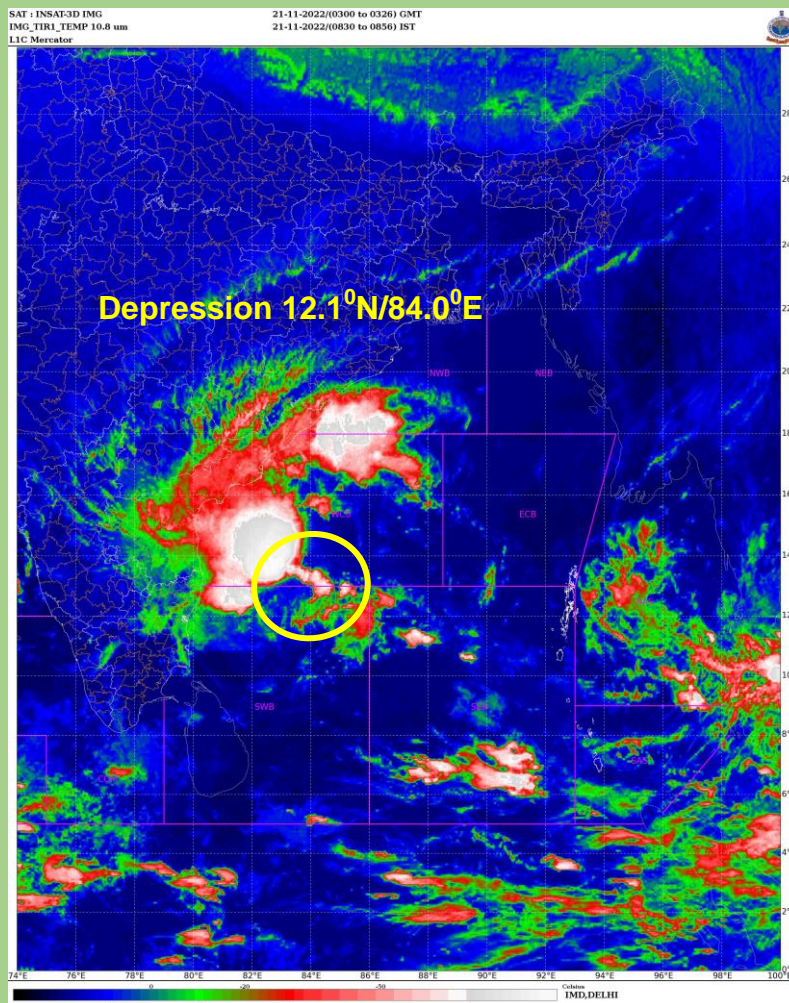




**GOVERNMENT OF INDIA  
MINISTRY OF EARTH SCIENCES  
INDIA METEOROLOGICAL DEPARTMENT**

**Depression over southwest & adjoining southeast Bay of Bengal  
(20<sup>th</sup> – 22<sup>nd</sup> November 2022): A Report**



**INSAT-3D Satellite imagery of Depression over Southwest Bay of Bengal at 0300 UTC of 21<sup>st</sup>  
November, 2022**

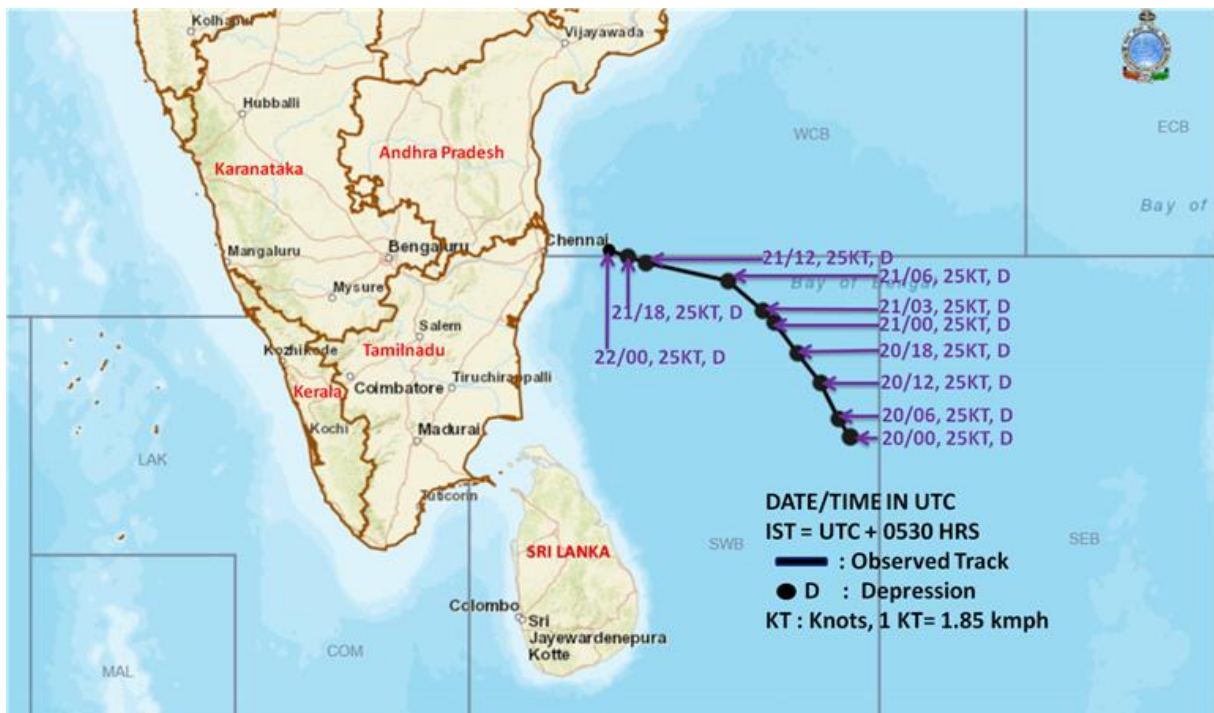
**Cyclone Warning Division  
India Meteorological Department  
New Delhi  
November, 2022**

## Depression over Southwest & adjoining Southeast Bay of Bengal during 20<sup>th</sup> - 22<sup>nd</sup> November, 2022

### 1. Introduction

A cyclonic circulation lay over South Andaman Sea & neighbourhood and extended up to middle tropospheric levels in the morning (0530 hours IST) of 15<sup>th</sup> November. Under the influence of the upper-air cyclonic circulation, a Low pressure area formed over Southeast BoB & adjoining Andaman Sea in the morning (0530 hours IST) of 17<sup>th</sup> November, 2022. The low-pressure system moved west-northwestwards and became a well-marked low pressure area (WML) over central parts of south BoB in the morning (0530 hours IST) of 19<sup>th</sup> November. Moving in the same direction, under favourable environmental conditions, the system concentrated into a depression over southwest and adjoining Southeast BoB in the morning (0530 hours IST) of the 20<sup>th</sup> November. Moving west-northwestwards it weakened into a WML over Westcentral and adjoining Southwest Bay of Bengal off South Andhra Pradesh-North Tamil Nadu coasts in the morning (0830 hours IST) of the 22<sup>nd</sup> November, 2022. The remnant of the system continued to move west-northwestwards and gradually weakened further into a low pressure area on in the evening (1730 hours IST) of 22<sup>nd</sup> November.

The best track parameters of the system are presented in table 1 and observed track of the system was presented in Fig. 1.



**Fig.1: Observed track of the depression over Southwest & adjoining Southeast BoB (20<sup>th</sup> – 22<sup>nd</sup> Nov, 2022) KT: Knots(nautical mile per hour), 1 KT=1.85 kmph, D: Depression**

**Table1: Best track positions and other parameters of the Depression over Southwest and adjoining Southeast BoB during 20nd -22nd November, 2022**

Date	Time (UTC)	Centre		C.I. NO	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
		Lat. <sup>o</sup> N/	Long. <sup>o</sup> E					
20.11.2022	0000	10.0	85.5	1.5	1005	25	4	D
	0300	10.0	85.5	1.5	1005	25	4	D
	0600	10.3	85.3	1.5	1005	25	4	D
	1200	10.9	85.0	1.5	1003	25	4	D
	1800	11.4	84.6	1.5	1003	25	4	D
21.11.2022	0000	11.9	84.2	1.5	1003	25	4	D
	0300	12.1	84.0	1.5	1003	25	4	D
	0600	12.6	83.4	1.5	1003	25	4	D
	1200	12.9	82.0	1.5	1003	25	4	D
	1800	13.0	81.7	1.5	1003	25	4	D
22.11.2022	0000	13.1	81.4	1.5	1004	25	4	D
	0300	Weakened into a well marked low pressure area over Westcentral and adjoining Southwest Bay of Bengal off South Andhra Pradesh-North Tamilnadu coast.						

## **2. Brief life history - Genesis Intensification and movement**

### **2.1. Genesis**

A cyclonic circulation lay over south Andaman Sea and adjoining Southeast Bay of Bengal (BoB) in the morning (0530 hours IST) of 15<sup>th</sup> November which extended up to 4.5 km above mean sea level. Under its influence a low pressure area formed over Southeast BoB & adjoining Andaman Sea in the morning (0530 hours IST) of 17<sup>th</sup> November, 2022. It became a well-marked low pressure area (WML) over central parts of south BoB in the morning (0530 hours IST) of 19<sup>th</sup> November.

On 19th November, the Madden Julian Oscillation (MJO) was in phase 5 with amplitude more than 1 and consequently the MJO index was favourable for

enhanced convective activity over the region. Sea surface temperature (SST) was around 28-29°C over most parts of the BoB. The ocean heat content (OHC) was around 80-100 KJ/cm<sup>2</sup> over central & adjoining south BoB and less than 40 KJ/cm<sup>2</sup> over Westcentral and Southwest BoB along the east coast of India. The low level vorticity was  $50 \times 10^{-6} \text{ s}^{-1}$  around the system centre and was prominently extending up to 500 hPa level. One of the low level convergence maxima were  $10 \times 10^{-5} \text{ s}^{-1}$  to the west of system centre over Southwest BoB and another over east of system centre. In a similar way, the upper level divergence showed one zone of  $20 \times 10^{-5} \text{ s}^{-1}$  over Southwest BoB to the southwest of system centre and another zone of  $10 \times 10^{-5} \text{ s}^{-1}$  to the northeast of system centre. The Poleward outflow in upper levels supported further intensification of the system. The Middle level (850-500 hpa) wind shear was moderate (15-20 knots) over central & adjoining south BoB and along the expected track. The upper tropospheric ridge was running along 18.0°N over the BoB. Therefore, the environmental conditions favoured with broad poleward & equatorward divergence in upper levels, low vertical wind shear and warm SST. The system concentrated into a depression over Southwest and adjoining Southeast BoB in the morning (0530 hours IST) of the 20<sup>th</sup> November.

## **2.2. Intensification and movement:**

During 20<sup>th</sup> to 21<sup>st</sup> November nearly similar environmental situation persisted over the Bay of Bengal region near the system. The Madden Julian Oscillation index (MJO) lay in phase 6 with amplitude greater than 1 and the Sea surface temperature (SST) was around 28-29°C over southwest BoB. At the same time, the Low level vorticity was about 50 to  $100 \times 10^{-6} \text{ s}^{-1}$  around the system centre which was vertically extending up to 500 hPa level. It was east-west oriented, indicating more westerly component in the movement, thus gradual west-northwestwards movement of the system thereafter. The low level convergence was around  $10$  to  $20 \times 10^{-5} \text{ s}^{-1}$  to the north and west of system centre. The upper level divergence increased and was around  $40 \times 10^{-5} \text{ s}^{-1}$  to the north of system centre. The vertical wind shear was moderate (10-15 knots) around the system center and along the expected direction of movement. The shear was high towards Tamilnadu-Puducherry and south Andhra Pradesh coasts. Total precipitable water imagery indicated that warm moist air advection was continuing into the core of system center. Upper tropospheric ridge roughly ran along 18°N over Bay of Bengal and the system was under the grip of mid-tropospheric southeasterly winds which steered the system towards northwest till evening of 21<sup>st</sup> November. Thereafter, supported by the environmental conditions and guided by the monsoon trough and south-southeasterly steering winds, the system moved nearly west-northwestwards maintaining its intensity till morning of 22<sup>nd</sup> November.

## **2.3 Weakening:**

Subsequently, a slight weakening trend in the intensity of the system was seen while it was moving over Southwest Bay of Bengal off North Tamil Nadu coast along with associated changes in all the thermodynamic parameters and increased wind

shear around the system. Consequently, moving further west-northwestwards the system weakened gradually into a well-marked low pressure area over Westcentral and adjoining Southwest Bay of Bengal off South Andhra Pradesh-North Tamil Nadu coasts in the morning (0300 hours UTC/0830 hours IST) of the 22<sup>nd</sup> November, 2022. The remnant of the system continued to move west-northwestwards and gradually weaken further into a low pressure area on in the evening (1730 hours IST) of 22<sup>nd</sup> November.

### **3. Monitoring of the depression over Southwest and adjoining Southeast BoB**

India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean for the genesis of the low pressure system since the formation of the system was first indicated in the extended range outlook issued on 10<sup>th</sup> November (10 days prior to formation of depression over Southwest & adjoining Southeast BoB on 20<sup>th</sup> November). It was indicated that the development of a fresh cyclonic circulation over south Andaman Sea/ southeast BoB during middle of week 1 (around 14<sup>th</sup> Nov) which would form a low pressure area, move west-northwestwards and intensify gradually. The low pressure system was monitored with the help of available satellite observations from INSAT 3D and 3DR and other polar orbiting satellites. At the same time, various numerical weather prediction models of 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**

Satellite monitoring of the system was mainly done by using half hourly INSAT-3D and 3DR imageries. Satellite imageries of other international geostationary satellites, high resolution polar orbiting satellites and scatterometer imageries from ASCAT were also considered for monitoring of the system. Typical INSAT-3D visible/ IR imageries, enhanced colored imageries are presented in **Fig.2(a) to 2(e)**. The organized cloud mass sheared characteristics was tracked and observed during the life cycle of the depression. The detailed features from the satellite pictures are discussed in this section.

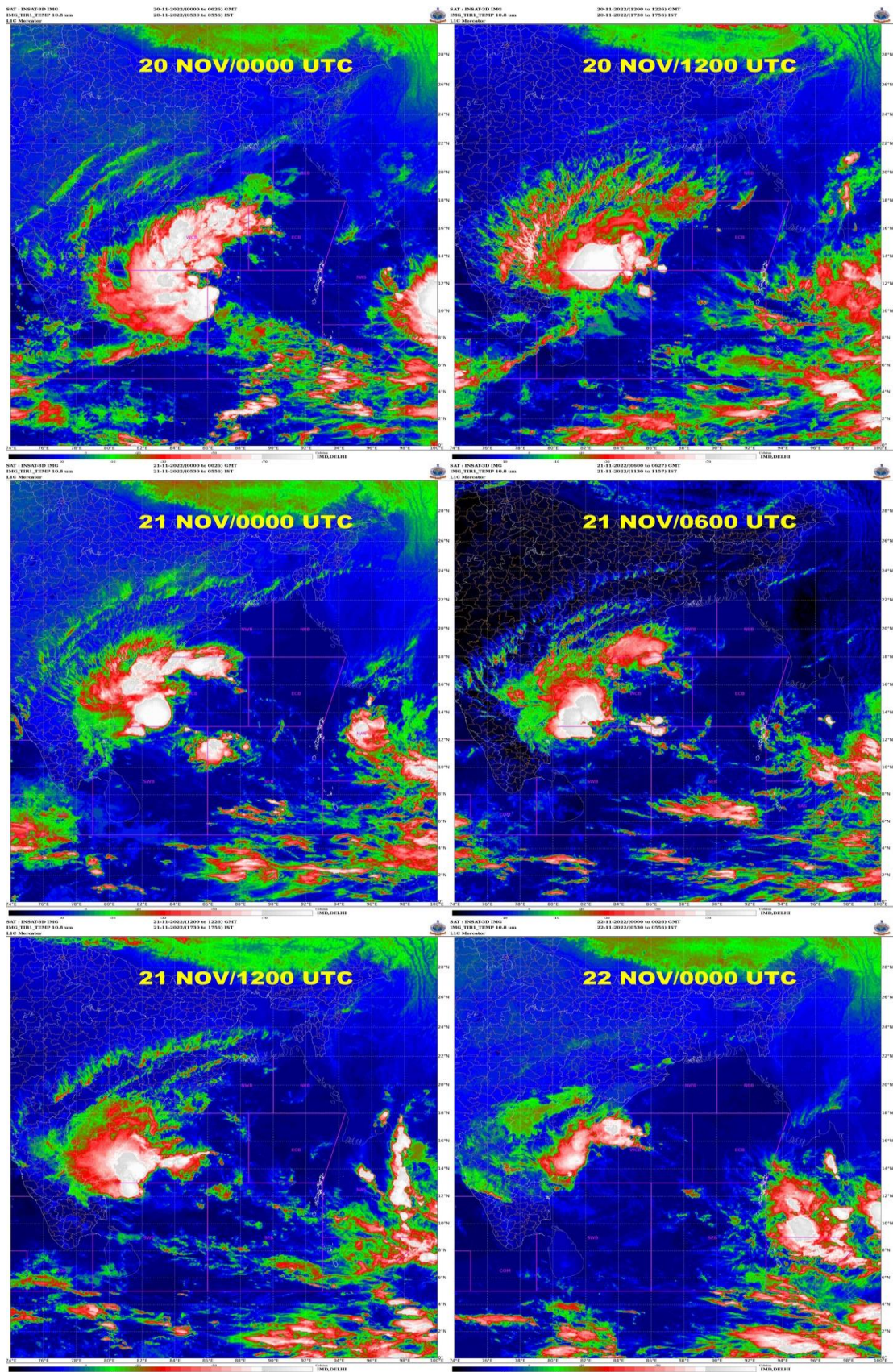
As per INSAT 3D imagery at 0830 hours IST of 17 November, scattered to broken low and medium clouds with embedded intense to very intense convection lay over central & southwest BoB and Andaman Sea due to the presence of the low pressure system. Scattered low and medium clouds with embedded moderate to intense convection also lay over southeast BoB.

At 0830 hours IST of 18 November, associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over central & south BoB. Minimum cloud top temperature is - 90°C. The cloud mass increased further gradually. In the morning of 19 November at 0830 hours IST, as the system became well marked low, associated scattered to broken low and medium clouds mass with embedded intense to very intense convection lay over central & south BoB with minimum cloud top temperature is - 93°C.

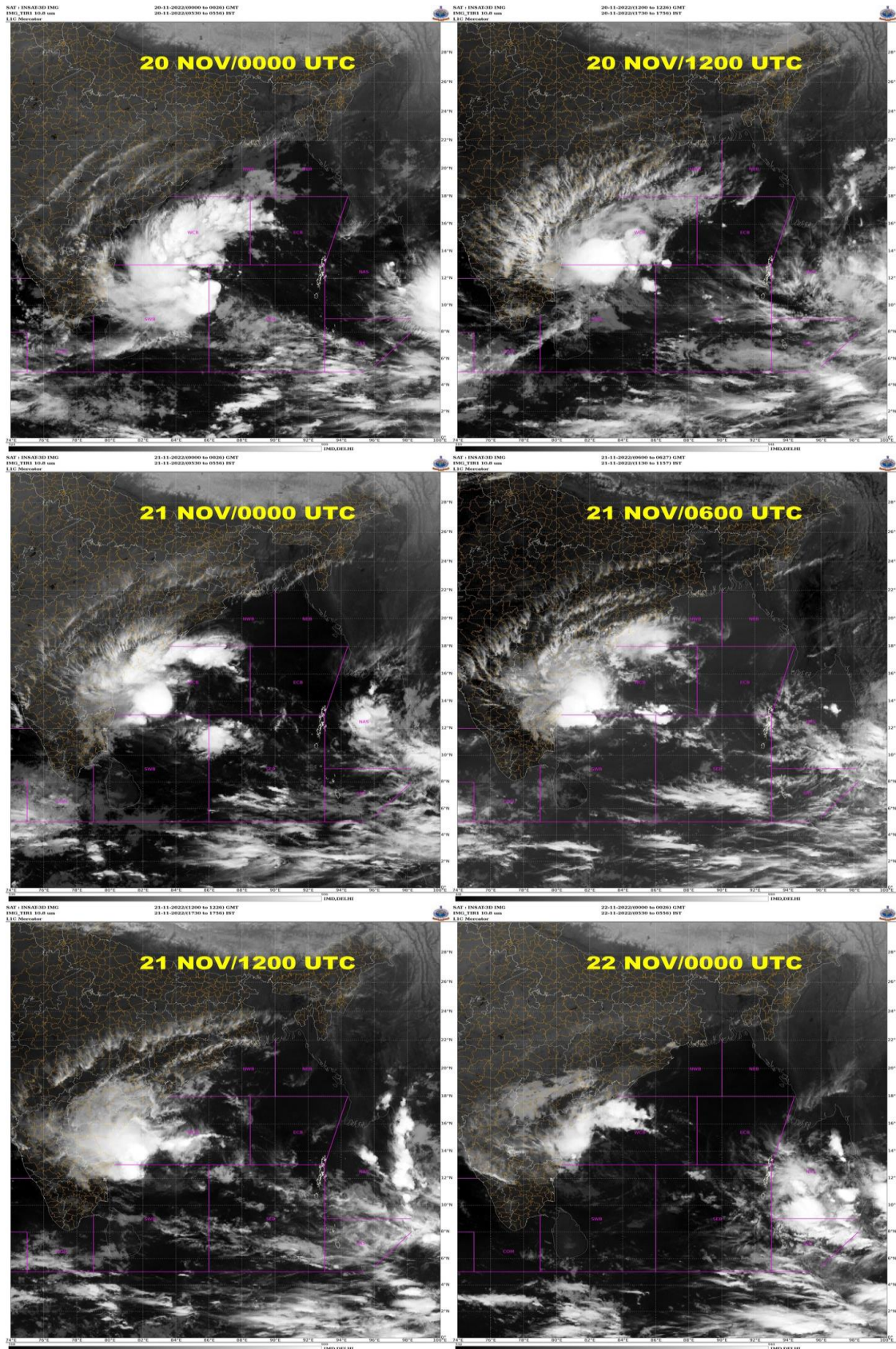
As per INSAT 3D imagery at 0830 hours IST of 20 November, the cloud mass showed further organization and the intensity of the system was characterized as T1.5. The system depicted shear pattern with convective cloud sheared to the northwest of system centre. In association with the system, associated broken low and medium clouds with embedded intense to very intense convection lay over southwest and adjoining Westcentral bay of BoB with minimum cloud top temperature is -93°C. The system maintained its organized cloud mass throughout the day.

The INSAT 3D imageries in the morning (at 0830 hours IST) of 21 November characterized the system intensity as T1.5. The system continued to show shear pattern with convective cloud sheared to the west of system centre. In association with the system, associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over BoB between latitude 11.0°N & 19.5°N and longitude 80.0°E & 88.0°E & coastal Andhra Pradesh with minimum cloud top temperature of - 90°C. In the evening of the day, the outer rain bands entered South Andhra Pradesh and north Tamil Nadu coasts. Consequently, the land interactions commenced as the system approached coasts. However, the intense cloud mass was still over Southwest & adjoining Westcentral BoB off South Andhra Pradesh and North Tamil Nadu coasts with minimum cloud top temperature of - 93°C

The INSAT 3D imageries represented a slight weakening trend and at 0830 hours IST of 22 November, the system was characterized as T1.0. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over Westcentral and adjoining Southwest BoB between latitude 13.0°N & 17.0°N and longitude 80.0°E & 84.0°E & coastal Andhra Pradesh and adjoining coastal Tamil Nadu with relatively higher minimum cloud top temperature of -85°C.

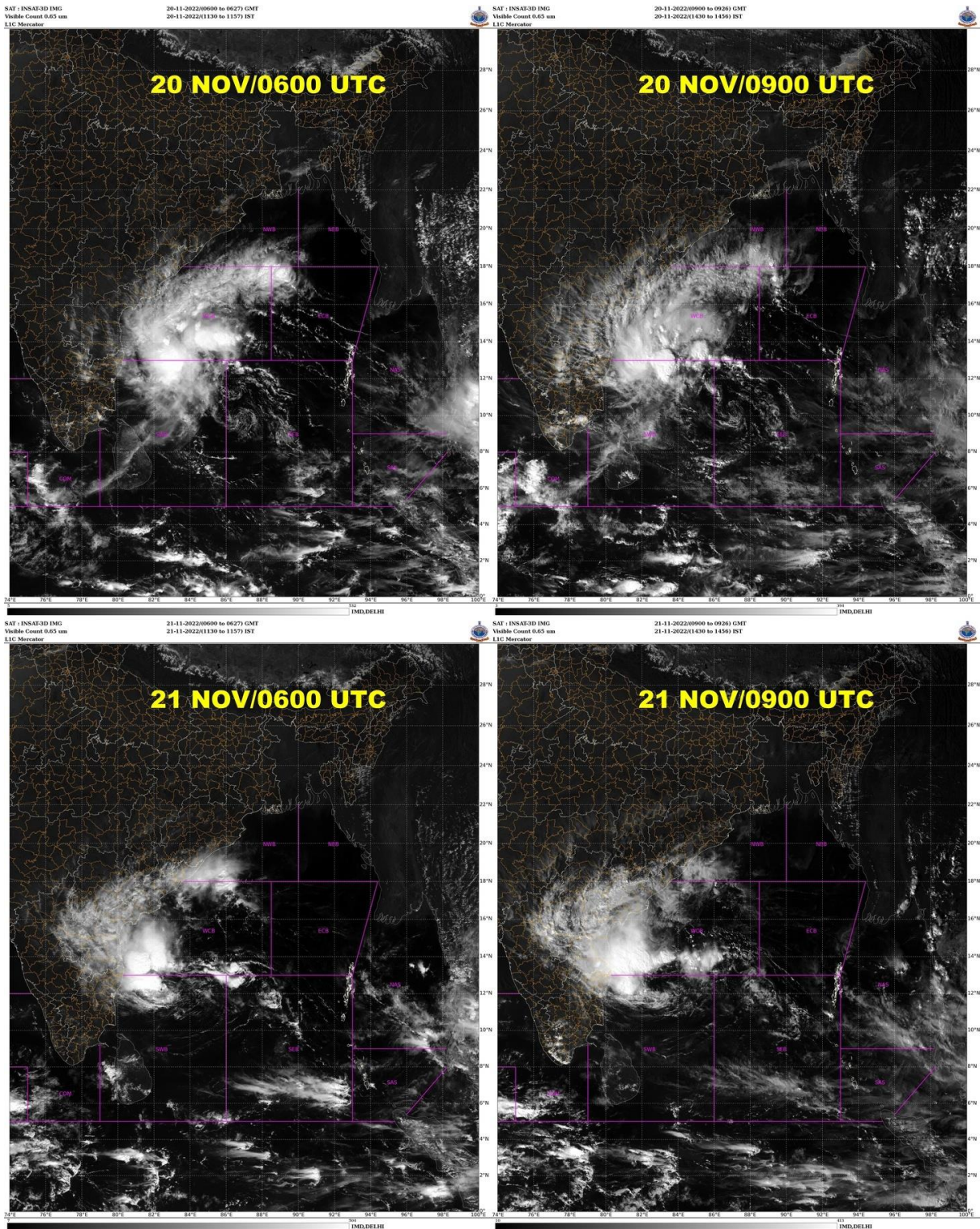


**Fig.2(a): INSAT-3D enhanced colored imageries during life cycle of Depression southwest & adjoining southeast Bay of Bengal during 20-22 Nov, 2022**

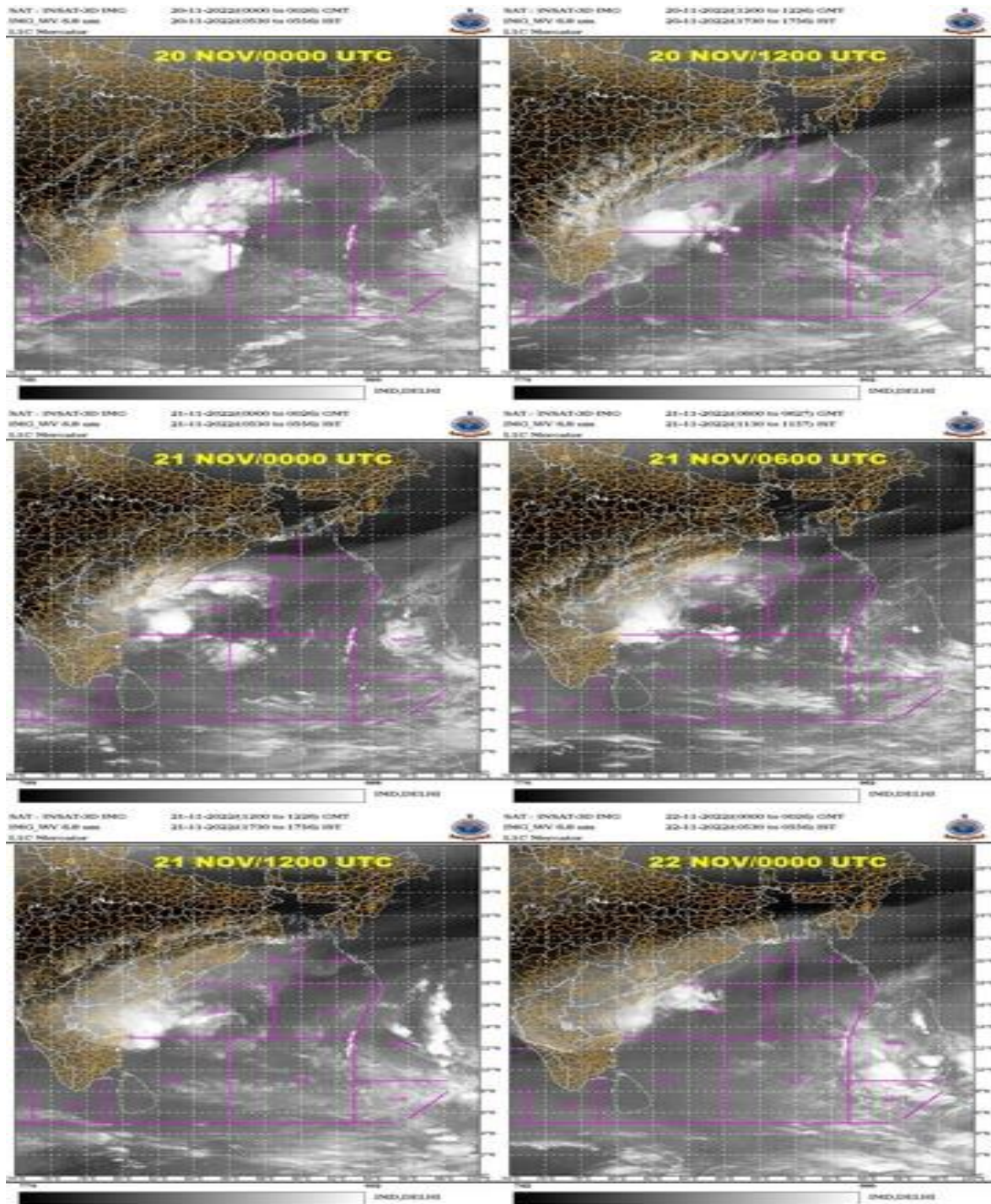


**Fig.2(b): INSAT-3D IR imageries during life cycle of Depression southwest & adjoining southeast Bay of Bengal during 20-22 Nov, 2022**

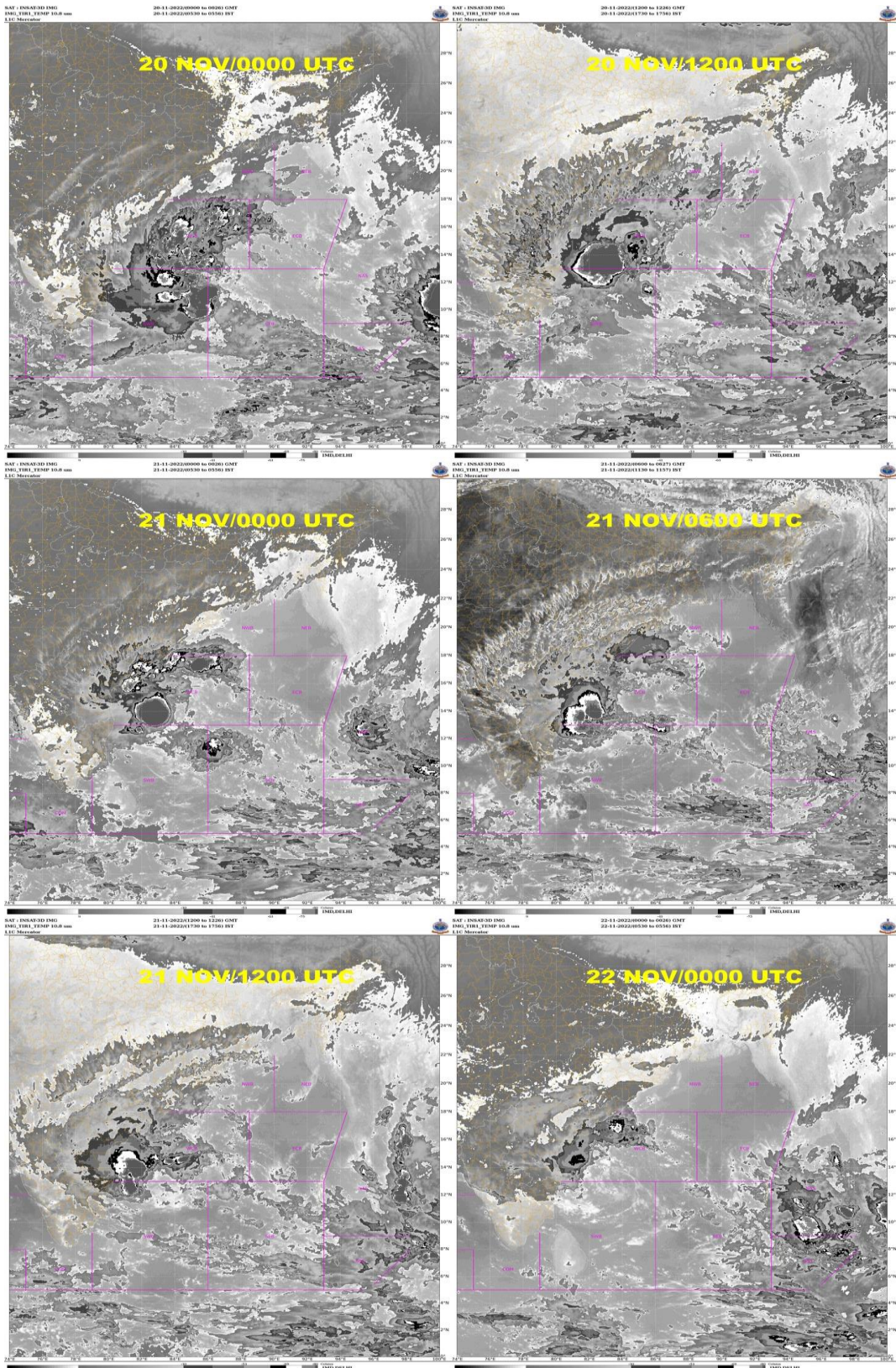




**Fig.2(c): INSAT-3D Visible imageries during life cycle of Depression southwest & adjoining southeast Bay of Bengal during 20-22 Nov, 2022**



**Fig.2(d): INSAT-3D Water Vapour imageries during life cycle of Depression southwest & adjoining southeast Bay of Bengal during 20-22 Nov, 2022**

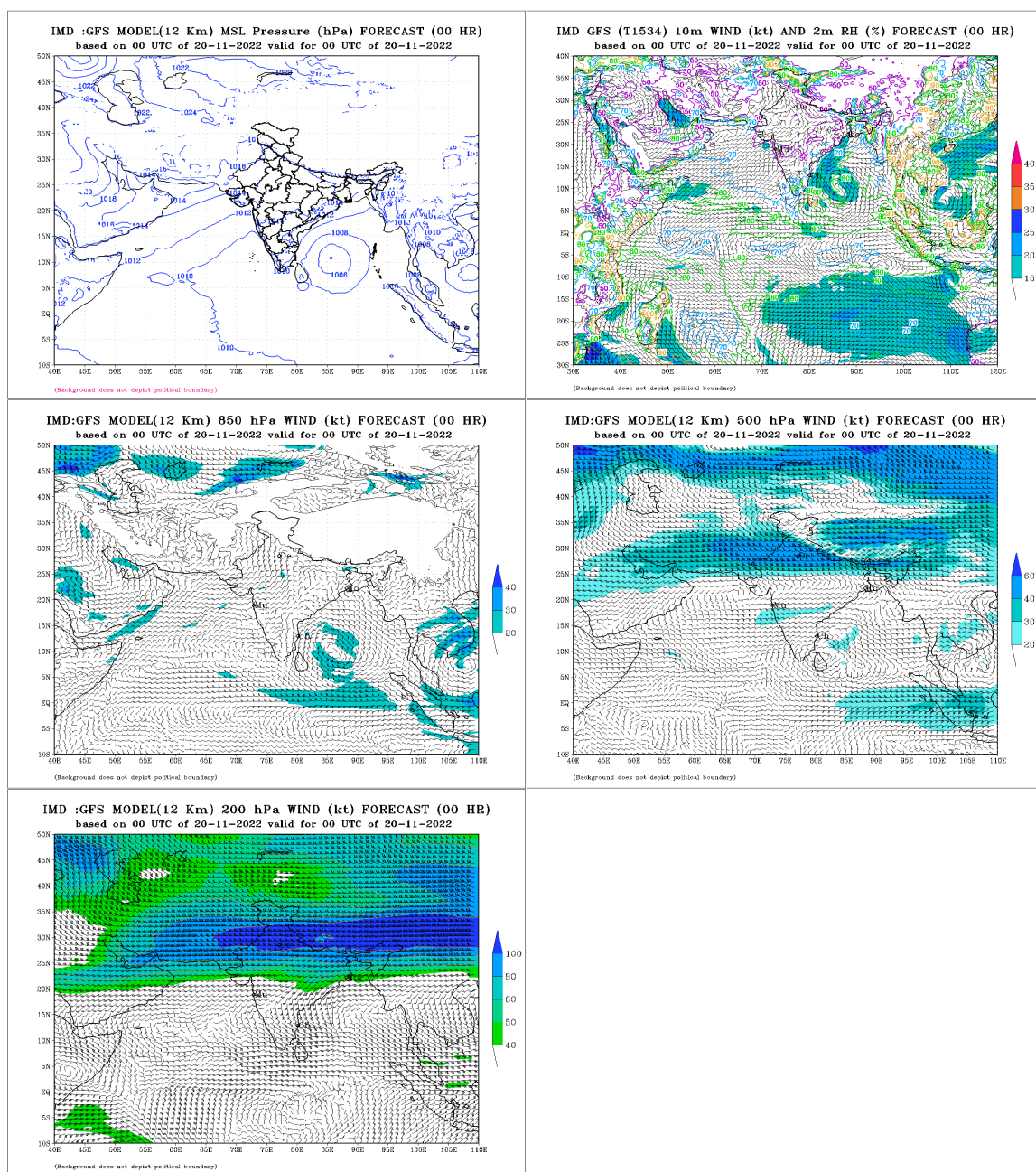


**Fig.2(e): INSAT-3D BD imageries during life cycle of Depression southwest & adjoining southeast Bay of Bengal during 20-22 Nov, 2022**

#### 4. Dynamical features

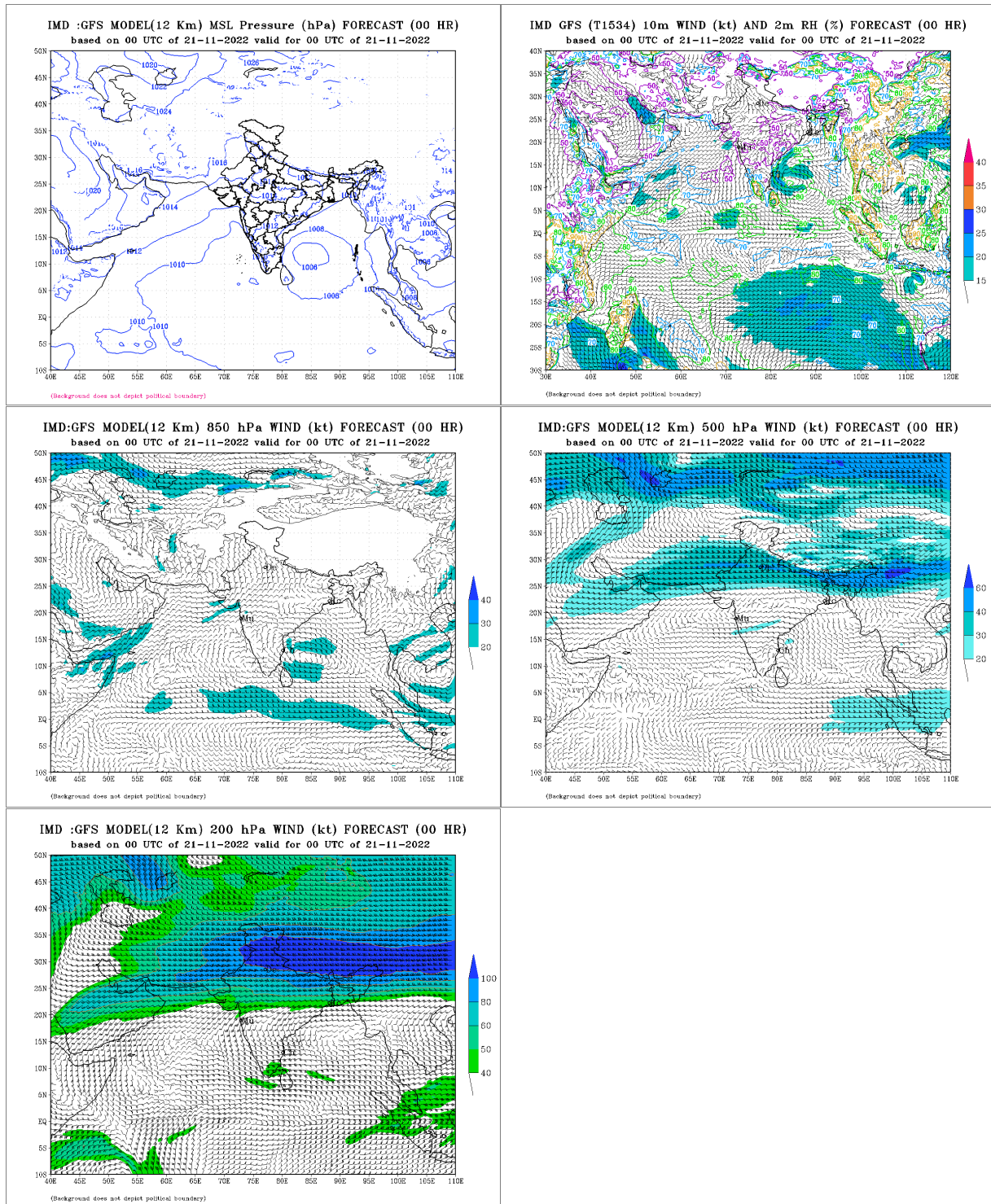
IMD GFS (T1534) daily analyses at 0000 UTC of mean sea level pressure (MSLP), winds at 10 m, 850, 500 and 200 hPa levels from 20th November to 22nd November are presented in **Fig. 3(a) to 3(c)** respectively.

The MSLP analysis at 0000 UTC with two closed isobars clearly depicts the low pressure system as a depression over Southwest and adjoining Southeast BoB with a little the size of the system. The wind fields over South Bay of Bengal indicates the depression which is extended up to the 500 hPa. The east-northeasterly winds prevailed in the upper level at 200 hPa with a ridge along 17°N indicating west-northwestwards movement.



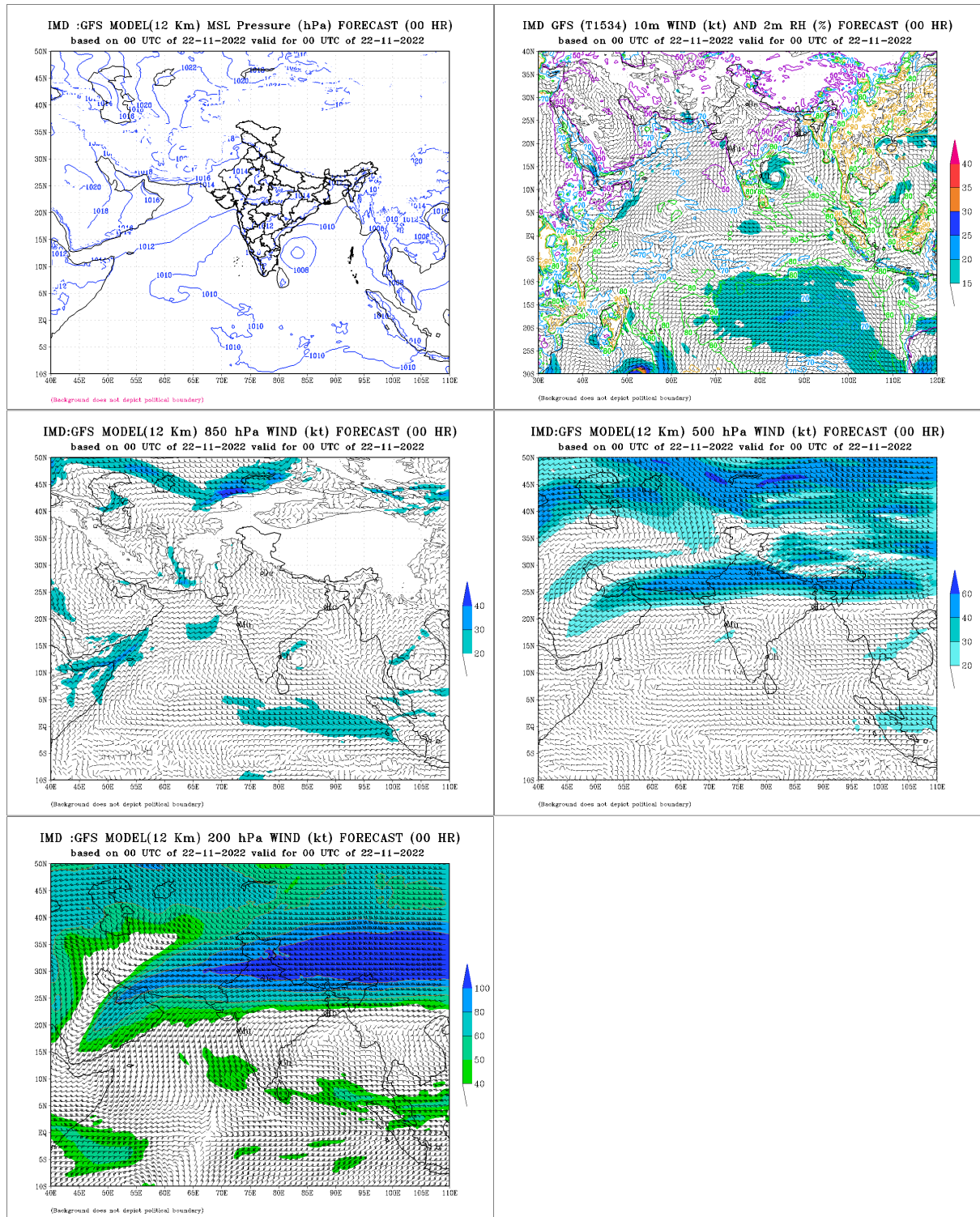
**Fig. 3(a):** IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 20<sup>th</sup> Nov 2022

In the Fig. 3(b), the MSLP analysis indicates the weakening of the system at 0000 UTC of 21st November over Southwest BoB. The system is vertically sheared towards southwest direction as the system center at 500 hPa is seen over North Sri Lanka and adjoining area. Therefore, the model analysis could not capture the intensity of the system as it maintained the intensity of depression.



**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 21<sup>st</sup> Nov 2022**

The MSLP analysis of 22<sup>nd</sup> November in Fig 3(c) show the system moved northwestwards towards north Tamil Nadu- south Andhra Pradesh coasts. The isobaric analysis portrays two closed isobars within nearly 5°x5° box area and depicted the system as a depression.



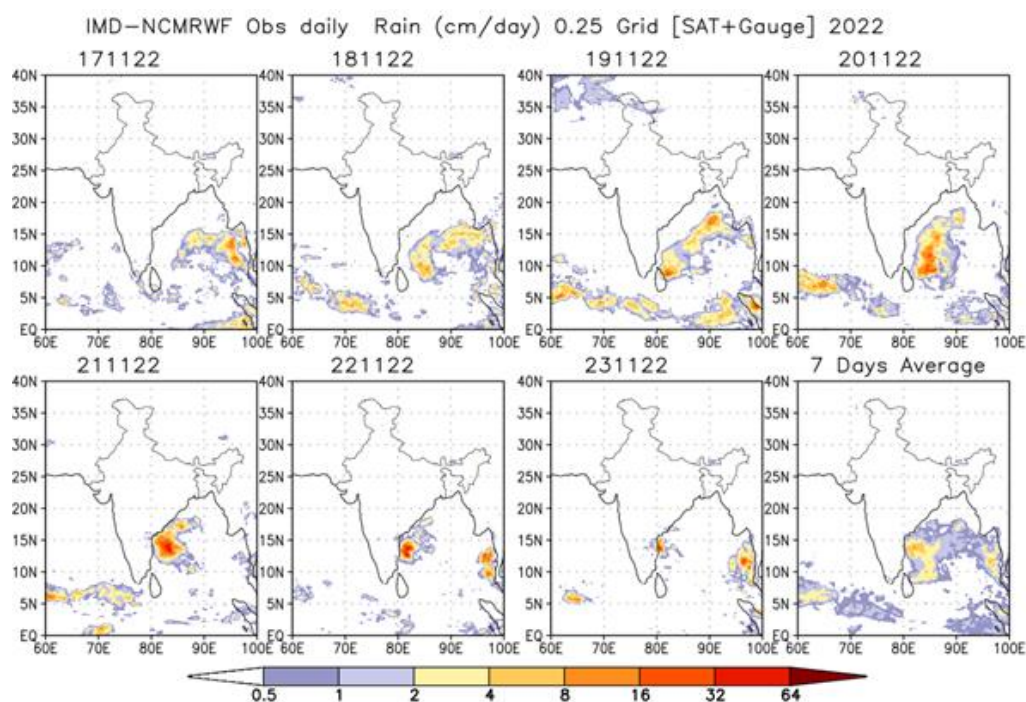
**Fig. 3(c): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 22<sup>nd</sup> Nov 2022**

The wind analyses at different levels represent that the system is sheared towards west but the cyclonic circulation at 500 hPa is not distinctly visible rather embedded in an east-west trough. Although the analyses of upper-air wind fields indicated the weakening signature, the MSLP and 10 m wind circulation was not supporting the fact.

Overall, the IMD-GFS analyses captured the movement of the system fairly well. But, the intensity evolution of the system could not be resembled as the model presented a weaker system on 21st November compared to 22nd November against the observed circumstance.

## 5. Realized Weather

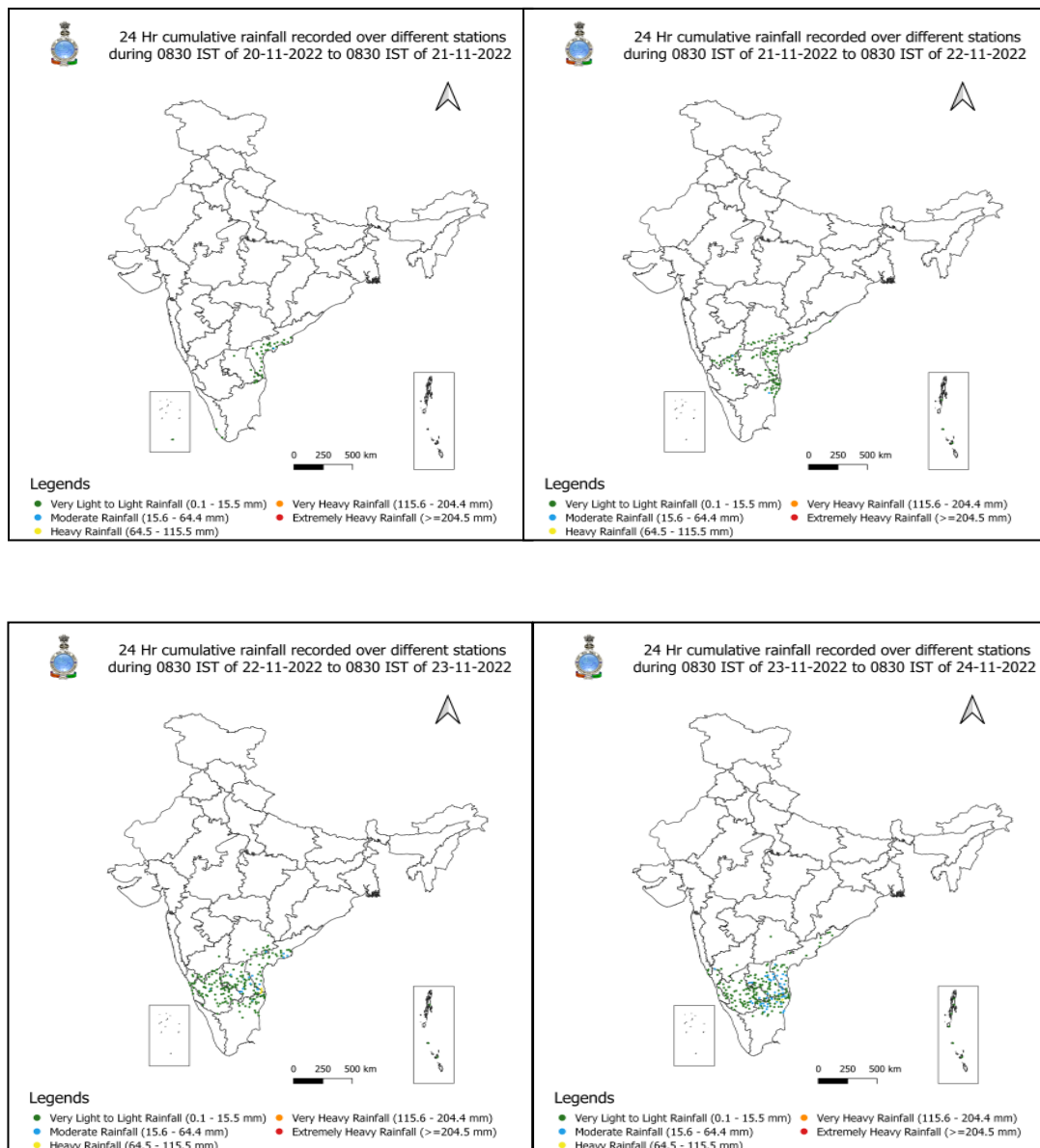
Rainfall associated with the depression based on IMD-NCMRWF GPM-gauge merged analyses and station-wise rainfalls are depicted in Fig 4 respectively.



**Fig. 4(a): IMD-NCMRWF Rain gauge and satellite merged rainfall plots during 17<sup>th</sup> Nov to 23<sup>rd</sup> Nov, 2022 weekly average rainfall (cm/day)**

Fig. 4(a) represents daily observed and weekly average rainfalls distribution for the week over Indian region. The spatial distribution of rainfall during 17th to 23th November clearly show the rainfall belts over Bay of Bengal, Andaman Nicobar islands, coastal Andhra Pradesh & Yanam, and Tamil Nadu region due to the depression. It also indicates higher rainfall activity in the southern sector of the system. The scattered plot over map in the Fig. 4(b) furnish the spatial distributions of station-wise daily 24 hours cumulative rainfall over India during 21st to 24th November, 2022. It shows fairly widespread light to moderate rainfall occurred over south Andhra Pradesh, north Tamil Nadu coasts on 21<sup>st</sup> November. during 22<sup>nd</sup> to 24<sup>th</sup> November, widespread light to moderate rainfall with isolated heavy rainfall

happened over south Andhra Pradesh, north Tamil Nadu and adjoining areas Rayalaseema.



**Fig. 4(b): Daily 24 hr cumulative rainfall distribution recorded over different stations of IMD during 20<sup>th</sup>-24<sup>th</sup> November 2022.**

## 6. Rainfall forecast verification

The forecast for heavy to extremely heavy rainfall episodes are verified with the 24 hours accumulated rainfall at various stations exceeding 7 cm. The details of the day-wise verification are given in Table -2.



**Table 2: Day wise daily 24 hours cumulative rainfall forecast verification with station observations**

Date/Time of issue of forecast	forecast	Verification
<b>20 November 0300 UTC (0830 hours IST)</b>	Light to moderate rainfall is likely to commence from 20th November evening over coastal Andhra Pradesh and adjoining north Tamil Nadu & Rayalaseema. The intensity of rainfall is likely to increase with light to moderate rainfall at many places and isolated heavy rainfall is likely over North Tamilnadu-Puducherry and south coastal Andhra Pradesh & Rayalaseema on 21st and 22nd November and light to moderate rainfall at a few places over North coastal Andhra Pradesh during the same period	<b>23<sup>rd</sup> November:</b>  <u><b>COASTAL ANDHRA PRADESH &amp; YANAM:-</b></u> TADA-9, SULLURPETA-9  <u><b>RAYALASEEMA:-</b></u> SATYAVEDU-9
<b>21<sup>st</sup> November 0300 UTC (0830 hours IST)</b>	Light to moderate rainfall at many places with isolated heavy rainfall is very likely over North Tamilnadu-Puducherry and south coastal Andhra Pradesh & adjoining Rayalaseema on 21st and 22nd November and light to moderate rainfall at a few places over North coastal Andhra Pradesh during the same period.  Light to moderate rainfall at many places is likely over North Tamil Nadu-Puducherry, South Coastal Andhra Pradesh and Rayalseema on 23rd November.	

## 7. Damage due to the system

No damage was reported in association with this system.

## 8. Operational Forecast Performance

- First information about likely formation of a cyclonic circulation over central BoB and adjoining North Andaman Sea during week 2 with low probability of it's further intensification and west-northwestwards movement was given in the extended range outlook issued on 03<sup>rd</sup> November, 2022.
- The formation of the system was first indicated in the extended range outlook issued on 10<sup>th</sup> November (10 days prior to formation of depression over Southwest & adjoining Southeast BoB on 20<sup>th</sup> November). It was indicated that the development of a fresh cyclonic circulation over south Andaman Sea/ southeast BoB during middle of week 1 (around 14th Nov) which would form a low pressure area, move west-northwestwards and intensify gradually.
- The daily tropical weather outlook issued at 1130 hours IST of 17<sup>th</sup> November, 2022 indicated formation of low pressure area over Southeast Bay Of Bengal & adjoining North Andaman Sea at 0000 UTC of 17th November, 2022.

- Actually, The Low Pressure Area over Southeast Bay Of Bengal & neighbourhood moved West-Northwestwards and concentrated into a Well marked Low Pressure Area over central parts of South Bay Of Bengal in the morning of 19<sup>th</sup> November, 2022 and depression formed over Southwest and adjoining Southeast Bay Of Bengal at 0530 hours IST of the 20<sup>th</sup> November , 2022
- In the first bulletin issued on 20<sup>th</sup> November at 0530 hours IST, it was indicated that the depression would continue to move slowly West-Northwestwards towards Tamilnadu-Puducherry and South Andhra Pradesh Coasts During Next 48 Hours.
- Thus, the track, initial movement intensification/weakening of the system were well predicted by IMD/RSMC New Delhi.

### 9. Bulletins issued by IMD

IMD issued regular bulletins to WMO/ESCAP Panel member countries including Bangladesh, Myanmar, Thailand, National & State Disaster Management Agencies of Andaman & Nicobar ,Odisha, Tamil Nadu , Puducherry ,Andhra Pradesh, West Bengal, general public and media. Regular Bulletins every six hourly were issued since formation of depression over northwest BoB. In addition, RSMC New Delhi also issued Press Release and SMS to registered users. A total of 6 national bulletins, 6 RSMC bulletins to WMO/ESCAP Panel member countries, regular Press Release, six hourly SMS were issued. Bulletins issued by Cyclone Warning Division of IMD in association with the system are given in Table 2

**Table 3: Bulletins issued by Cyclone Warning Division, IMD, New Delhi**

S. No.	Bulletins	No. of Bulletins	Issued to
1	National Bulletin	12	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, Administrator, Andaman & Nicobar Islands, Chief Secretary: Odisha, Tamil Nadu, Puducherry, Andhra Pradesh, West Bengal
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	3	1. Disaster Managers, Media persons by email and uploaded on website
4	Facebook /Twitter	15 times	Highlights uploaded on facebook/twitter since formation of low pressure area.
5	SMS	200479	Sent to general public and fishermen Sent to farmers of Odisha, Andhra Pradesh and West Bengal

## 10. Summary

Under the influence of a cyclonic circulation over south Andaman Sea and adjoining southeast Bay of Bengal (BoB), a low pressure area formed over Southeast BoB & adjoining Andaman Sea in the morning (0530 hours IST) of 17th November, 2022. It became a well-marked low pressure area (WML) over central parts of south BoB in the morning (0530 hours IST) of 19th November. Under favourable environmental conditions, the system concentrated into a depression over southwest and adjoining southeast BoB in the morning (0530 hours IST) of the 20th November. It moved west-northwestwards and maintained its intensity till evening of 21<sup>st</sup> November. Moving further west-northwestwards, it weakened into a WML over Westcentral and adjoining Southwest Bay of Bengal off South Andhra Pradesh-North Tamil Nadu coasts in the morning (0830 hours IST) of the 22nd November, 2022. The remnant of the system continued to move west-northwestwards and gradually weaken further into a low pressure area on in the evening (1730 hours IST) of 22<sup>nd</sup> November. Due to the formation of the depression, the active northeast monsoon conditions prevailed over the southern peninsular region of the country and as the system approached south Andhra Pradesh-north Tamil Nadu coasts and its remnant moved west-northwestwards to reach the specified coasts, isolated heavy to extremely heavy rainfall occurred at various locations over south coastal Andhra Pradesh & Yanam, and north Tamil Nadu region.

## 11. Acknowledgement:

India Meteorological Department (IMD) and RSMC New Delhi duly acknowledge the contribution from all the stake holders and disaster management agencies who contributed to the successful monitoring, prediction and early warning service of the system. We acknowledge the contribution of all sister organisations of Ministry of Earth Sciences including National Centre for Medium Range Weather Forecasting Centre (NCMRWF), Indian National Centre for Ocean Information Services (INCOIS), National Institute of Ocean Technology (NIOT), Indian Institute of Tropical Meteorology (IITM) Pune, research institutes including IIT Bhubaneswar, 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) Mumbai, Cyclone Warning Centre (CWC) Thiruvananthapuram & Ahmedabad, Meteorological Centre (MC) Bengaluru. The contribution from Numerical Weather Prediction Division, Satellite and Radar Division, Surface & Upper air instruments Divisions, New Delhi and Information System and Services Division at IMD was also duly acknowledged.

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