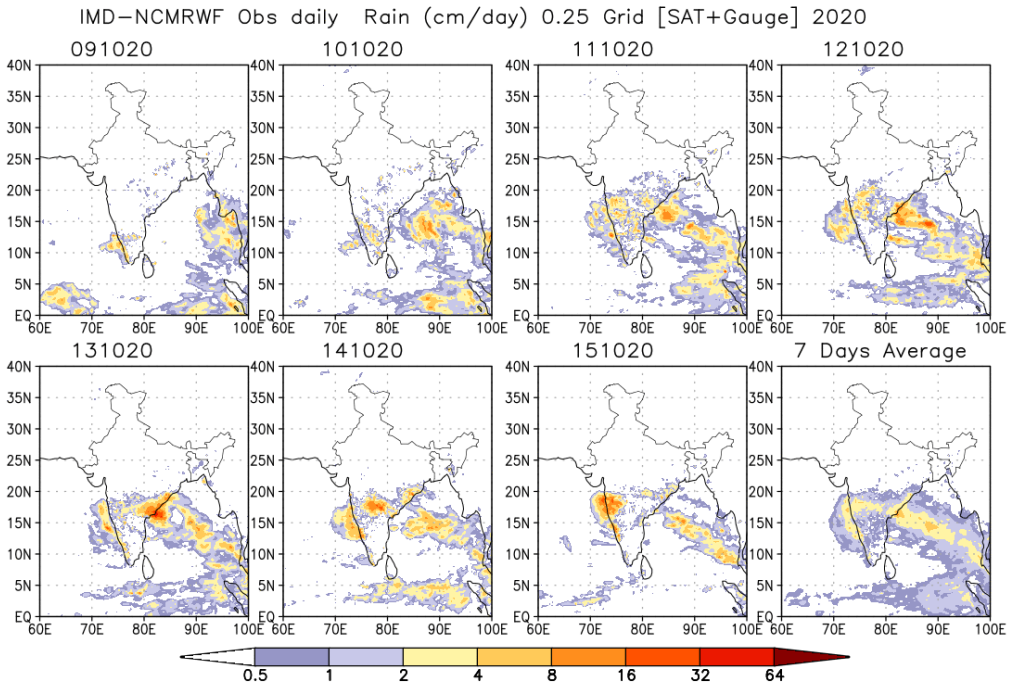


Fig.9: Daily rainfall distribution based on merged gridded rainfall data of IMD/ NCMRWF during 09-15 October, 2020

(Rainfall distribution: Isolated places: upto 25%, A few places: 26-50%, Many places: 51-75%, Most places: 76-100% of total stations in the region;
Heavy rainfall: 64.5 – 115.5 mm, Very heavy rainfall: 115.6 – 204.4 mm, Extremely heavy rainfall: 204.5 mm or more).

The 24 hour cumulative rainfall (≥ 7 cm) ending at 0300 UTC (0830 hours IST) of date during 11th – 15th October 2020 is presented below:

11th October

Coastal Andhra Pradesh (A.P) & Yanam: Racherla-10, Velairpad-8
Telangana: Kothagudam -14
Rayalaseema: Chinnamandem-13, Pakala-12, Badvel-10, Uravakonda-9, Orvakal-9, Atmakur (District: Kurnool) - 9, Kurnool -8, Gurramkonda-9, Atlur-8, Penagaluru-8, Pamidi-8, Sambepalle-8, Lepakshi-7

12th October

Coastal A.P. & Yanam: Bheemunipatnam-17, Visakhapatnam-15, Visakhapatnam AP-14, Kakinada-14, Peddapuram-14, Yanam-11, Anakapalle-10, Amalapuram-10, Marripudi-8, Tuni-8, Prathipadu-7, Dowleshwaram-7, Yelamanchili-7
Telangana: Kondapak-10, Ramayampet-10, Ghattu-7, Mirdoddi-7, Bhiknur-7, Sarangapur-7, Domakonda-7.
Rayalaseema: Simhadripuram-7
North interior Karnataka: Hukkeri-13, Hungund-10, Khajuri-9, Bevoor-9

13th October

Odisha: Mohana-14, Paralakhemundi-12, Nuagada-11, Berhampur-10, Aska-10, Kashinagar-9, Purushottampur-9, Mahendragarh-8, Chhatrapur-8, R.Udaigiri-7, Gunupur-7
Coastal A.P. & Yanam: Yanam-25, Amalapuram-19, Tanuku-19, Nuzvid-19, Tadepalligudem-18, Vijayawada A.P.-16, Bheemunipatnam-16, Kaikalur-15, Palasa-15, Ichchapuram-15, Tiruvuru-15, Yelamanchili-14, Chintalapudi-13, Sompeta-13, Gudivada-13, Mandasa-13, Narsapuram-12, Kakinada-12, Prathipadu-12, Koyyalagudem-12, Palakoderu-12, Bheemavaram-12, Dowleshwaram-11, Peddapuram-11, Bhimadole-11, Rajahmundry-11, Narsipatnam-11, Eluru-11, Vijayawada(ARG)-10, Tuni-10, Prakasam Barrage-9, Nandigama-9, Bondapalle-9, Anakapalle-9, Chodavaram-9, Vepada-9, Visakhapatnam A.P-8, Vararamachandrapur-8, Therlam-8, Kukunoor-8, Paderu-8, Pathapatnam-8, Pusapatirega-8, Visakhapatnam-8, Velairpad-7, Denkada-7, Palakonda-7, Ranastalam-7, Parvathipuram-7, Mangalagiri-7, Nellimarla-7, Mentada-7, Nandigama (ARG)-7, Paleru Bridge-7, Koida-7, Gajapathinagaram-7, Garugubilli-7, Polavaram-7, Merakamudidam-7, Kalingapatnam-7, Garividi-7, Kunavaram-7.
Telangana: Sathupalle-19, Mahabubabad-13, Madhira-11, Mulakalapalle-11, Aswaraopeta-11, Bayyaram-10, Chandrugonda-9, Thimmajipeta-9, Thollada-8, Tupran (ARG) -8, Suryapet-7, Devarakonda-7, Wanaparthy-7, Chandur-7, Kusumanchi-7
North interior Karnataka: Badami-8, Kushtagi-7.
South interior Karnataka: Sandur-10, Agumbe EMO-7, Hagaribommanahalli-7

14th October

Odisha: Aska-21, Purushottampur-19, Daspalla-10, Sorada-10, Daitari-9, Berhampur-7, Daringibadi-7, R.Udaigiri-7, Digapahandi-7, Brahmagiri-7, Mohana-7, Raikia-7.

Coastal A.P. & Yanam: Avanigada-10, Nandigama (ARG) -10, Sattenapalle-10, Therlam-10, Macherla-9, Sompeta-9, Machilipatnam CDR -9, Narsapuram-9, Nandigama-8, Jangamaheswarapuram-8, Repalle-7, Bheemavaram-7.
Telangana: Hayathnagar-30, Jogipet-24, Ibrahimpatnam-23, Hakimpet IAF- 20, Hyderabad A.P.-19, Golkonda-18, Manchal-18, Warangal-18, Tekmal-17, Marpalle-17, Nalgonda-16, Kondapur-16, Sangareddy-15, Kohir-15, Mominpet-15, Medchal-15, Dindigul-15, Chandur-15, Maheswaram-15, Shamirpet-15, Hathanoora-15, Narsapur-15, Nidamanur-14, Yacharam-14, Saroornagar-14, Munipalli-13, Naykal-13, Raikode-13, Peddemul-12, Doultabad-12, Medak-12, Sadasivpet-11, Palakurthi-11, Nawabpet-11, Alladurg-11, Chevella-11, Narmetta-11, Gajwel-11, Regode-11, Chegunta-10, Ghanpur-10, Kondapak-10, Kowdipalle-10, Ramayampet-10, Jagadevpur-10, Mahabubabad-9, Zaffergadh-9, Vicarabad-9, Aswaraopeta-9, Mirdoddi-9, Tandur-9, Dubbak-9, Nanganur-9, Jangaon-8, Bejjanki-8, Marriguda-8, Huzurabad-8, Nagareddipet-8, Kamareddy-8, Sathupalle-7, Jukkal-7, Bhiknur-7, Doma-7, Mustabad-7, Jajireddigudem-7, Papannapet-7, Noothankal-7, Narayankhed-7.
Marathwada: Nilanga-13, Deoni-8, Umarga-8, Chakur-7, Ausa-7.
Konkan & Goa: Malvan-9, Dodamarg-7.
North interior Karnataka: Manthala-15, Basavakalyan-15, Humnabad-13, Kalaburgi obsy-13, Bidar PTO-13, Kalaburgi AWS-13, Chincholi-11, Khajuri-11, Aland-9, Aurad-8, Afzalpur HMS-7, Raddewadgi ARG-7.
South interior Karnataka: Agumbe EMO-14, Kottigehara-9, Arasalu-7
Coastal Karnataka: Kollur-24, Kota-17, Mulki-17, Mani-15, Mangaluru A.P obsy-15, Mudubidre-13, Brahmavar AWS-13, Karkala-13, Udupi-13, Kundapur-12, Belthangadi-12, Puttur HMS-12, Mangaluru-12, Panambur obsy-12, Vitla ARG-12, Dharmasthala-11, Bhatkal-10, Sulya-10, Shirali PTO -9, Siddhapura ARG-8, Siddhapura-8, Subramanya-8, Uppinangadi-7.

15th October

Marathwada: Paranda-18, Tuljapur-14, Lohara-10, Shirur Kasar-7, Georai-7.
Madhya Maharashtra: Gaganbawada-17, Indapur-16, Barshi-16, Pandharpur-16, Jeur IMD Part time-16, Baramati-15, Sangli IMD obsy-15, Panhala-14, Malshiras-14, Mangalvedha-13, Mahabaleshwar- IMD obsy-13, Kolhapur/Karvir IMD-13, Vita-11, Pune city IMD obsy-11, Bhor-11, Karad-11, Ambegaon Ghodegaon-11, Patan-10, Palus-10, Lonavala agri-10, Shirala-10, Karmala-10, Tasgaon-9, Miraj-9, Kavathe Mahakal-9, Atpadi-9, Dahiwadi man-9, Khandala Bavda-9, Kagal-9, Daund-9, Wai-9, Kadegaon-9, Madha-9, Satara IMD obsy-9, Khatav Vaduj-9, Jat-9, Shirur Ghodnadi-9, Sholapur IMD obsy-8, Shirol-8, Purandar Sasvad-8, Khed Rajgurunagar-8, Phaltan-7, Javali Medha-7, Junnar-7, Hatkanangale-7, Mohol-7, Velhe-7, Akole-7, Vadgaon maval-7
Konkan & Goa: Alibag IMD part time-15, Lanja-15, Khed-14, Murud-13, Karjat agri-12, Vaibhavwadi-12, Khalapur-12, Pen-12, Ratnagiri IMD obsy-12, Matheran-12, Colaba IMD obsy-12, Rajapur-11, Sangameshwar Devrukh-11, Poladpur-10, Panvel agri-10, Mandangad-9, Sudhagad Pali-9, Bhira IMD part time - 9, Santacruz IMD obsy-9, Roha-9, Malvan-8, Chiplun-8, Tbia IMD part time-8, Shriwardhan-7, Mahad-7, Mhasla-7, Guhagarh-7, Tala-7, Dodamarg-7, Uran-7.

6. Bulletins issued by IMD

IMD issued regular bulletins to National & State Disaster Management Agencies of Andhra Pradesh, Odisha, Maharashtra, Telangana, general public and media and WMO/ESCAP Panel member countries including Bangladesh and Myanmar. Regular Bulletins every six hourly were issued since formation of depression over northwest BoB. In addition, CWD New Delhi also issued Press Release and SMS to registered users.

In all, one video by DGM IMD about the system, 6 Nos. of Press Release along with 2 Nos. of informatory messages, 4 bulletins from DGM, IMD, 19 National Bulletins for central level disaster managers, 12 RSMC Bulletins for WMO/ESCAP panel member countries and frequent updates on Facebook, Twitter and Whatsapp groups were issued in association with this system.

A few Districts of coastal Andhra Pradesh & Yanam experienced very heavy rainfall during the 24 hours period ending at 0830 hrs IST on 12th October (maximum reported by Bheemunipatnam-17 cm) and very heavy to extremely heavy rainfall (maximum reported by Yanam-25 cm) on 13th October. Similarly many districts of Telangana experienced very heavy rainfall during the 24 hours period ending at 0830 hrs IST on 13th October and very heavy to extremely heavy rainfall (maximum reported by Hayathnagar-30 cm) on 14th October. Major rainfall activity with heavy to very heavy rainfall at a few places occurred over Karnataka during the 24 hour period ending at 0830 hrs IST of 14th October and that over Maharashtra on 15th October. Along with this a few districts of south Odisha also experienced very heavy rainfall during the 24 hour period ending at 0830 hrs IST of 13th October and extremely heavy rainfall (maximum reported by Aska-21cm)on 14th October.

IMD indicated the likelihood of enhanced rainfall activity over south Peninsular India comprising Andhra Pradesh, Telangana and adjoining areas of Karnataka and Maharashtra via consistent Press releases issued since 7th October 2020, in relation to the expected development of the system. Warning for Extremely heavy rainfall (≥ 20 cm per day) at isolated places over north coastal Andhra Pradesh on 13th October was issued from the very first Bulletin issued with respect to the system on 11th October, early morning. This Bulletin also contained the respective heavy to very heavy rainfall warnings for the remaining affected states viz., Telangana, Odisha, Karnataka and Maharashtra.

Apart from the number of bulletins, social media messages and Video clips which also contained the likely impacts and suggested actions, circulated as mentioned below, city specific impact based forecasts were also issued by the respective State meteorological Centres located at Amravati, Hyderabad, Bangaluru as well as by the Regional Meteorological Centre Mumbai and O/ o Climate Research & Services, Pune.

6.1: Bulletins issued by Cyclone Warning Division, New Delhi

Bulletins issued by Cyclone Warning Division of IMD in association with the system are given in Table 2

Table 2(a): Bulletins issued by Cyclone Warning Division, IMD, New Delhi

S.N.	Bulletins	No. of Bulletins	Issued to
1	National Bulletin	19	1. IMD's website 2. FAX and e-mail to Control Room NDM, Ministry of Home affairs, Control Room NDMA, Cabinet Secretariat, Minister of Sc. & Tech, Secretary MoES, DST, HQ Integrated Defence Staff, DG Doordarshan, All India Radio, DG-NDRF, Director Indian Railways, Indian Navy, IAF, Chief Secretary: Odisha, Maharashtra, Telangana, Karnataka and Kerala
2	RSMC Bulletin	12	1. IMD's website 2. All WMO/ESCAP member countries through GTS and E-mail. 3. Indian Navy, IAF by E-mail
3	Press Release	6	1. Disaster Managers, Media persons by email and uploaded on website
4	Facebook /Twitter	4 times a day	Highlights uploaded on facebook /twitter since formation of depression.
5	SMS	4 times a day	To disaster managers of central and state level and general public registered with RSMC website.

Table 2(b): Bulletins issued by Area Cyclone Warning Centre (ACWC) Chennai, Cyclone Warning Centre (CWC) Vishakhapatnam, CWC Bhubaneswar, ACWC Mumbai, Meteorological Centre (MC) Amravati and CWC Thiruvanantapuram

S.No.	Type of Bulletin	No. of Bulletins issued					
		ACWC Chennai	CWC Visakhapatnam	CWC Bhubaneswar	ACWC Mumbai	MC Amaravati	CWC Thiruvananthapuram
1.	Sea Area Bulletins	06	--	NIL	8	--	NIL
2.	Coastal Weather Bulletins	06	8	08	8	--	8
3.	Fishermen Warnings issued	12	12	16	16	9	16
4.	Port Warnings	04	4	12	NIL	---	NIL
5.	Heavy Rainfall Warning	05	4	04	4	15	15
6.	Gale Wind Warning	NIL	---	NIL (Wind Warning	NIL	---	NIL

				for Odisha Coast issued) 07			
7.	Storm surge Warning	NIL	---	NIL	NIL	----	NIL
8.	Information & Warning issued to State Government and other Agencies	03	7	08 (In addition to regular Bulletins)	220	30	33
9.	SMS	NIL	150	NIL	Approx 1,50,000	848	166
10.	No. of Press releases	08	6	03	4	--	NIL
11.	No. of impact based warnings for a. District b. City	-	167 195	(District level Special Forecasts and Warnings were issued and Impact briefed verbally to State Govt. Authority and Media.) 04 (Issued for Bhubaneswar and Cuttack Capital City Area)	5	--	NIL
12.	No. of whatsapp messages	200	6	5344	All warning	--	NIL

					s and messages communicated to all concerned groups		
13.	No. of updates on facebook	08	25	31	5	--	NIL
14.	No. of updates on tweeter	08	17	44	13	--	NIL
15	No. of warning video released	06	2	06	3	--	NIL

7. Operational Forecast Performance

7.1 Genesis:

- In the extended range outlook issued on 1st October, low probability (1-33%) of formation of depression over central BoB was indicated during 11th-15th October (about 10 days prior to formation of depression over westcentral BoB on 11th morning).
- From 4th October onwards, in the tropical weather outlook, it was indicated that an LPA would form over north Andaman Sea and adjoining eastcentral BoB around 9th October (about 5 days prior to formation of LPA on 9th). It would move northwestwards towards north Andhra Pradesh and Odisha coast with gradual intensification into a depression around 11th (about 7 days prior to formation of depression on 11th).

7.2 Intensification, landfall and movement:

- In the first bulletin issued at 0900 hrs IST of 11th on formation of depression over westcentral BoB, it was indicated that the system would intensify further into a deep depression around 12th, move west-northwestwards and cross north Andhra Pradesh coast between Narsapur & Vishakhapatnam during 12th October 2020 night.
- The warnings were further updated and it was informed that the system would move west-northwestwards and cross north Andhra Pradesh coast between Narsapur & Vishakhapatnam, close to Kakinada during the early morning of 13th October 2020.
- Actually, the system moved west-northwestwards, intensified into a deep depression in the forenoon of 12th and crossed north Andhra Pradesh coast close to Kakinada in the early hours (between 0630 & 0730 hrs IST) of 13th October 2020, as a deep depression with a maximum sustained wind speed of 55-65 kmph gusting to 75 kmph.

IMD issued regular warning bulletins to the concerned central and state disaster management authorities and press & media. The verification of heavy rainfall warnings issued by IMD for the deep depression during 11th - 14th October is presented in Table 3. It can be found that the occurrence of heavy rainfall in association with the system could be predicted well in advance.

Table -3: Verification of heavy rainfall warning issued by IMD for Deep Depression over the Bay of Bengal (11-14 October, 2020)

Date/Base Time of observation (UTC)	24 hr Heavy rainfall warning ending at 0830 hrs IST of next day	Realised 24-hour heavy rainfall ending at 0300 UTC of date
11/10/2020 0300 UTC	✓ Light to moderate rainfall at most places with heavy to very heavy falls at isolated places likely to occur over coastal Andhra Pradesh, Telangana, Rayalaseema and north interior Karnataka and heavy falls at isolated places over south Odisha, coastal & south Interior Karnataka, Madhya Maharashtra, Marathwada and Kerala on 11th October 2020. ✓ Light to moderate rainfall at most places with heavy to very heavy falls at isolated places likely to occur over south Odisha, coastal Andhra Pradesh, Telangana, Rayalaseema, Karnataka & north Kerala and heavy falls at isolated places over Madhya Maharashtra, Marathwada and Vidarbha on 12th October 2020. **Extremely heavy rainfall (≥ 20 cm per day)** is also likely at isolated places over north coastal Andhra Pradesh and also over north Kerala and	**11th October** **Coastal Andhra Pradesh (A.P) & Yanam:** Racherla-10, Velairpad-8 **Telangana:** Kothagudam -14 **Rayalaseema:** Chinnamandem-13, Pakala-12, Badvel-10, Uravakonda-9, Orvakal-9, Atmakur (District: Kurnool) - 9, Kurnool -8, Gurramkonda-9, Atlur-8, Penagaluru-8, Pamidi-8, Sambepalle-8, Lepakshi-7 **12th October** **Coastal A.P. & Yanam:** Bheemunipatnam-17, Visakhapatnam-15, Visakhapatnam AP-14, Kakinada-14, Peddapuram-14, Yanam-11, Anakapalle-10, Amalapuram-10, Marripudi-8, Tuni-8, Prathipadu-7, Dowleshwaram-7, Yelamanchili-7 **Telangana:** Kondapak-10, Ramayampet-10, Ghattu-7, Mirdoddi-7, Bhiknur-7, Sarangapur-7, Domakonda-7. **Rayalaseema:** Simhadripuram-7 **North interior Karnataka:** Hukkeri-13, Hungund-10, Khajuri-9, Bevoor-9 **13th October** **Odisha:** Mohana-14, Paralakhemundi-12, Nuagada-11, Berhampur-10, Aska-10, Kashinagar-9, Purushottampur-9, Mahendragarh-8, Chhatrapur-8, R.Udaigiri-7, Gunupur-7 **Coastal A.P. & Yanam:** Yanam-25, Amalapuram-19, Tanuku-19, Nuzvid-19, Tadepalligudem-18, Vijayawada A.P.-16, Bheemunipatnam-16, Kaikalur-15, Palasa-15, Ichchapuram-15, Tiruvuru-15, Yelamanchili-14, Chintalapudi-13, Sompeta-13, Gudivada-13, Mandasa-13, Narsapuram-12, Kakinada-12, Prathipadu-12, Koyyalagudem-12,

	adjoining coastal Karnataka on 12th October. ✓ Light to moderate rainfall at most places with heavy to very heavy falls at isolated places likely to occur over Telangana, north interior Karnataka, Madhya Maharashra & Marathwada and heavy falls at isolated places over south Odisha, coastal Andhra Pradesh, Rayalaseema, coastal Karnataka and Vidarbha on 13th October 2020.	Palakoderu-12, Bheemavaram-12, Dowleshwaram-11, Peddapuram-11, Bhimadole-11, Rajahmundry-11, Narsipatnam-11, Eluru-11, Vijayawada(ARG)-10, Tuni-10, Prakasam Barrage-9, Nandigama-9, Bondapalle-9, Anakapalle-9, Chodavaram-9, Vepada-9, Visakhapatnam A.P-8, Vararamachandrapur-8, Therlam-8, Kukunoor-8, Paderu-8, Pathapatnam-8, Pusapatirega-8, Visakhapatnam-8, Velairpad-7, Denkada-7, Palakonda-7, Ranastalam-7, Parvathipuram-7, Mangalagiri-7, Nellimarla-7, Mentada-7, Nandigama (ARG)-7, Paleru Bridge-7, Koida-7, Gajapathinagaram-7, Garugubilli-7, Polavaram-7, Merakamudidam-7, Kalingapatnam-7, Garividi-7, Kunavaram-7. **Telangana:** Sathupalle-19, Mahabubabad-13, Madhira-11, Mulakalapalle-11, Aswaraopeta-11, Bayyaram-10, Chandrugonda-9, Thimmajipeta-9, Thollada-8, Tupran (ARG) -8, Suryapet-7, Devarakonda-7, Wanaparthy-7, Chandur-7, Kusumanchi-7 **North interior Karnataka:** Badami-8, Kushtagi-7. **South interior Karnataka:** Sandur-10, Agumbe EMO-7, Hagaribommanahalli-7
12/10/2020 0300 UTC	✓ **12th October 2020:** Light to moderate rainfall at most places with **heavy to very heavy falls** at a few places and **Extremely heavy rainfall (>20 cm per day)** at isolated places would occur over east & west Godavari, Vishakhapatnam, Vijayanagaram & Srikakulam districts of north coastal Andhra Pradesh and **Yanam**, **heavy to very heavy falls** at isolated places over Ganjam, Gajapati, Koraput, Raygada, Navrangpur, Malkangiri, Khurda & Puri districts of south Odisha, Krishna district of south	**14th October** **Odisha:** Aska-21, Purushottampur-19, Daspalla-10, Sorada-10, Daitari-9, Berhampur-7, Daringibadi-7, R.Udaigiri-7, Digapahandi-7, Brahmagiri-7, Mohana-7, Raikia-7. **Coastal A.P. & Yanam:** Avanigada-10, Nandigama (ARG) -10, Sattenapalle-10, Therlam-10, Macherla-9, Sompeta-9, Machilipatnam CDR -9, Narsapuram-9, Nandigama-8, Jangamaheswarapuram-8, Repalle-7, Bheemavaram-7. **Telangana:** Hayathnagar-30, Jogipet-24, Ibrahimpatnam-23, Hakimpet IAF- 20, Hyderabad A.P.-19, Golkonda-18, Manchal-18, Warangal-18, Tekmal-17, Marpalle-17, Nalgonda-16, Kondapur-16, Sangareddy-15, Kohir-15, Mominpet-15, Medchal-15, Dindigul-15, Chandur-15, Maheswaram-15, Shamirpet-15, Hathanoora-15, Narsapur-15,

	coastal Andhra Pradesh, Kurnool District of Rayalaseema, Telangana, south Konkan & Goa, south Madhya Maharashtra, Marathwada, Karnataka, & north Kerala and heavy rainfall at isolated places over south Chhattisgarh ✓ **13th October 2020:** Light to moderate rainfall at most places with **heavy to very heavy falls** at a few places and **Extremely heavy rainfall (>20 cm per day)** at isolated places would occur over Telangana, heavy to very heavy falls at isolated places over Karnataka, Rayalaseema, south Konkan & Goa, Madhya Maharashtra & Marathawada and heavy falls at isolated places over north coastal Andhra Pradesh, south Odisha, and Vidarbha. ✓ **14th October 2020:** Light to moderate rainfall at most places with **heavy to very heavy falls** at a few places and **Extremely heavy rainfall (>20 cm per day)** at isolated places would occur over north Madhya Maharashtra, **heavy to very heavy falls** at	Nidamanur-14, Yacharam-14, Saroornagar-14, Munipalli-13, Naykal-13, Raikode-13, Peddemul-12, Doultabad-12, Medak-12, Sadasivpet-11, Palakurthi-11, Nawabpet-11, Alladurg-11, Chevella-11, Narmetta-11, Gajwel-11, Regode-11, Chegunta-10, Ghanpur-10, Kondapak-10, Kowdipalle-10, Ramayampet-10, Jagadevpur-10, Mahabubabad-9, Zaffergadh-9, Vicarabad-9, Aswaraopeta-9, Mirdoddi-9, Tandur-9, Dubbak-9, Nanganur-9, Jangaon-8, Bejjanki-8, Marriguda-8, Huzurabad-8, Nagareddipet-8, Kamareddy-8, Sathupalle-7, Jukkal-7, Bhiknur-7, Doma-7, Mustabad-7, Jajireddigudem-7, Papannapet-7, Noothankal-7, Narayankhed-7. **Marathwada:** Nilanga-13, Deoni-8, Umarga-8, Chakur-7, Ausa-7. **Konkan & Goa:** Malvan-9, Dodamarg-7. **North interior Karnataka:** Manthala-15, Basavakalyan-15, Humnabad-13, Kalaburgi obsy-13, Bidar PTO-13, Kalaburgi AWS-13, Chincholi-11, Khajuri-11, Aland-9, Aurad-8, Afzalpur HMS-7, Raddewadgi ARG-7. **South interior Karnataka:** Agumbe EMO-14, Kottigehara-9, Arasalu-7 **Coastal Karnataka:** Kollur-24, Kota-17, Mulki-17, Mani-15, Mangaluru A.P obsy-15, Mudubidre-13, Brahmavar AWS-13, Karkala-13, Udupi-13, Kundapur-12, Belthangadi-12, Puttur HMS-12, Mangaluru-12, Panambur obsy-12, Vitla ARG-12, Dharmasthala-11, Bhatkal-10, Sulya-10, Shirali PTO -9, Siddhapura ARG-8, Siddhapura-8, Subramanya-8, Uppinangadi-7. **15th October** **Marathwada:** Paranda-18, Tuljapur-14, Lohara-10, Shirur Kasar-7, Georai-7. **Madhya Maharashtra:** Gaganbawada-17, Indapur-16, Barshi-16, Pandharpur-16, Jeur IMD Part time-16, Baramati-15, Sangli IMD obsy-15, Panhala-14, Malshiras-14, Mangalvedha-13, Mahabaleshwar- IMD obsy-13, Kolhapur/Karvir IMD-13, Vita-11, Pune city IMD obsy-11, Bhor-11, Karad-11, Ambegaon Ghodegaon-11, Patan-10, Palus-10, Lonavala agri-10, Shirala-10, Karmala-10,

	isolated places over Konkan & Goa, south Madhya Maharashtra and Marathawada and heavy falls at isolated places over coastal & south interior Karnataka.	Tasgaon-9, Miraj-9, Kavathe Mahakal-9, Atpadi-9, Dahiwadi man-9, Khandala Bavda-9, Kagal-9, Daund-9, Wai-9, Kadegaon-9, Madha-9, Satara IMD obsy-9, Khatav Vaduj-9, Jat-9, Shirur Ghodnadi-9, Sholapur IMD obsy-8, Shirol-8, Purandar Sasvad-8, Khed Rajgurunagar-8, Phaltan-7, Javali Medha-7, Junnar-7, Hatkanangale-7, Mohol-7, Velhe-7, Akole-7, Vadgaon maval-7 **Konkan & Goa:** Alibag IMD part time-15, Lanja-15, Khed-14, Murud-13, Karjat agri-12, Vaibhavwadi-12, Khalapur-12, Pen-12, Ratnagiri IMD obsy-12, Matheran-12, Colaba IMD obsy-12, Rajapur-11, Sangameshwar Devrukh-11, Poladpur-10, Panvel agri-10, Mandangad-9, Sudhagad Pali-9, Bhira IMD part time - 9, Santacruz IMD obsy-9, Roha-9, Malvan-8, Chiplun-8, Tbia IMD part time-8, Shriwardhan-7, Mahad-7, Mhasla-7, Guhagarh-7, Tala-7, Dodamarg-7, Uran-7.
13/10/2020 0300 UTC	✓ **13th October 2020:** Light to moderate rainfall at most places with **heavy to very heavy falls** at a few places and **Extremely heavy rainfall (>20 cm per day)** at isolated places would occur over Telangana and adjoining Districts of north Interior Karnataka; heavy to very heavy falls at isolated places over coastal & remaining districts of north interior Karnataka, south Konkan & Goa, Madhya Maharashtra & Marathawada and heavy falls at isolated places over north Andhra Pradesh, Rayalaseema, south interior Karnataka, south Odisha, south Chhattisgarh and Vidarbha. ✓ **14th October 2020:** Light to moderate rainfall at most places with **heavy to very heavy falls** at a few places and **Extremely heavy rainfall (>20 cm per day)** at isolated places would occur over Madhya Maharashtra,	

	heavy to very heavy falls at isolated places over Konkan & Goa, north interior Karnataka and Marathawada and heavy falls at isolated places over coastal & south interior Karnataka.	
14/10/2020 0300 UTC	✓ **14th October 2020:** Light to moderate rainfall at most places with **heavy to very heavy falls** at a few places and **Extremely heavy rainfall (>20 cm per day)** at isolated places would occur over Madhya Maharashtra, south Konkan & Goa, coastal Karnataka, Ghat section of south interior Karnataka and adjoining Districts of north interior Karnataka and **heavy to very heavy falls** at isolated places over north Konkan and remaining districts of north interior Karnataka. Also **Heavy to very heavy falls** at isolated places likely over Marathawada during next 12 hours. ✓ **15th October 2020:** Light to moderate rainfall at most places with **heavy to very heavy falls** at a few places and **Extremely heavy rainfall (>20 cm per day)** at isolated places would occur over Konkan & Goa, **heavy to very heavy falls** at isolated places over	

	coastal Karnataka and **heavy falls** at isolated places over Madhya Maharashtra south Gujarat region.	

Table 3: Verification of heavy rainfall warning issued by IMD for Deep Depression over west-central Bay of Bengal and neighborhood (11-14 October, 2020)

7. Summary and Conclusions:

The system was originally located as a low pressure area over north Andaman Sea & neighbourhood in the early morning (0530 hrs IST) of 9th October 2020. It lay as a well marked low pressure area over east-central Bay of Bengal (BoB) and adjoining north Andaman Sea in the early morning of 10th October and concentrated into a **Depression** over west-central BoB in the early morning of 11th October. It intensified into **Deep Depression** in the forenoon (0600 UTC) of 12th October. Moving west-northwestwards, it crossed north Andhra Pradesh coast close to Kakinada near latitude 17.0°N & longitude 82.4° E between 0100 & 0200 UTC of 13th October 2020, as a Deep Depression with a maximum sustained wind speed of 55-65 kmph gusting to 75 kmph. Continuing to move west-northwestwards, it weakened into a Depression over Telengana in the forenoon (0600 UTC) of 13th October. It moved west-northwestwards as a depression across Telangana and North Interior Karnataka to Maharashtra till evening of 14th October. It weakened into a well marked low pressure area and lay centred over South Madhya Maharashtra and neighbourhood in the evening (1200 UTC) of 14th October. It moved across Maharashtra and emerged as a well marked low pressure area over east-central Arabian Sea off Maharashtra coast on 16th morning. It had impacts over Odisha, Andhra Pradesh, Telangana, Karnataka and Maharashtra in terms of heavy to extremely heavy rainfall and squally wind.

IMD monitored and predicted the genesis, movement and weather associated with the system accurately and timely bulletins were disseminated to the user agencies.

8. Acknowledgements:

India Meteorological Department (IMD) duly acknowledges the contribution from all the stake holders who contributed to the successful monitoring, prediction and early warning service of the system. We specifically acknowledge the contribution from Indian Space Research Organisation (ISRO) and all Sister organizations of Ministry of Earth Sciences including Indian Institute of Tropical Meteorology (IITM), Pune, National Centre for Medium Range Weather Forecasting Centre (NCMRWF) NOIDA, National Institute of Technology (NIOT) Chennai & Indian National Centre for Ocean Information Services (INCOIS). The support from various Divisions/Sections of IMD including Area Cyclone Warning Centres Chennai & Mumbai, Cyclone Warning Centres Vishakhapatnam & Bhubaneswar, Meteorological centres Amravati, Hyderabad, & Bengaluru, Numerical Weather Prediction (NWP) Division, Information System & Services Division (ISSD) and Satellite and Radar

Division at IMD HQ New Delhi is also duly acknowledged for monitoring and predicting the system.