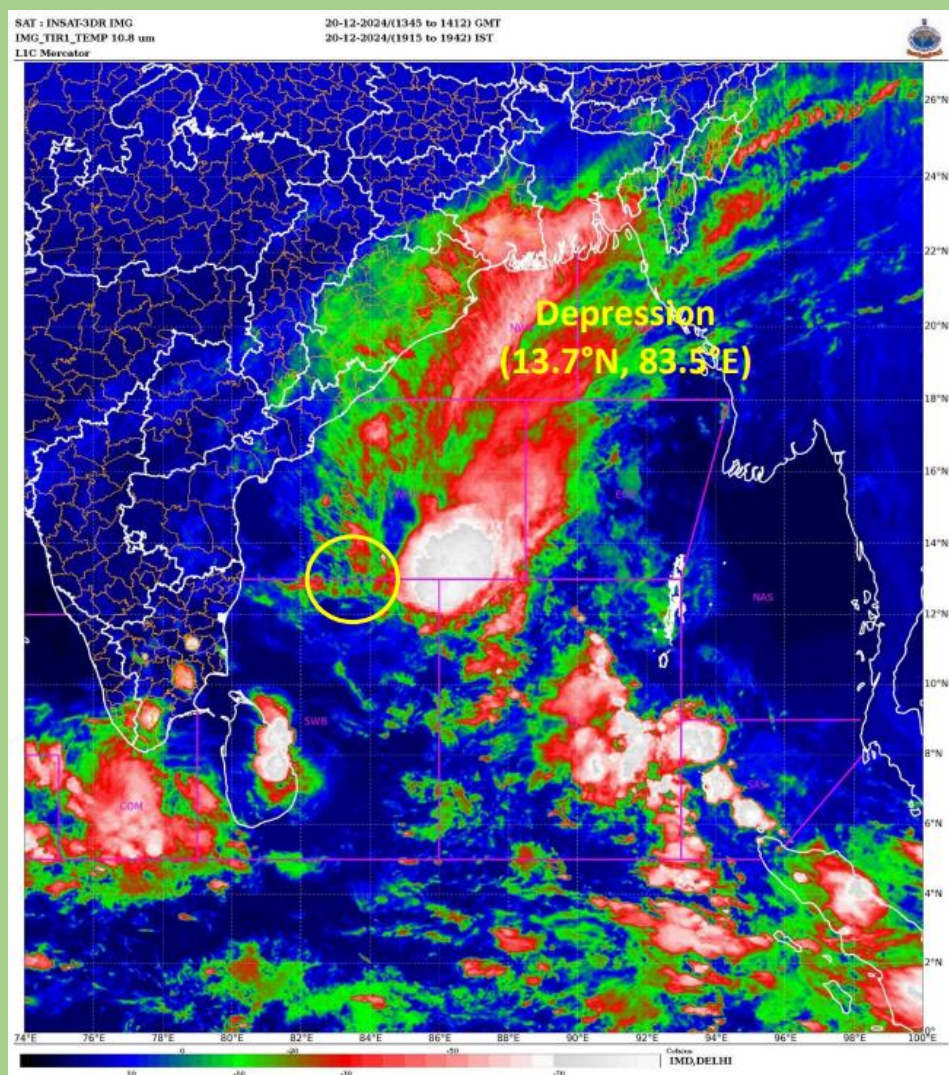




GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
INDIA METEOROLOGICAL DEPARTMENT

Depression over westcentral Bay of Bengal off Andhra Pradesh Coast during 20th - 21st December, 2024: A Report

INSAT-3D Satellite imagery of Depression over westcentral Bay of Bengal off Andhra Pradesh coast at 1200 UTC of 20th, Dec 2024



Cyclone Warning Division
India Meteorological Department
New Delhi
December, 2024

1. Life History of Depression over westcentral Bay of Bengal off Andhra Pradesh coast during 20th - 21st December, 2024

- Under the influence of an upper air cyclonic circulation over south Andaman Sea and adjoining southeast Bay of Bengal (BoB), a low-pressure area formed over central parts of south BoB in the morning (0830 hours IST/0300 UTC) of the 16th December, 2024.
- It lay as a well-marked low-pressure area over southwest BoB in the morning (0830 hours IST/0300 UTC) of the 18th December, 2024.
- It moved southwestwards and lay over southwest and adjoining westcentral BoB in the morning (0830 hours IST/0300 UTC) of 19th December, 2024.
- Thereafter, it moved nearly northwards and lay over westcentral and adjoining southwest BoB in the morning (0830 hours IST/0300 UTC) of 20th December, 2024.
- Further moving northwards, it concentrated into a depression over westcentral BoB off Andhra Pradesh coast in the evening (1730 hours IST/1200 UTC) of 20th December, 2024.
- It moved east-northeastwards and lay over westcentral BoB in the morning (0830 hours IST/0300 UTC) of the 21st December, 2024.
- It moved east-northeastwards and weakened into a well-marked low-pressure area over the same region in the evening (1730 hours IST/1200 UTC) of 21st December, 2024.

The Observed track of the system is presented in **Fig.1**. The best track parameters associated with the system are given in **Table 1**.

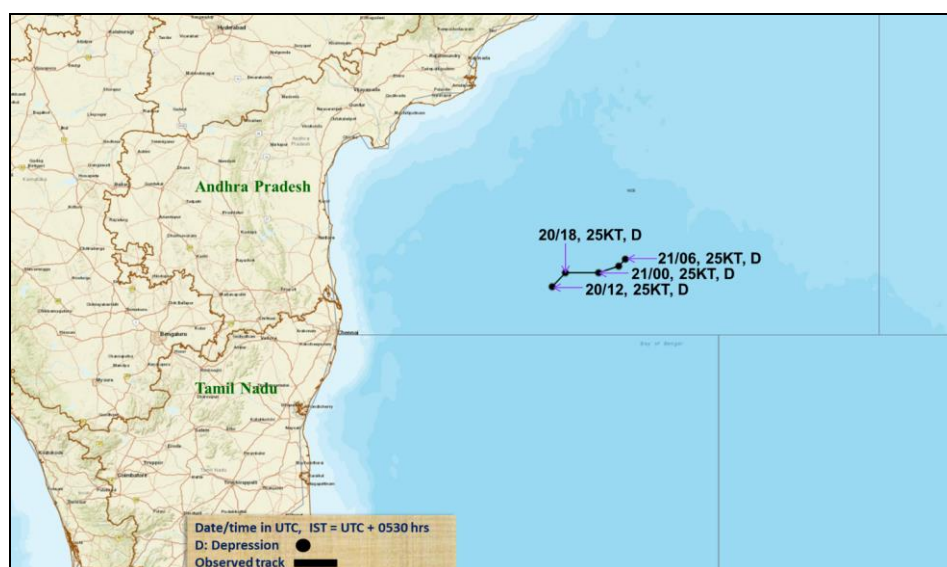


Fig. 1: Observed track of Depression over westcentral BoB off Andhra Pradesh coast

Table1: Best track positions and other parameters of the Depression over westcentral BoB off Andhra Pradesh coast during 20th– 21st December, 2024

Date	Time (UTC)	Lat.	Long.	C.I no	ECP	ΔP	MSW (kt)	Category
20.12.24	1200	13.7	83.5	1.5	1002	3	20	D
	1800	13.9	83.7	1.5	1002	3	20	D
21.12.24	0000	13.9	84.2	1.5	1002	4	25	D
	0300	14.0	84.5	1.5	1004	4	25	D
	0600	14.1	84.6	1.5	1004	3	20	D
	1200	Weakened into a well-marked low-pressure area over westcentral BoB.						

kt: Knot (nautical mile per hour), 1 kt =1.85 kmph, D: Depression

2. Genesis, Intensification and movement

At 1200 UTC of 20th December, a well-marked low-pressure area was over the sea area with warm sea surface temperature (SST) around 28°C and tropical cyclone heat potential (TCHP) was around 70 KJ/cm² over southwest and adjoining westcentral BoB. The total precipitable water imagery (TPW) was indicating warm moist air incursion into the system core with feeding from southeast sector. However, cold dry air was also entering into the core from southwest sector. Low level positive relative vorticity at 850 hpa level was around $80 \times 10^{-6} \text{s}^{-1}$ to the south of the system area over southwest BoB with vertical extension upto 500 hpa level. The low-level convergence was around $10 \times 10^{-6} \text{s}^{-1}$ to the north of system centre. Upper-level divergence was around $10 \times 10^{-6} \text{s}^{-1}$ over an elongated region extending over southwest to northeast sectors. The vertical wind shear (VWS) was moderate (15-20 kt) over the system area. The ridge was lying near 12°N latitude to the south of system area. The southwesterly winds to the north of ridge steered the system north-northeastwards. Under these favorable conditions, the well-marked low-pressure area over southwest BoB concentrated into a depression over the same region.

At 0300 UTC of 21st December, there was prevalence of westerly wind anomaly and Madden Julian Oscillation (MJO) over south BoB and easterly wind anomaly over central parts of BoB along with Kelvin wave to the south. These equatorial waves supported the system to maintain its intensity. However, the low level positive relative vorticity at 850 hpa level decreased significantly and was around $50 \times 10^{-6} \text{s}^{-1}$ to the north-northeast of system centre with vertical extension upto 500 hpa level. The low-level convergence had increased and was around $30 \times 10^{-6} \text{s}^{-1}$ to the north-northeast of system centre and the upper-level divergence was fragmented and was around $10 \times 10^{-6} \text{s}^{-1}$ to the southeast and another zone to northeast sector of system. Divergence was significantly less than the convergence indicating no further

intensification of the system. The mid-level VWS was moderate (10-20 kt) over the system area, which supported the system to maintain its intensity. The west-southwesterly winds prevailing in the mid-tropospheric levels were steering the system east-northeastwards. Further, the presence of convergence zone to the southeast of system area indicated vorticity advection towards southeast sector. While the vorticity advection suggested southeastwards movement of the system, the mid-level flow suggested east-northeastwards movement of the system. Due to these diverging forces, the system moved slowly in east-northeastwards. At that time, the system was in a moderately favorable environment (SST 27-28°C, moderate VWS and poleward outflow) and thus maintained its intensity.

At 1200 UTC of 21st December, the system was over the sea area with warm SST (27-29°C) and TCHP around 70 KJ/cm². The total precipitable water imagery was indicating significant decrease in warm moist air around system area and cold and dry air incursion was also seen from southwest sector. Low level positive relative vorticity at 850 hpa level was around $50 \times 10^{-6} \text{s}^{-1}$ to the north-northeast of the system centre with vertical extension upto 700 hpa level. Vertical extension of the system decreased. The low-level convergence was same and was around $20 \times 10^{-6} \text{s}^{-1}$ to the north-northeast of system centre. At the same time, the upper-level divergence decreased significantly with emergence of a large convergence zone to the northeast of system centre. The mid-level VWS was moderate (15-20 kt) over the system area. All these features led to weakening of the system into a well-marked low pressure area over westcentral BoB.

3. Monitoring

India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean (NIO) and the system was monitored well in advance since 16th December. IMD utilized all available data sources including satellite observations from INSAT 3D and 3DR, polar orbiting satellites, available ships & buoy observations in the region and coastal observations on the day of landfall. Various numerical weather prediction models run by Ministry of Earth Sciences (MoES) institutions, global models and dynamical-statistical models were utilized to predict the genesis, track, landfall and intensity of the system. A digitized forecasting system of IMD was utilized for analysis and comparison of various models' guidance, decision making process and warning products 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 enhanced colored imageries, visible/ IR, brightness temperature and water vapour imageries

are presented in **Fig. 2(a) to 2(d)**. During the entire life cycle, the clouds were organized in shear pattern. The detailed features based on satellite imageries are discussed in this section.

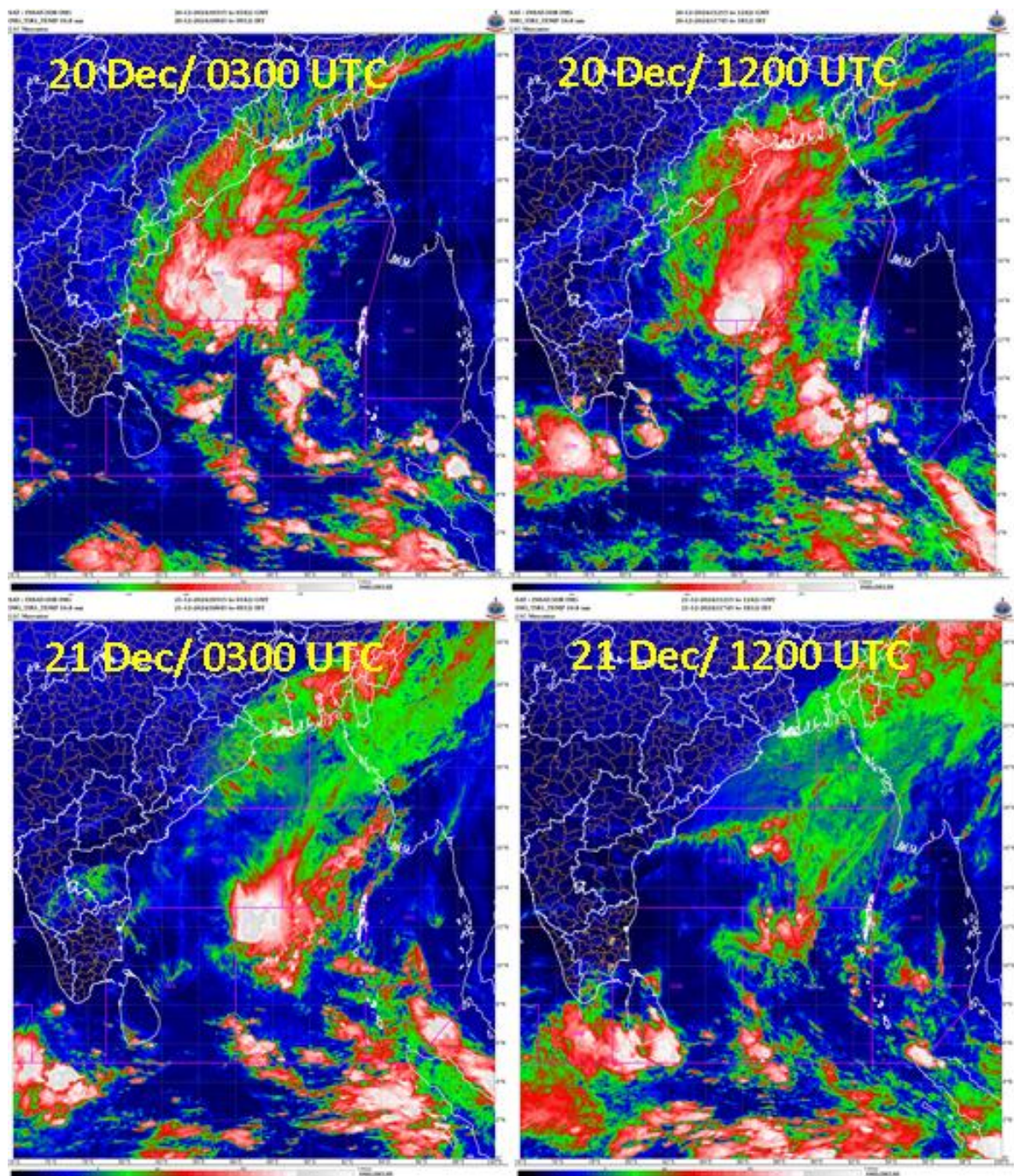


Fig.2(a): INSAT-3D enhanced colored imageries during life cycle of Depression over westcentral BoB off Andhra Pradesh coast during 20th - 21st December, 2024

At 0300 UTC of 20th December scattered to broken low and medium clouds with embedded intense to very intense convection lay over westcentral, adjoining eastcentral & South BoB (minimum cloud top temperature (CTT) -70 to -80°C). Scattered low and medium clouds with embedded moderate to intense convection lay over north BoB and south Andaman Sea.

At 1200 UTC of 20th December, associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over BoB between latitude 12.0°N to 18.0°N and longitude 82.0°E to 87.0°E with minimum CTT as -80 to -90°C and moderate to intense convection over south Gangetic West Bengal, Odisha and north coastal Andhra Pradesh.

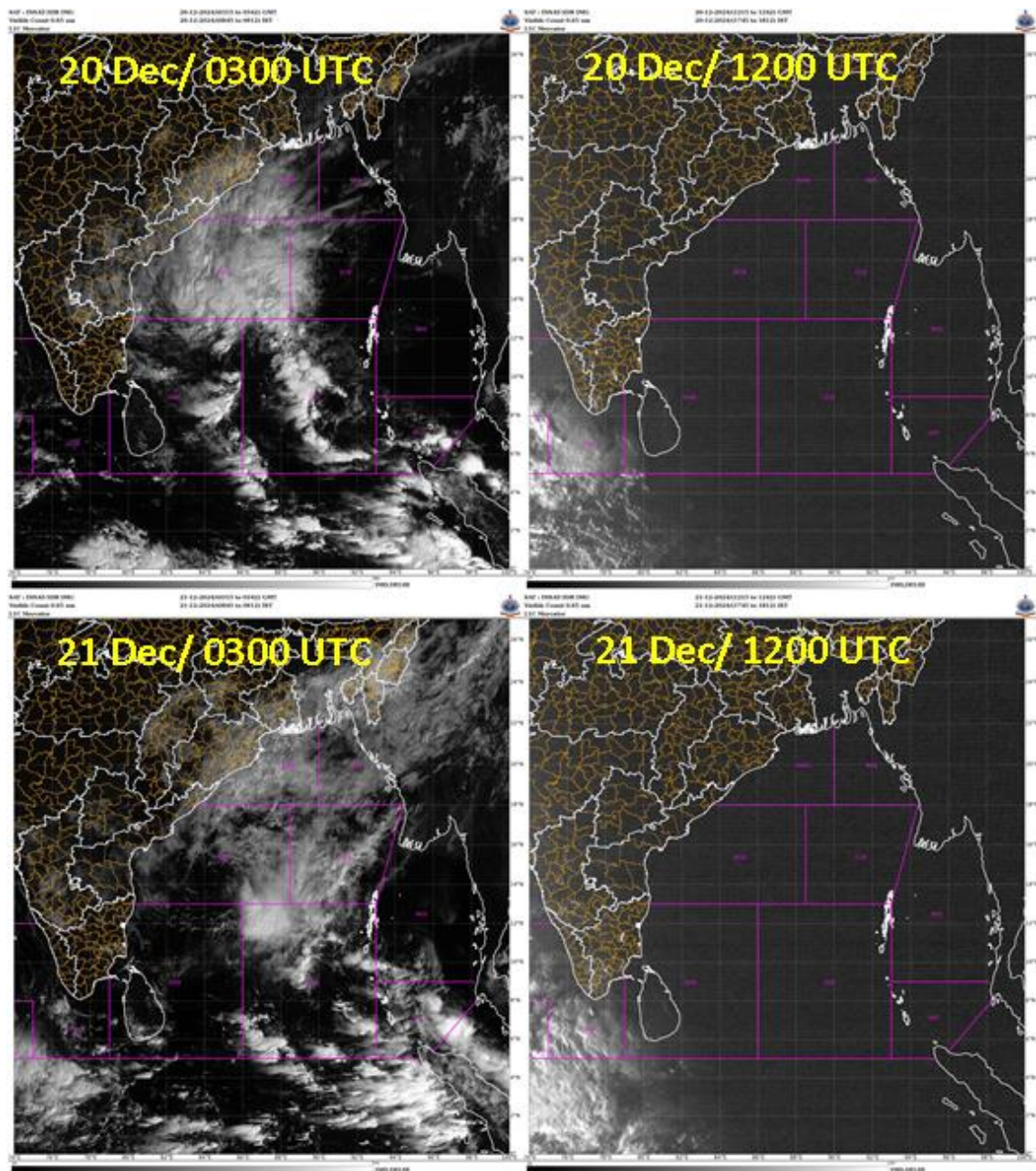


Fig.2 (b): INSAT-3D Visible imageries during life cycle of Depression over westcentral BoB off Andhra Pradesh coast during 20th - 21st December, 2024

At 0300 UTC of 21st December, intensity of system was **T1.5**. Clouds were organised in shear pattern. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over BoB between latitude 8.0°N to 15.0°N and longitude 82.0°E to 90.0°E with minimum CTT as -82 to -90°C and moderate convection lay over Mizoram, Tripura and adjoining areas and low/medium clouds over south Gangetic West Bengal, Odisha, north coastal Andhra Pradesh and north eastern states. As per the ASCAT imagery at 0344 UTC, broad scale circulation prevailed over west & adjoining south BoB.

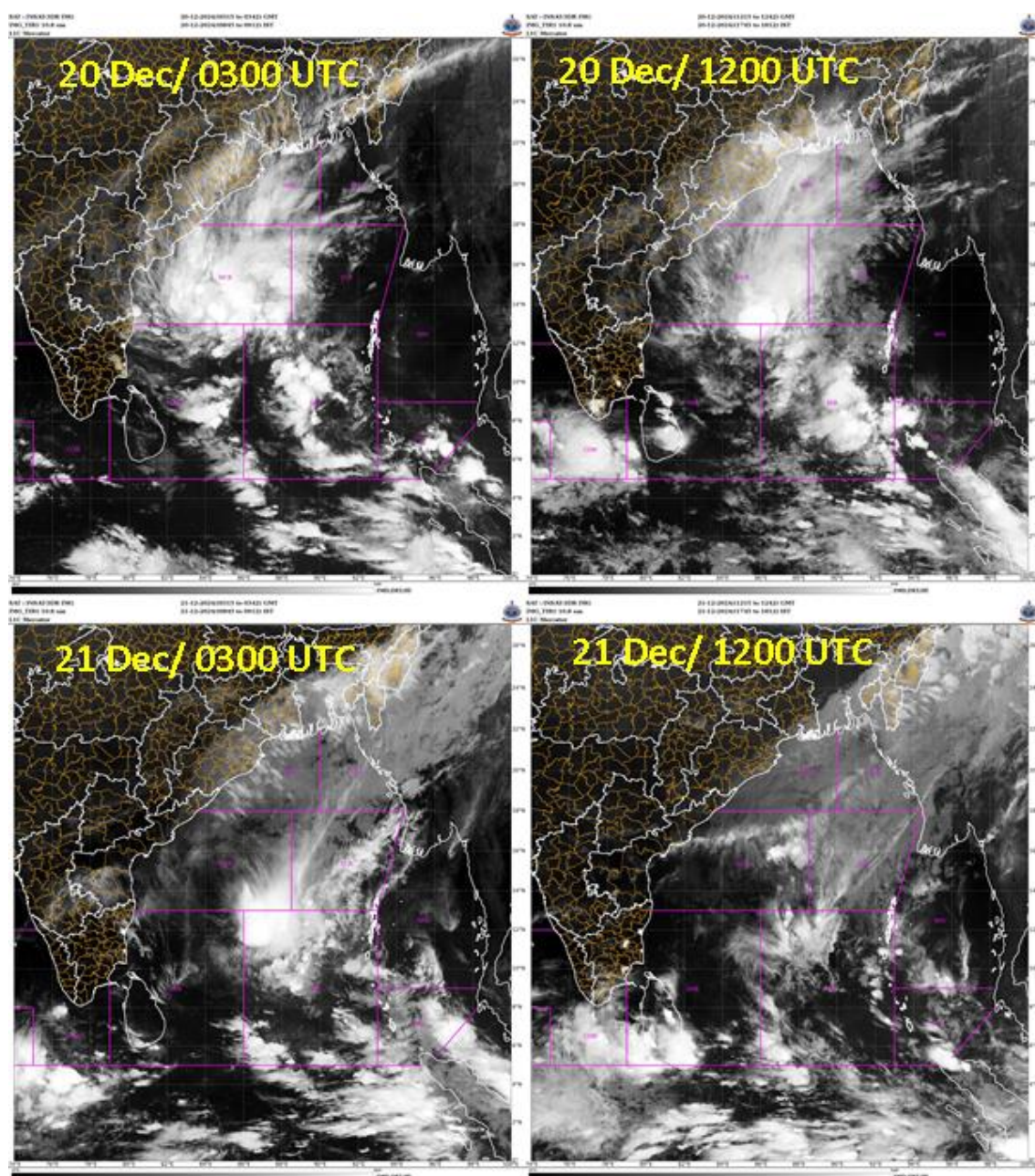


Fig.2(c): INSAT-3D IR imageries during life cycle of Depression over westcentral BoB off Andhra Pradesh coast during 20th - 21st December, 2024

At 1200 UTC of 21st December, intensity of the system was **T1.5**. Clouds were organised in shear pattern. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over BoB between latitude 8.0°N to 15.0°N and longitude 82.0°E to 90.0°E with minimum CTT as -82 to -90°C and moderate convection lay over Mizoram, Tripura and adjoining areas and low/medium clouds over south Gangetic West Bengal, Odisha, north coastal Andhra Pradesh and northeastern states.

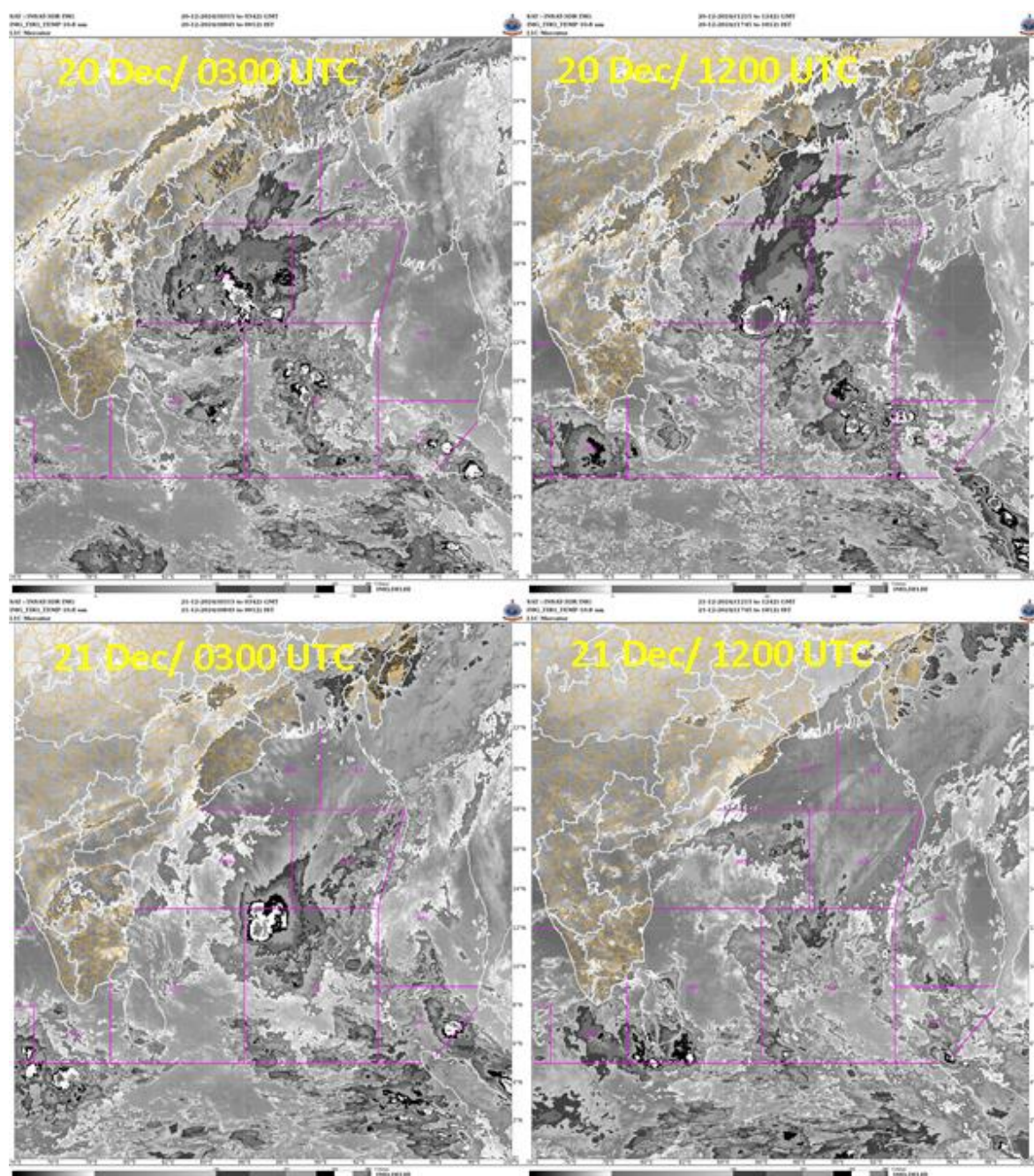


Fig. 2(d): INSAT-3D IR enhanced imageries during life cycle of Depression over westcentral BoB off Andhra Pradesh coast during 20th - 21st December, 2024

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 on 20th Dec to 21st Dec are presented in **Fig. 3(a) to 3(b)** respectively.

At 0000 UTC of 20th December, the model indicated a depression over southwest & adjoining westcentral BoB near 13.2° N/83.8° E. At that time, it lay as a depression over westcentral BoB near 13.7°N/83.5°E. Vertically, the system extended upto 500 hPa level. Thus, the model could correctly capture the genesis and intensity of the system.

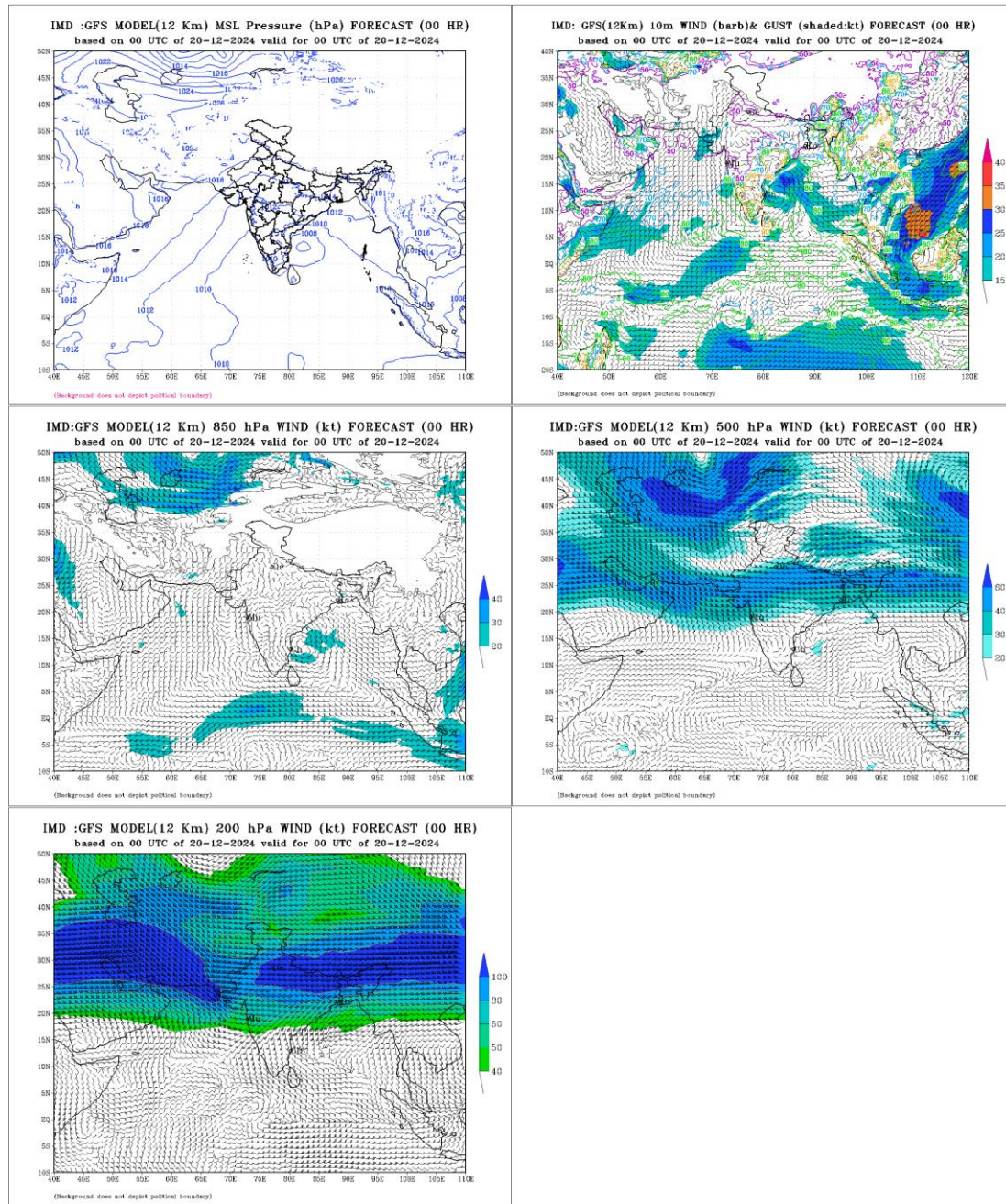


Fig. 3(a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 20th December 2024

At 0000 UTC of 21st December, the model indicated a low pressure area over westcentral & adjoining southwest BoB off South Andhra Pradesh-North Tamil Nadu coasts. At 0000 UTC of 21st December, the system moved nearly northeastwards and lay as a depression over westcentral BoB. Thus, the model could not capture the movement and intensity of the system.

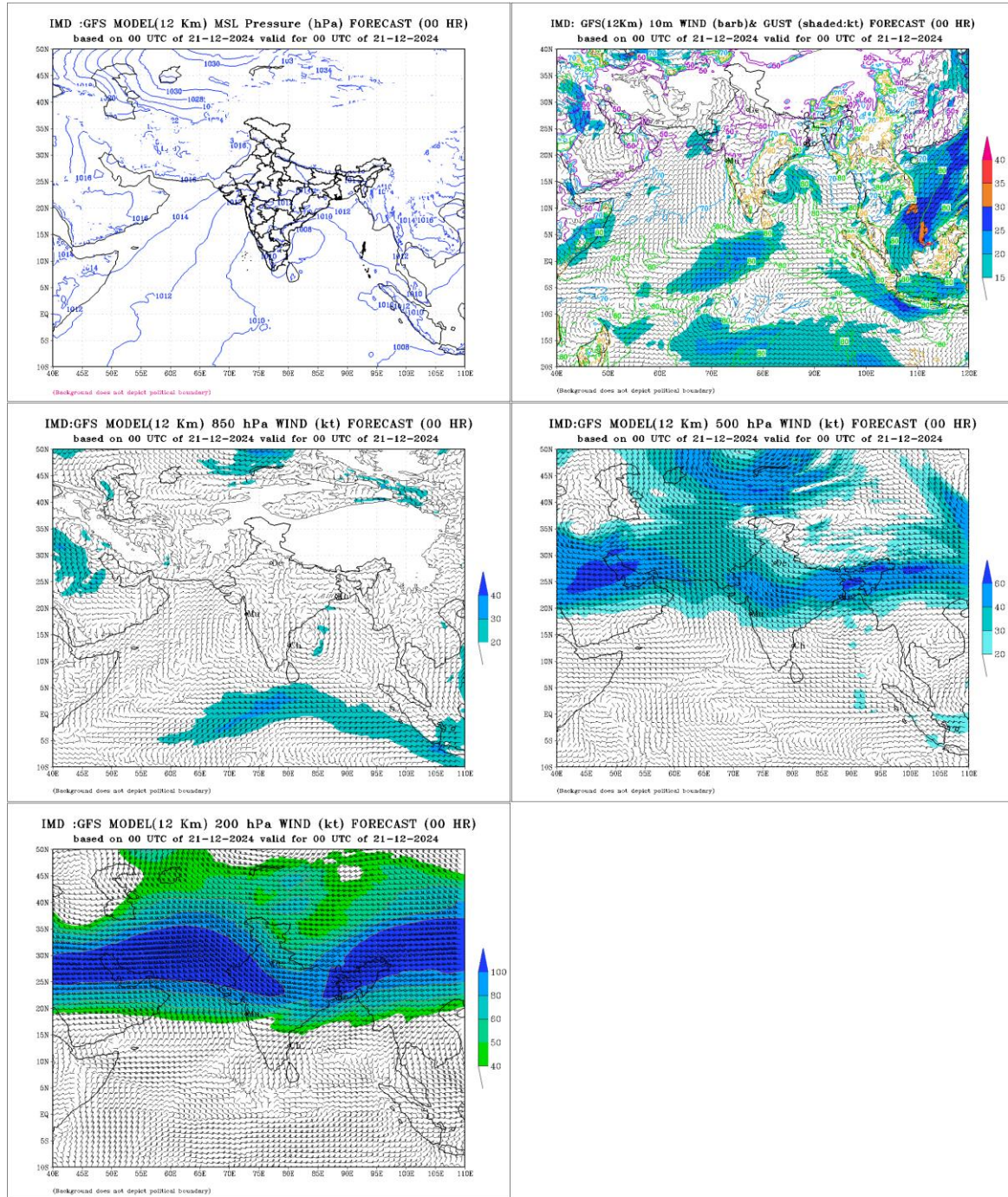


Fig. 3(b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 21st December 2024

Though IMD GFS correctly captured the genesis of the system, its further movement and intensity was not correctly captured.

5. Realized Weather

Rainfall associated with the depression based on IMD-NCMRWF satellite gauge merged data are depicted in **Fig 4**. It is seen that light to moderate rainfall occurred at isolated places with heavy to very heavy rainfall at isolated places over coastal areas of Tamil Nadu, Puducherry & Karaikal, South Odisha and Andhra Pradesh & Yanam on 19th December. Light to moderate rainfall occurred at isolated places with heavy rainfall at isolated places over coastal areas of Odisha and Gangetic West Bengal on 20th December.

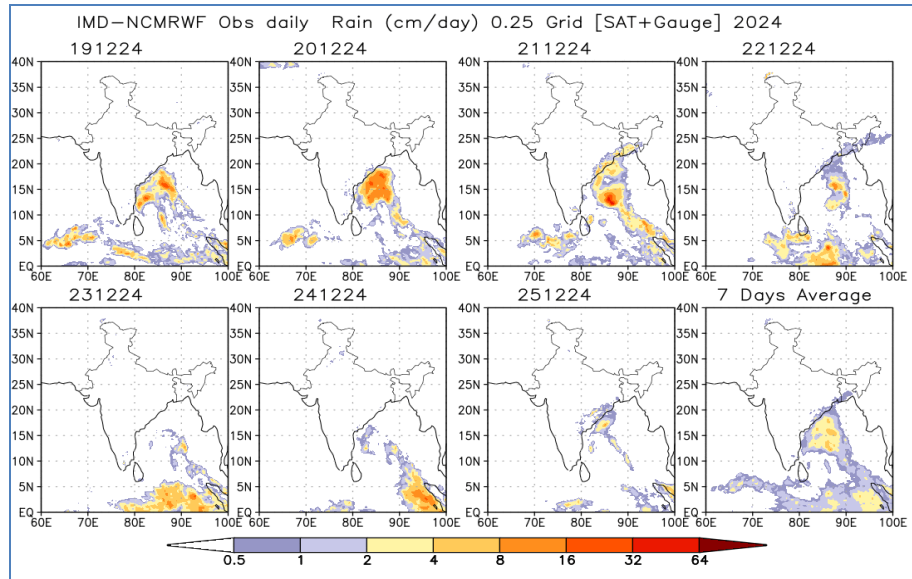


Fig. 4: NCMRWF-IMD satellite gauge merged data plots of realized 24 hours accumulated rainfall from 20th to 21st December, 2024.

5.1 Rainfall forecast verification

The forecast for heavy rainfall in association with the system are verified with the 24 hours accumulated rainfall realized at various stations ending at 0830 IST of date. The details of the day-wise verification are given in **Table -2**.

6. Operational Forecast Performance

- The daily Tropical Weather Outlook issued from 14th December indicated that a fresh low-pressure area is likely to form over southeast BoB around 15th December 2024.
- Extended Range Outlook for Cyclogenesis dated 19th December indicated that there is a low probability of cyclogenesis over westcentral BoB during first half of week 1.
- The first bulletin issued on formation of depression on 20th December indicated that the system would move north-northeastwards without further intensification during next 24 hours.

- Actually, the low pressure area formed over central parts of south BoB on 16th December and the depression formed over westcentral BoB off Andhra Pradesh coast on 20th December. It moved nearly east-northeastwards and weakened into a well-marked low pressure area over westcentral BoB on 21st December evening.
- Thus, it is seen that all parameters including the genesis, movement and intensity of the system were predicted by IMD/RSMC New Delhi 3-4 days ahead.

Table 2: Heavy rainfall forecast verification

Date/Base Time of observation	24 hr Heavy rainfall warning ending at 0300 UTC of next day	Realised 24-hour heavy rainfall (≥ 7 cm) ending at 0300 UTC of date
20.12.2024 / 0830 IST	Coastal Andhra Pradesh: Heavy rainfall at isolated places is very likely over coastal Andhra Pradesh on 20 th December and over north coastal Andhra Pradesh on 21 st December 2024.	<p>20th December: Tamil Nadu, Puducherry & Karaikal: Needamangalam (dist Thiruvapur) 7</p> <p>21st December: Tamil Nadu, Puducherry & Karaikal: Sandhiyur (dist Salem) 8 and Kodumudiyaru Dam (dist Tirunelveli), Balamore (dist Kanyakumari), Oothu (dist Tirunelveli) and Nandhiyar Head (dist Thiruchirappalli) 7 each.</p> <p>Coastal Andhra Pradesh & Yanam: Bondapalle (dist Vizianagaram) 9, Merakamudidam (dist Vizianagaram) 8, Bobbili (dist Vizianagaram), Therlam (dist Vizianagaram), Mentada (dist Vizianagaram), Bheemunipatnam (dist ishakhapatnam) 8 each and Nellimarla (dist Vizianagaram), Garividi (dist Vizianagaram), Cheepurupalle (dist Vizianagaram), Gajapathinagaram (dist Vizianagaram) 7 each.</p> <p>Odisha: Ranpur (dist Nayagarh) 11, Begunia (dist Khurda) 8, Berhampur (dist Ganjam) 8 each and Jatni (dist Khurda), Khordha (dist Khurda), Pipili (dist Puri), Naugaon (dist Jagatsinghpur), Banpur (dist Khurda), Belaguntha (dist Ganjam), Krishnaprasad (dist Puri), Gop (dist Puri), Purushottampur (dist Ganjam) 7 each.</p>

7. Bulletins issued by IMD

- Track and intensity forecast: IMD continuously monitored, predicted and issued bulletins containing track & intensity forecast from the stage of depression till the system weakened into a low-pressure area. The forecast of these parameters was issued from the 16th December onwards.
- Adverse weather warning bulletins: The forecast of expected adverse weather like heavy rain was issued five times daily to central, state and district level disaster management agencies including MHA NDRF, NDMA for all Tamil Nadu, Puducherry, Andhra Pradesh, Odisha, West Bengal, Andaman & Nicobar Islands. The bulletins also contained the suggested action for disaster managers and general public in particular for fishermen. These bulletins were also issued to Defense including Indian Navy & Indian Air Force, NDRF, Indian Coast Guard, ports, Shipping, Fishery, Railways and Surface Transport & Aviation Authorities.
- Warning graphics: The graphical display of the observed and forecast track was disseminated by email and uploaded in the RSMC, New Delhi website (<http://rsmcnewdelhi.imd.gov.in/>) regularly. The adverse weather warnings related to heavy rain were also presented in graphics along with colour codes in the website.
- Warning and advisory for marine community: The bulletins under Global Maritime Distress Safety System (GMDSS) were issued by the Marine Weather Services Division at New Delhi 3 times daily. Bulletins for maritime interest were also issued by Area Cyclone Warning centre of IMD at Kolkata & Chennai and Cyclone Warning Centres at Visakhapatnam and Bhubaneswar to ports, fishermen, coastal and high sea shipping community.
- Fishermen Warning: Regular warnings for fishermen for deep sea of BoB and the states of Tamil Nadu, Puducherry, Andhra Pradesh, Odisha, West Bengal were issued since 16th December onwards.
- Warning and advisory through social media: Daily updates (every six hourly or whenever there was any significant change in intensity/track) were uploaded on Facebook and tweeter regularly during the life period of the system from 20th evening onwards, updates were posted on facebook and twitter.
- Diagnostic and prognostic features of Depression: The prognostics and diagnostics of the system were described in the RSMC bulletins.

Statistics of bulletins issued by RSMC New Delhi in association with this system are given in **Table 3**.

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

SN	Bulletins	No. of Bulletins	Issued to
1	National Bulletin	6	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 Defense Staff, DG Doordarshan, All India Radio, DG-NDRF, Director Indian Railways, Indian Navy, IAF, Chief Secretary: Tamil Nadu, Puducherry, Andhra Pradesh, Odisha, West Bengal, Andaman & Nicobar Islands.
2	RSMC Bulletin	6	1. IMD's website 2. All WMO/ESCAP member countries including Bangladesh through GTS and E-mail. 3. Indian Navy, IAF by 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	Frequently	SMS to (i) disaster managers at national level and concerned states (every time when there was change in track, intensity and landfall characteristics) by IMD Headquarters, (ii) to General Public registered through RSMC website by IMD Headquarters and RMC Kolkata office (iii) to fishermen through INCOIS network.
5	Warnings through social media	Daily	Cyclone Warnings were uploaded on social networking sites (Facebook and Twitter) since inception to weakening of system (every six hourly).

Table 4: Bulletins issued by Area Cyclone Warning Centre (ACWC) Kolkata and Cyclone Warning Centre (CWC)Bhubaneswar

SN	Bulletins	ACWC Kolkata	CWC Bhubaneswar	CWC Visakhapatnam	ACWC Chennai
1	Sea Area Bulletin for Bay of Bengal	5	-	-	
2	Coastal Weather Bulletin for respective coastal area	4	3	5	2

3	Port Warnings for respective ports under jurisdiction	4	2	5	2
4	Fishermen Warnings for Bay of Bengal	3	5	7	7

8. 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 contribution from WMO/ ESCAP panel member countries for sharing observations. 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 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) Kolkata, Cyclone Warning Centre (CWC) Visakhapatnam and Bhubaneswar is duly acknowledged. 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 is also duly acknowledged.
