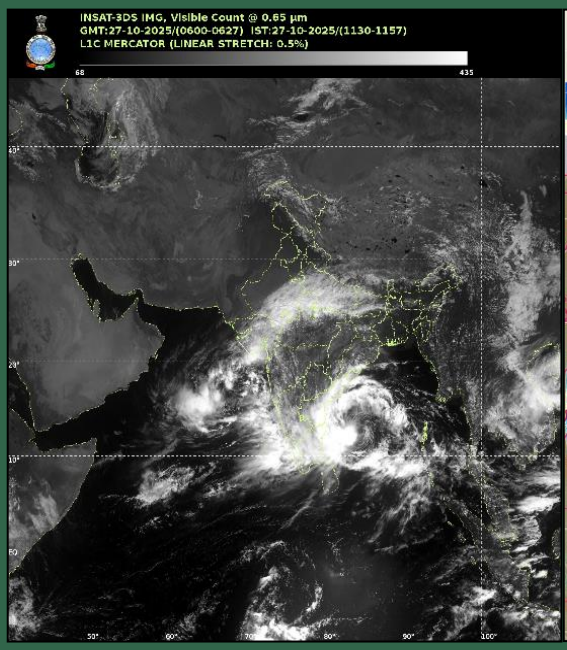
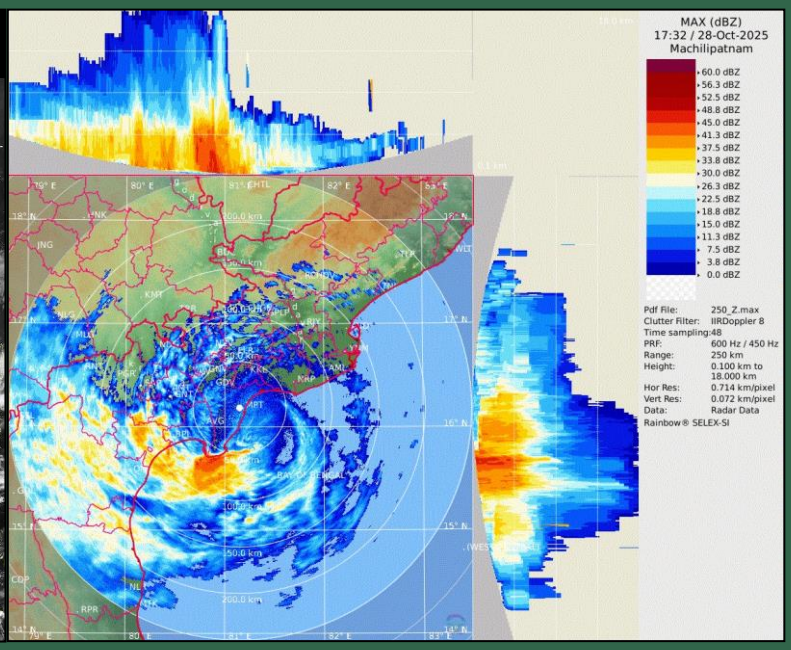
World Meteorological Organisation

Government of India
Ministry of Earth Sciences
India Meteorological Department

ESSO/MoES/IMD/RSMC-Tropical Cyclone Report/01(2026)/16

REPORT ON CYCLONIC DISTURBANCES OVER NORTH INDIAN OCEAN DURING 2025





SATELLITE AND RADAR IMAGERY OF SEVERE CYCLONIC STORM, "MONTHA"

RSMC-TROPICAL CYCLONES, NEW DELHI

JANUARY 2026

WMO

INDIA METEOROLOGICAL DEPARTMENT

RSMC- TROPICAL CYCLONES, NEW DELHI

INDIA METEOROLOGICAL DEPARTMENT

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12.	Abstract	The activities of Regional Specialised Meteorological Centre (RSMC) – Tropical Cyclone New Delhi are briefly presented alongwith the current state of art for monitoring and prediction of cyclonic disturbances over the north Indian Ocean. This report further describes the characteristics of cyclonic disturbances formed over the north Indian Ocean during 2025. The special emphasis has been given on the features associated with genesis, intensification, movement, landfall and associated adverse weather like heavy rain, strong wind and storm surge. The performance of the forecasts issued by RSMC, New Delhi with respect to tropical cyclones are verified and discussed. Also the performance of various dynamical and statistical models for cyclone forecasting has been evaluated and discussed.

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INTRODUCTION

Regional Specialized Meteorological Centre (RSMC) - Tropical Cyclones, New Delhi, which is co-located with Cyclone Warning Division has the responsibility of issuing Tropical Weather Outlook and Tropical Cyclone Advisories for the benefit of the countries in the World Meteorological Organization (WMO)/ Economic and Social Co-operation for Asia and the Pacific (ESCAP) Panel region bordering the Bay of Bengal and the Arabian Sea, namely, Bangladesh, India, Iran, Maldives, Myanmar, Pakistan, Qatar, Sultanate of Oman, Sri Lanka, Thailand, United Arab Emirates, Saudi Arabia and Yemen. It has also the responsibilities as a Tropical Cyclone Advisory Centre (TCAC) to provide Tropical Cyclone Advisories to the designated International Airports as per requirement of International Civil Aviation Organization (ICAO).

The broad functions of RSMC- Tropical Cyclones, New Delhi are as follows:

- Round the clock watch on weather situations over the entire north Indian Ocean.
- Analysis and processing of global meteorological data for diagnostic and prediction purposes.
- Detection, tracking and prediction of cyclonic disturbances in the Bay of Bengal and the Arabian Sea.
- Running of numerical weather prediction models for tropical cyclone track and storm surge predictions.
- Interaction with National Disaster Management Authority and National Disaster Management, Ministry of Home Affairs, Govt. of India to provide timely information and warnings for emergency support services. RSMC-New Delhi also coordinates with National Institute of Disaster Management (NIDM) for sharing the information related to cyclone warning.
- Implementation of the Regional Cyclone Operational Plan of WMO/ESCAP Panel.
- Issue of Tropical Weather Outlook and Tropical Cyclone Advisories to the Panel countries in general.
- Issue of Tropical Cyclone advisories to International airports in the neighbouring countries for International aviation.
- Collection, processing and archival of all data pertaining to cyclonic disturbances viz. wind, storm surge, pressure, rainfall, damage report, satellite and Radar derived information etc. and their exchange with Panel member countries.
- Preparation of comprehensive annual reports on cyclonic disturbances formed over North Indian Ocean every year.
- Preparation of annual review report on various activities including meteorological, hydrological and disaster preparedness and prevention activities of panel member countries.
- Research on storm surge, track and intensity prediction techniques.Organisation of annual training on tropical cyclone monitoring and prediction as well as associated severe weather forecasting and warning services for WMO/ESCAP Panel countries.

CHAPTER- I

ACTIVITIES OF REGIONAL SPECIALIZED METEOROLOGICAL CENTER – TROPICAL CYCLONES, NEW DELHI

1.1 Area of Responsibility

The area of responsibility of RSMC- New Delhi covers Sea areas of north Indian Ocean north of equator between 40^0E and 100^0E and includes the member countries of WMO/ESCAP Panel on Tropical Cyclones viz, Bangladesh, India, Iran, Maldives, Myanmar, Oman, Pakistan, Qatar, Saudi Arabia, Sri Lanka, Thailand, United Arab Emirates and Yemen as shown in Fig. 1.1.

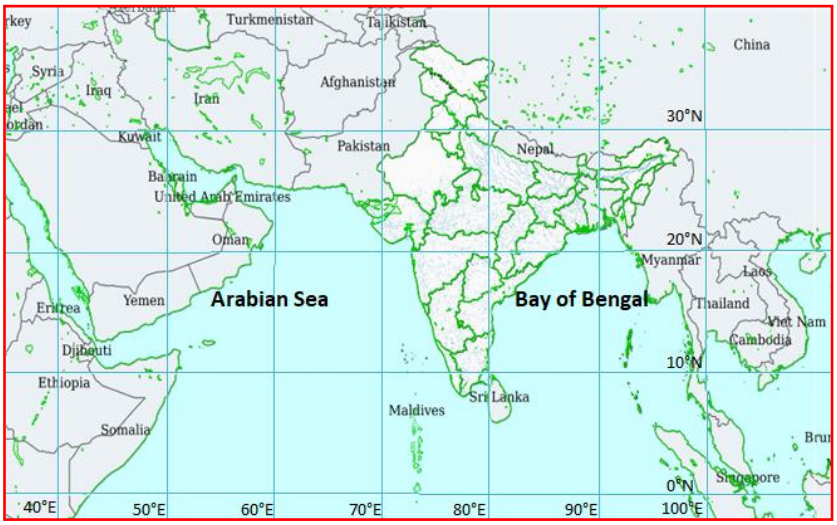


Fig. 1.1 Area of responsibility of RSMC- Tropical Cyclone, New Delhi

1.2 Naming of tropical cyclones over north Indian Ocean:

The WMO/ESCAP Panel on Tropical Cyclones at its twenty-seventh Session held in 2000 in Muscat, Sultanate of Oman agreed in principle to assign names to the tropical cyclones in the Bay of Bengal and Arabian Sea. After long deliberations among the member countries, the naming of the tropical cyclones over north Indian Ocean commenced from September 2004, by RSMC New Delhi. The first name was 'ONIL' which developed over the Arabian Sea (30 September to 03 October, 2004). According to approved principle, a list of 64 names in eight columns of a table has been prepared. The names of Panel members who contributed cyclone names, have arranged in rows. The RSMC (tropical cyclones) New Delhi gives a tropical cyclone an identification name from the table of names. The Panel member's name is listed alphabetically country wise in each column. The names are used sequentially column wise. The first name starts from the first row of column one and continues sequentially to the last row in column eight. The names are not rotated every few years unlike that over the Atlantic and Eastern Pacific lists. All the names in the first list effective from September 2004 have been used. The second list in the series was released in April, 2020 with representation from all the 13 WMO member countries having a total of 169 names. Till the end of year 2025, a total of 26 names have already been utilized for naming the Tropical Cyclones over North Indian Ocean. The same is available on RSMC website at http://www.rsmcnewdelhi.imd.gov.in/ images/pdf/cyclone-awareness/tc-names/tc-names.pdf.

1.3 Observational System

A brief description of different types of observational network of India Meteorological Department (IMD) and observations collected from networks are given below.

1.3.1 Surface Observatories

IMD has a good network of surface observatories satisfying the requirement of World Meteorological Organization. There are 560 surface observatories in IMD. The data from these stations are used on real time basis for operational forecasting. A number of moored ocean buoys including Meteorological Buoy (MB), Shallow Water (SW), Deep Sea (DS) and Ocean Thermal (OT) buoys have been deployed over the Indian Sea, under the National Data Buoy Programme (NDBP) of the Ministry of Earth Sciences, Government of India. The surface observatory network of IMD is shown in Fig 1.2

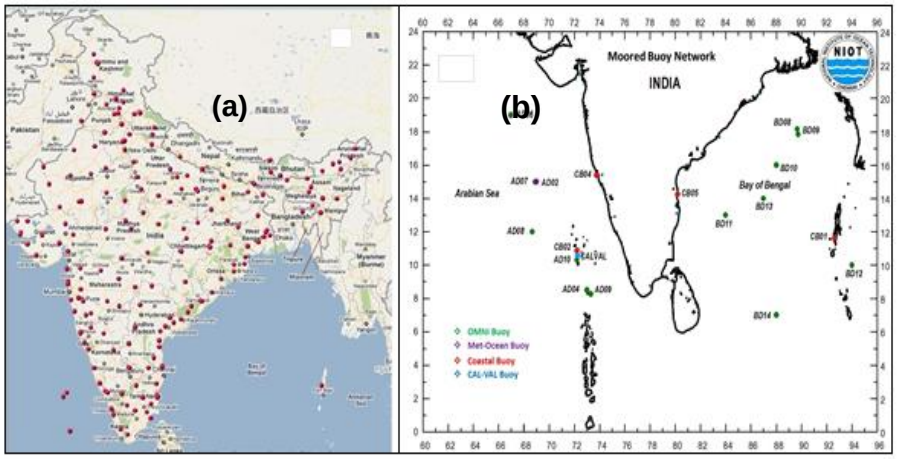


Fig.1.2. (a) The surface Observatory Network of IMD (b) Buoy network of NIOT

As a routine, a large number of ship observations over Indian seas from about 50 ships per day, both Indian and International are also received and are assimilated in the analysis.

A fairly dense network of 1008 AWSs as shown in Fig. 1.3 is now available for operational utilization. In addition to AWS, a network of 1382 ARG Stations has been established in different states. Recently different state government AWS/ARG data is also integrated with IMD Server for optimum utilization of AWS data. The recent imitative to strengthen further the observational network in Ladakh will very helpful.

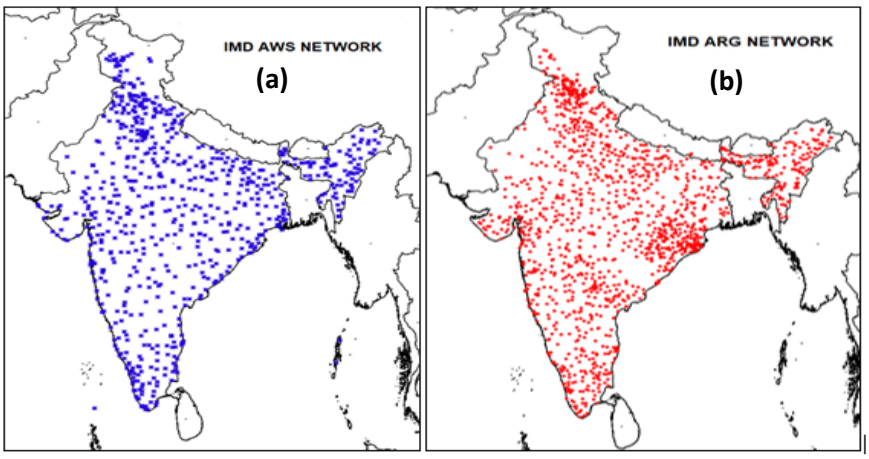


Fig. 1.3 (a) Network of 1008 AWS and (b) 1382 ARGs.

As a part of addressing the Impact of severe weathers over Megacities in the country; Meso scale observational networks of AWS/ARG are established in Mumbai and Pune for location specific real-time weather updates on web and on Mobile App recently. This was done jointly with local state government authorities. Further, more cities will be taken up in coming time.

In addition, 37 Nos. of High Wind Speed Recorders (HWSRs) are installed for continuous monitoring of High wind speed and Station Level Pressure along East & West coast of India during cyclone and severe weather. The HWSR system have wind sampling capacity (every second data sample) using state-of-the-art Ultrasonic wind sensor and data is made available in real time to users. Some HWSRs are also planned in the interior of country specifically monitoring Gusty wind during severe Thunderstorm.

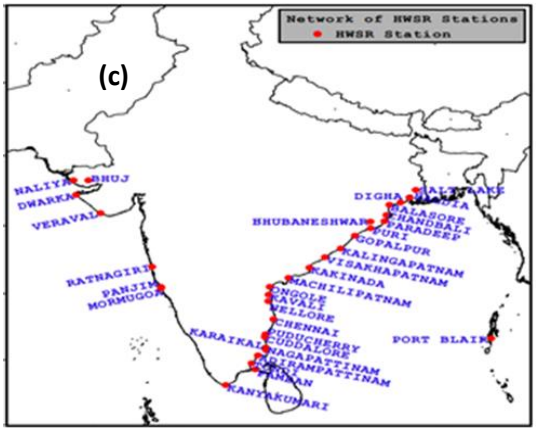


Fig. 1.3 (c) Network of 35 HWSR

1.3.2 Upper Air Observatories

There are at present 62 Pilot Balloon Observatories (PBOs), 56 Radiosonde observatories. All the 56 stations are latest of the art- GPS based observatories. Out of these, six radiosonde stations at Regional Meteorological Centre's in New Delhi, Mumbai, Kolkata, Chennai, Guwahati and Nagpur are of WMO-GUAN (Global Climatological Observations System Upper Air Network) standards. These have been included into GUAN. The pilot balloon observation and radiosonde observatory network of IMD is shown in Fig 1.4

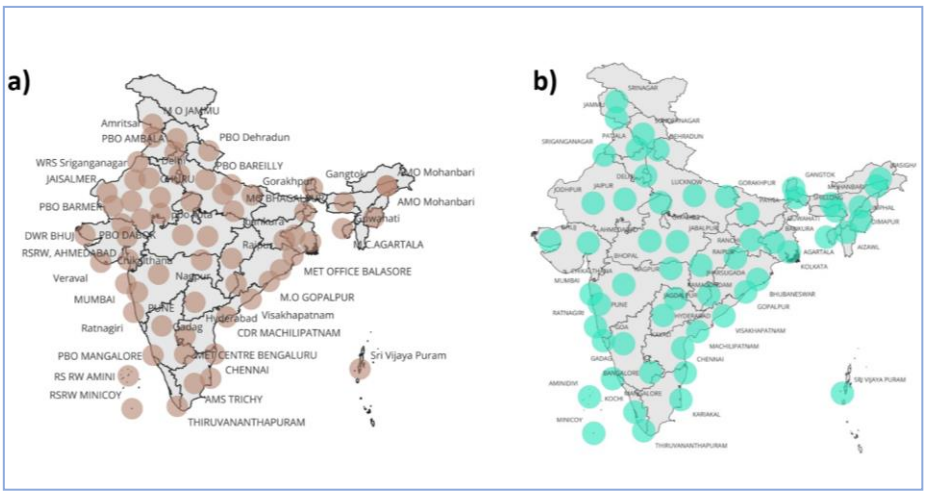


Fig.1.4 (a) Network of (a) Pilot Balloon and (b) Radiosonde/ Radio wind observatories

To monitor the daily ascent status and the stock of various consumables the observatory performance monitoring system has been started on the intra IMD portal, https://ddgmui.imd.gov.in. The upper air meteorological data collected all over the country are used for operational forecasting. The PBOs at New Delhi, Mumbai and Lucknow have been upgraded with GPS based PBO.

1.3.3 Radars

1.3.3.1 Current status

Weather radar network of India is managed by IMD, and consists of 47 Doppler Weather Radars (DWRs) presently, spreading across the country (Fig. 1.5). RADAR network includes 3 ISRO and 7 IITM RADARs.

- India has a network of 16 RADARs covering the Indian Coast line. Eight radars (Chennai, Kolkata, Machilipatnam, Visakhapatnam, Paradip, Gopalpur, Sriharikota, Karaikal) on the East Coast and five radars (Kochi, Goa, Mumbai, Bhuj, and Thiruvananthapuram) on West Coast. Recently, two more indigenously developed DWRs: one X-band DWR at Pallikarnai, Chennai and one C-band at Veravali, Mumbai have been added in IMD radar network. Thus there are 16 radars along the coast.
- IMD also utilizes the data inputs from DWRs of ISRO located at VSSC Thiruvananthapuram (C-Band), Sohra / Cherrapunji (S-Band) and SHAR (Sriharikota-S Band) and radar set up by India Institute of Tropical Meteorology, Pune at Silkheda (Madhya Pradesh), Juhu, Panvel , Dombivali, Vasai and Solapur, (Maharashtra).

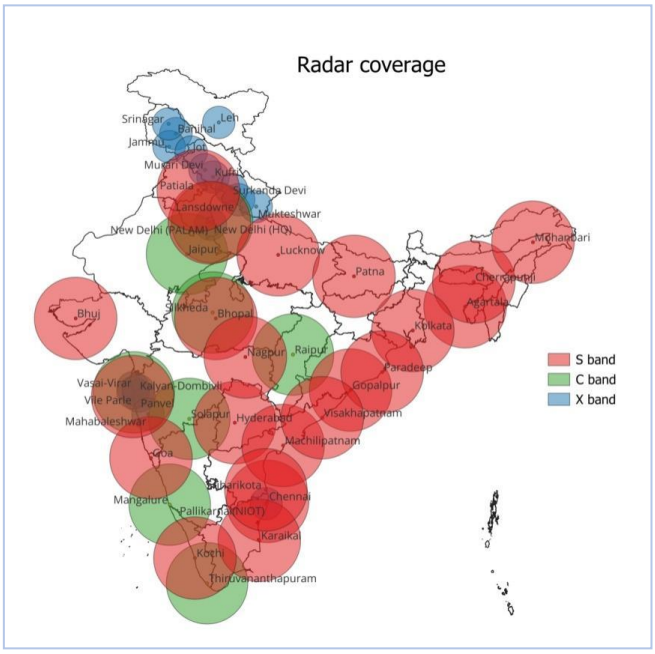


Fig. 1.5 Network of Doppler Weather Radar used for weather monitoring and forecasting (47 Nos.)

Radars of IMD are being used for detection of rainfall, hail storm, thunderstorms and for tracking of cyclonic storms. Various meteorological and hydrological products derived from radar data using software algorithms are extremely useful to the forecasters for estimating the storm's center, direction of movement, structure and intensity. The existing radars have also been networked to provide near real time data to super computers for ingesting into numerical weather prediction (NWP) models for short range forecasting. Composite images are also being generated centrally. Data is also converted to scientific formats such as NetCDF (Network Common Data Format), HDF5 (Hierarchical Data Format version 5), and Opera BUFR (Binary Universal Form for Representation) for assimilation in NWP models. A national Radar data centre has been established at IMD, New Delhi for archival and retrieval of radar data. Radar data products are also provided to various users. Open source GIS (Geographic Information System) platforms are used to display the radar data on the web pages. The radar data are combined with lightning data and satellite imagery for a unified display on the website using GIS platform. This now provides accurate positional information of the location of the storm cells.

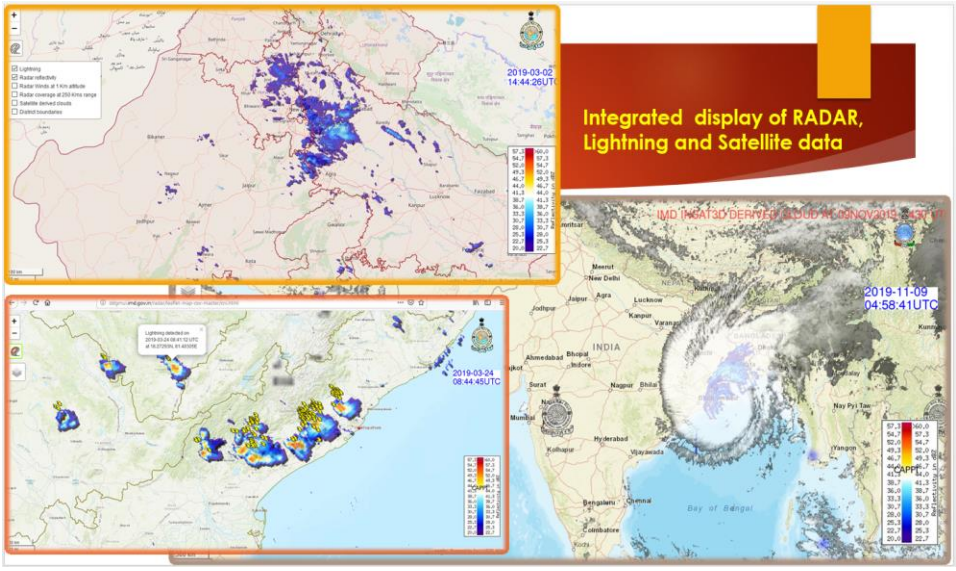


Fig. 1.6: Integrated display using RADAR, Lightning and Satellite data

Location specific information of lightning is also being generated in the radar data center and is available in the web page. A unique audio alert system announces the location and number of lightning occurrences district wise which alerts the forecaster and other end users to severe weather events.

1.3.3.2 Future Plan:

The Radar division is involved in implementation of modernization of Radar Network by replacing old conventional Radars with state of art DWRs. IMD plans to install 85 more number of DWRs and 19 numbers of wind profiler radars under Mission Mausam Scheme in the phased manner to bring entire Country and coasts under radar coverage. For improved efficient management, there are also plans, to establish a Weather Radar Operation Center, which would be responsible for weather radar related activities of the department. It will

manage radar network, archival, dissemination of data, development of algorithms, network planning and related Research & Development. IMD has also planned the procurement of Wind profilers under MoU with ISRO, Bangalore. The information on wind profilers improves the weather prediction in the tropics. Therefore, wind profilers are planned to be installed at nine locations. Further, 10 wind profilers have been proposed under mission mausam scheme in different locations in India. The total number of 19 wind profilers network is as shown in Fig. 1.7.

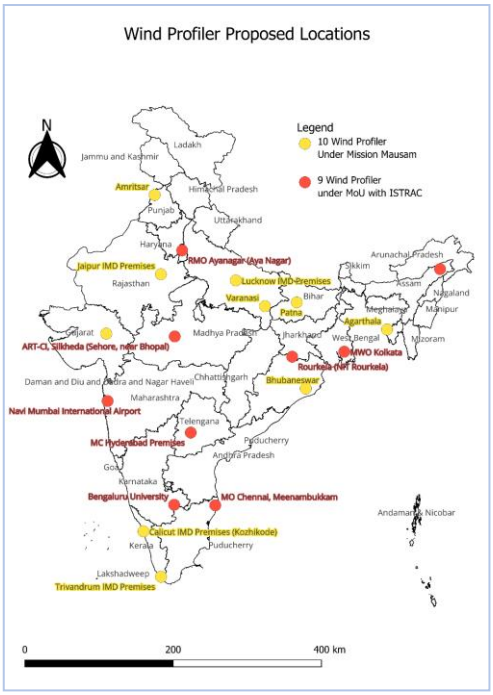


Fig.1.7: Wind profilers planned across the country (19 Nos.).

Further under Mission Mausam, 53 Radars and 10 wind profilers will be procured and added to the network. Total Radar coverage of DWRs is shown under Fig. 1.8.

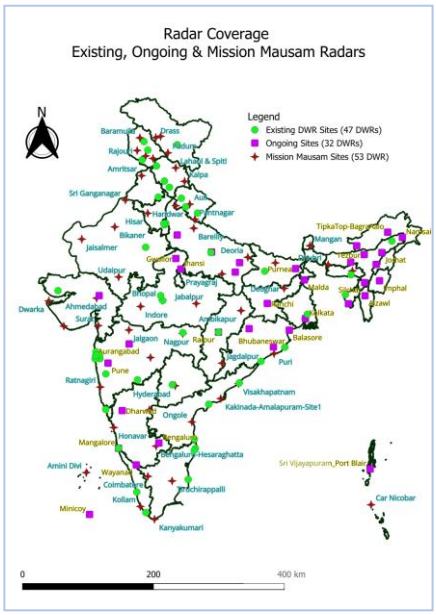


Fig. 1.8: Total DWRs Network after implementation of Mission Mausam

1.3.4 Satellite Monitoring

Multi Mission Meteorological Data Receiving and Processing System (MMDRPS) is being used on an operational basis to receive and process meteorological data from INSAT-3D and INSAT3-DR satellites on round the clock basis in Satellite Meteorological Division. MMDRPS systems consist of advance & latest state of art servers capable to process the complete set of data within 7 minutes after completion of scanning along with the storage capacity of order 2.0/2.0PB (Main/ Mirror) & 324TB SSD which will facilitate online sharing of processed data for all Indian meteorological satellites to the registered users as per IMD data policy through Web based secured satellite Data Supply System.

The MMDRPS facility generated more than 30,000 images and data products from INSAT 3DR & 3DS, and handles around 800 GB of geostationary data each. It amounts to approximately 10 lakh images and data products, as well as 20 TB of data handling, each month, while running 24x7x365. The system is maintained to run around-the-clock without any failures, and intermittent maintenance issues are addressed as per the needs and escalation process. One significant failure issue arose on 01st July 2025, due to an electrical supply line failure, and the entire facility went blacked out, resulting in the shutdown of the MMDRPS facility. The division's satellite services were affected until they were restored on 04th July 2025.

Imager payload of these satellites (INSAT3DS/R) are operated in a staggered mode to get images every 15 minutes. Sounder payload of INSAT 3DS and INSAT 3DR satellite is operated in an integrated mode so that every hourly data of Indian land region and every one and half hour hourly data of Indian Ocean region is obtained for generating multi-level imageries and vertical profiles of humidity and temperature. Cloud Imagery and derived products data are disseminated to forecasting offices of the IMD as well as to the other users in India and foreign countries through dedicated web pages and online analysis and visualization tool (RAPID). All the received and processed data from the satellite are archived on a dedicated storage of MMRDPS

The following products derived from the satellite are useful for monitoring of tropical cyclones Enhanced grey scale imagery of cyclone.

- Enhanced coloured imagery of cyclone.
- Enhanced coloured imagery of cyclone.
- Outgoing Long wave Radiation (OLR) at pixel resolution
- The following Quantitative Precipitation Estimation (QPE)
  - GPI three hourly accumulated at 1x1 degree resolution,
  - Hydro estimator (HE) at pixel level
  - INSAT-Multi spectral Rainfall (IMR)at 0.1x0.1-degree resolution
  - Improved IMR at pixel level.
- Sea Surface Temperature (SST) at pixel resolution
- Upper Tropospheric Humidity (UTH) at pixel resolution
- Cloud Motion Vector (CMV)
- Water Vapour Wind (WVW)
- Vis/MIR wind
- Wind derived products such as: Lower level Vorticity, Upper level Divergence, Lower level convergence, Vertical wind shear & Wind shear tendency
- Temperature, Humidity profile
- Value added parameters from sounder products
- Geo-potential Height

- Layer Precipitable Water
- Total Precipitable Water
- Lifted Index
- Dry Microburst Index
- Maximum Vertical Theta-E Differential
- Wind Index
- Ozone

At present, Dvorak technique is used but manually applied. Recently, efforts have been made for automation of this technique. Automated Dvorak technique version (8.2.1) is running in experimental mode at Satellite Application Unit. Satellite Application Unit is also using microwave imageries operationally from NOAA, NASA-GPM, AMSR2, Metop, DMSP satellites for locating the tropical systems. Satellite Application Unit issues three hourly bulletins in general, and hourly and half hourly bulletins in case of tropical cyclones and other severe weather events.

ISRO successfully launched EOS-06 in November 2022. Satellite Meteorology Division, IMD had started receiving operational Scatterometer data from ISRO from May 2023. Satellite division, IMD, has indigenously devised a software module for operational handling of the Scatterometer data. Data are fetched between dual swath mode in a calendar day through file transfer protocol (FTP) and end products are generated by utilizing various Python libraries on a real time basis. Satellite division has also established a direct file transfer protocol access to the NRSC data repositories for seamless data transfer and product generation. The data output is currently generated in jpg format. The software code for this visualization has been exclusively made at SATMET division for the forecasters and end users. Typical OceanSat imagery during cyclone “SHAKHTI” is presented in Fig. 1.9.

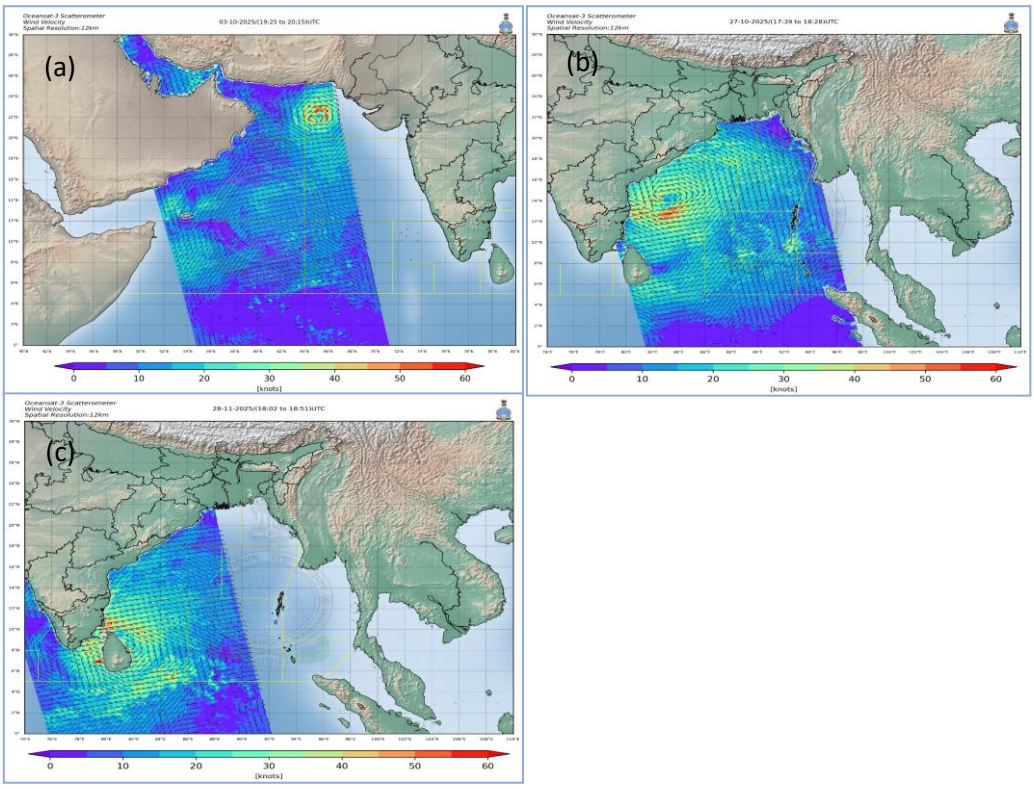


Fig.1.9: Oceansat-3 image of cyclones (a)Shakhti, (b)Montha & (c) Ditwah during 2025

Satellite based Land Surface temperature product is currently generated on a pilot mode for Delhi-NCR region. The region-specific land surface temperature values from INSAT 3D and 3DR are generated for improved understanding of the urban hotspots over the city. This module is also planned for other smart cities in near future. An example is presented is Fig 1.10.

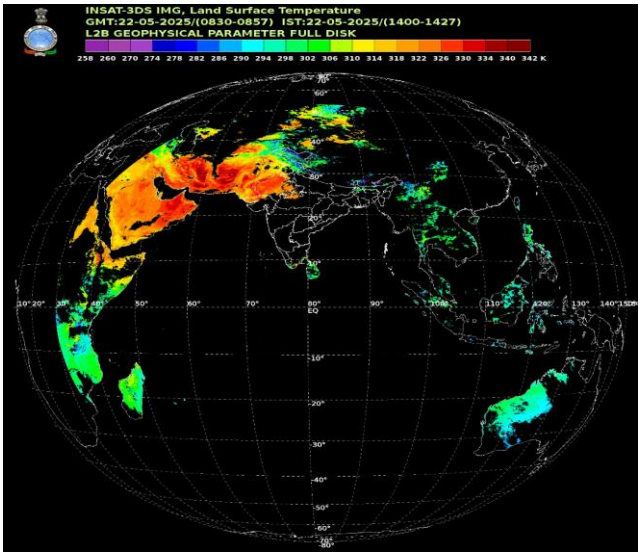


Fig 1.10: Satellite based land surface temperature

Real-time Analysis of Product and Information Dissemination (RAPID) is a visualization tool developed jointly by IMD & ISRO for monitoring and analysis of satellite imageries and products of INSAT 3DS and INSAT 3D(R). A satellite based nowcast tool for its prediction is also available in RAPID. As RAPID is a geo-reference platform, it provides real time information on genesis, growth and decay along with its location and other geo-physical parameters to help forecasters to provide more objective nowcast. This tool is available in IMD website at the link: http://www.rapid.imd.gov.in/

With the Web Archival System developed at IMD, INSAT-3DS and INSAT 3DR products & imageries are archived. Spectral Band images and product images are archived online for last 6 months. The generation of around ten new products has been put in operational chain of MMDRPS to meet the NWP, Forecaster and Agromet services requirement.

INSAT-3DR Imager payload is used to conduct rapid scans during active cyclones following a standard operating procedure. Each Rapid scan cover up 3 degree in N-S direction (6 Blocks/240 scan lines) in 4.5 minutes. Rapid scan data are being used to track these cyclones in real time basis. The processed data is being disseminated on a dedicated webpage (http://satellite.imd.gov.in/ rapid/rapid_scan.htm).

1.3.4.1 Advanced Capabilities of Modern Indian Satellites:

Modern Indian satellites are equipped with sophisticated instruments that provide comprehensive atmospheric observations. These instruments include:

- Multispectral Imagers: These imagers capture images in multiple spectral bands, allowing for detailed analysis of cloud cover, land surface conditions, and ocean features.
- Sounders: Sounders measure the temperature and moisture profiles of the atmosphere, providing crucial information for weather forecasting and climate studies.

The recently launched **INSAT-3DS**, with its improved blackbody calibration and advanced sounder payload, further enhances India's capabilities in satellite meteorology.

By harnessing the power of satellite technology, India has significantly improved its weather forecasting and climate monitoring capabilities, contributing to the safety and well-being of its citizens and the global community.

INSAT-3DS, launched on February 17, 2024, is the latest addition to India's geostationary satellite fleet. It is designed to provide enhanced meteorological observations and monitoring of land and ocean surfaces, significantly improving weather forecasting and disaster warning capabilities.

1.3.4.2 Key Features of INSAT-3DS:

- Advanced Payloads: Similar to INSAT-3D and INSAT-3DR, INSAT-3DS carries a 6-channel imager and a 19-channel sounder.
- Improved Capabilities: The satellite incorporates advancements in radiometric accuracy, black body calibration, thermal management, and imaging throughput.
- Enhanced Data Quality: Provides higher-quality data for more precise weather analysis and forecasting.
- Real-time Monitoring: Contributes to real-time monitoring of weather systems, including cyclones, thunderstorms, and fog.
- Improved Disaster Warning: Helps in early warning systems for extreme weather events like floods, droughts, and heatwaves.

Contribution to Weather Forecasting:

INSAT-3DS, along with INSAT-3DR, plays a crucial role in:

- Accurate Weather Prediction: Provides high-resolution imagery and atmospheric profiles for precise weather forecasting.
- Tropical Cyclone Tracking: Enables real-time monitoring of cyclone formation, intensification, and movement.
- Monsoon Monitoring: Helps in understanding and predicting the Indian monsoon, a vital weather system for the country.
- Extreme Weather Event Monitoring: Detects and tracks extreme weather events like heatwaves, cold waves, and heavy rainfall.
- Climate Studies: Contributes to long-term climate studies and monitoring climate change impacts.

By leveraging the capabilities of these advanced satellites, India is strengthening its capacity to monitor weather patterns, issue timely warnings, and mitigate the impacts of natural disasters

1.3.5. Lightning monitoring:

The occurrence of lightning in India is being monitored with the help of lightning detectors established by Ministry of Earth Sciences and Indian Air Force. Currently, there are 300 No. of lightning detectors in the country. The area of lightning during preceding 5 min, 10 min and 15 min are superimposed with satellite and radar imageries. It helps in proper monitoring of thunderstorm and lightning activities and nowcasting of such events.

A nationwide lightning detection network has been established by IITM Pune. Lightning observations are collected at a 1-minute temporal resolution and are provided to the India Meteorological Department (IMD) on a real-time basis. A merged real-time product combining lightning observations with satellite-derived cloud information from INSAT-3DR/3DS is generated as a half-hourly animation. In this animation, lightning data are categorized into three temporal bins of 10, 20, and 30 minutes and are displayed using different colours; the product is updated every 15 minutes. A time lag of approximately one hour exists between the satellite and lightning observations, primarily due to the satellite scan strategy. The 10-, 20-, and 30-minute intervals shown in the imagery (Fig 1.11) correspond to the timing of the received lightning data.

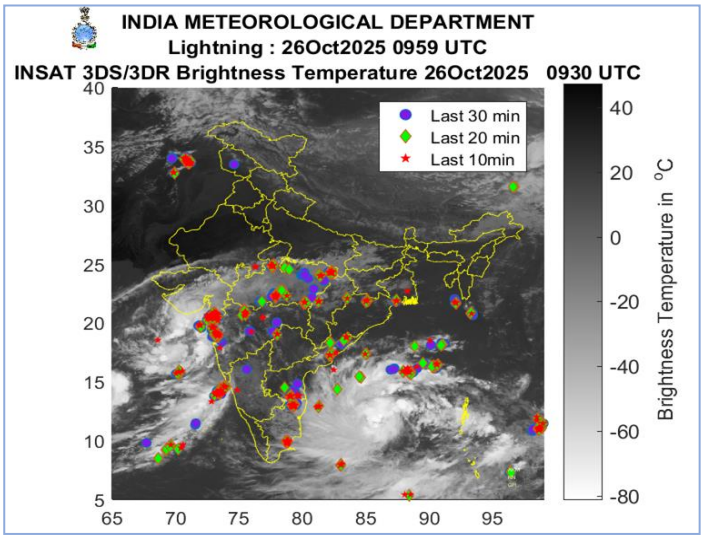


Fig 1.11: The points are lightning flashes/strikes (cloud-to-ground) which is being generated by the ground networks. These flashes/strikes are also superimposing on INSAT-3DR/DS cloud top temperature.

User can access this data through a dedicated link on IMD website: https://mausam.imd.gov.in/http://internal.imd.gov.in/section/satmet/lightning/

1.3.6 Operational forecast and warning production

1.3.6.1 Analysis and Prediction system

Various strategies have been adopted in recent years for improvement of analysis and prediction of cyclone. The tropical cyclone analysis, prediction and decision-making process is made by blending scientifically based conceptual models, dynamical & statistical models, meteorological datasets, technology and expertise. Conventional observational network, automatic weather stations (AWS), buoy & ship observations, cyclone detection radars and satellites are used for this purpose. A new weather analysis and forecasting system in a digital environment is used to plot and analyse different weather parameters, satellite, Radar and Numerical Weather Prediction (NWP) model products. An integrated fully automated forecasting environment facility is thus set up for this purpose.

The manual synoptic weather forecasting has been replaced by hybrid systems in which synoptic method could be overlaid on NWP models supported by modern graphical and GIS applications to produce

- high quality analyses
- Ensemble of forecasts from NWP models at different scales - global, regional and mesoscale
- Prediction of intensity and track of tropical cyclone

A schematic representation of the monitoring and analysis, forecast and warning procedure is given in Fig.1.12

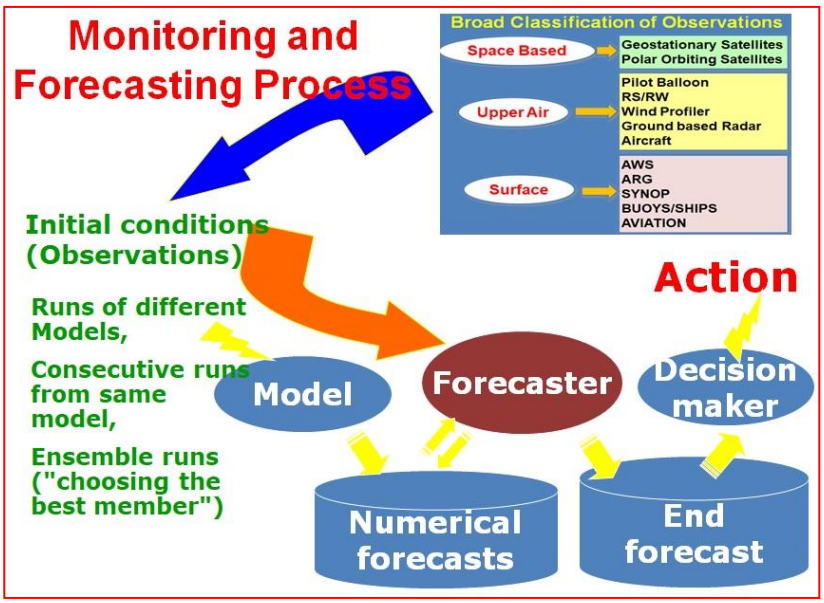


Fig.1.12. Strategy adopted for cyclone analysis and forecasting

The **indigenously developed decision support system has** following facilities.

- Analysis of all synoptic, satellite, radar and NWP model products for genesis, intensity and track monitoring and prediction
- Preparation of past and forecast tracks upto 120 hrs
- Depiction of uncertainty in track forecast
- Preparation of quadrant wind radii forecast upto 120 hrs.

All the available data and products from various national and international sources are systematically considered for analysis and prediction of cyclones. Various data and products utilized for this purpose are as follows.

- ❖ Data and analysis Products through digitized system as mentioned above.
- ❖ Radar data and products from IMD's radar network and neighbouring countries
- ❖ Satellite imageries and products from IMD and international Centers
- ❖ Dynamical and statistical Model products from various national and international Centers.
- ❖ Data, analysis and forecast products from various national and international Centers through internet.

Cloud imageries from Geostationary Meteorological Satellites INSAT-3DS and INSAT-3D (R) are the main sources of information for the analysis of tropical cyclones over the data-sparse region of north Indian Ocean. Data from scatteometry based satellites and Ocean buoys also provide vital information. Ship observations are also used critically during the cyclonic disturbance period. When the system comes closer to the coastline, the system location and intensity are determined based on hourly observations from Radar as well as

from coastal observatories. The AWS stations along coast are also very useful as they provide hourly observations on real time basis. The WVW and CMV in addition to the conventional wind vectors observed by Radio Wind (RW) instruments are very useful for monitoring and prediction of cyclonic disturbance, especially over the Sea region. The direction and speed of the movement of a tropical cyclone are determined primarily from the three hourly displacement vectors of the center of the cyclone. The consensus forecast that gather all or part of the numerical forecast and used synoptic and statistical guidance are utilised for issue of official forecast.

In addition, IMD has developed GIS based decision support indigenously which has the facility to overlay various model products at a single platform. It is utilized by the forecasters to generate probabilistic area of cyclogenesis, multi model based warnings for fishermen, probabilistic area of winds exceeding 25 knots and 34 knots, probabilistic heavy rainfall warning maps etc.

1.3.7 Operational NWP models during 2025

1.3.7.1. Global Forecast System

(a) The Global Forecast System (GFS), adopted from National Centre for Environmental Prediction (NCEP) USA is operationally run at India Meteorological Department (IMD), New Delhi on Cray XC40 based High Power Computing Systems (HPCS). The IMD-GFS (T1534/L64) global model is run with ~12 km horizontal resolution and 64 hybrid sigma-pressure layers with Ensemble Kalman Filter (ENKF) based Grid Point Statistical Interpolation (GSI) scheme as the global data assimilation to generate 10 days forecast. The model is run four times in a day (00, 06, 12 and 18 UTC). The real-time outputs are made available to the national web site of IMD (https://mausam.imd.gov.in/ under Short to Medium Range Model Guidance).
IMD also makes use of NWP products prepared by some other operational NWP Centers like, European Center for Medium Range Weather Forecasting (ECMWF), GFS (NCEP) USA, Japan Meteorological Agency (JMA), UK Meteorological Office (UKMO) model etc.

(b) Bharat Forecast System (Bharat FS) global model of about 6 km horizontal resolution operationally started using by IMD in 2025 May. The model uses novel grid structure Triangular cubical Octahedral grid (TCO) to achieve high resolution forecasts about size of cluster of Panchayats/villages. The Bharat Forecast system will significantly enhance predictive capabilities across a wide range of sectors, including public safety, energy, transportation and agriculture. Its high resolution forecast will support timely decision-making, improve preparedness, optimize resource allocation and in critical situations help save human lives.

1.3.7.2. Regional Forecast System

IMD operationally runs regional models Weather Research Forecast Advance Research for Weather Forecasting (WRFARW) (v3.9) with regional GSI based data assimilation, and Atmosphere-Ocean coupled Hurricane Weather Research and Forecast (HWRF) modelling system for short-range prediction during cyclone.

1.3.7.2.1. Mesoscale modeling system WRF-ARW with regional GSI based Data Assimilation system

The mesoscale Weather Research and Forecast WRF (version 3.9.1) with 3DVAR data assimilation is being operated daily twice to generate mesoscale analysis at 3 km horizontal resolution using IMD GFS-T1534L64 analysis as first guess and forecasts as boundary condition. Using analysis and updated boundary conditions from the WRFDA, the WRF (ARW) is run for the forecast up to 3 days with 3 km and 45 Eta levels in the vertical 4 times a day at 06 hourly interval.

The model domain covers the area between lat. 5ºS to 40ºN long 50ºE to 102ºE covering India and neighbouring south Asian countries. The model runs with its own regional data assimilation (Com GSI V3.7_EnKF1.3).

1.3.7.2.2. Hurricane WRF Model (HWRF)

Since 2011, time to time the HWRF modelling system is developed and customized atmospheric and ocean models with other associated pre-processing and post-processing components are implemented in IMD under the framework of MoU between Ministry of Earth Sciences (MoES) India and National Oceanic and Atmospheric Administration (NOAA) USA. The HWRF version H217 has been ported on the MHIR HPCS with horizontal resolution of 18 km for parent domain and 6km & 2 km for intermediate and innermost nested domains following the center of cyclonic storm. The model is running with 61 vertical levels with parent domain, intermediate and innermost domain covering area of 80°x80^{o}, 24°x24^{o} and 7°x7^{o} respectively. The special feature modified for tropical cyclone forecasting includes vortex initialization and correction, GSI based regional data assimilation, coupler for two-way coupling between atmosphere and ocean components and fine-tuned physical parameterization schemes. This model is customized specifically to forecast the track, intensity and structure of tropical cyclones. The HWRF modelling system uses the dynamics and infrastructure from the Non-Hydrostatic Mesoscale Model (NMM) WRF modelling system. It uses physics that are proven to be better for the tropics. Also, at this time, it is an Ocean coupled model system with a Moving two-way interactive nest, and advanced data assimilation. IMD is operationally running ocean coupled HWRF models during Tropical Cyclone (TC) events with two ocean models viz. Princeton Ocean Model (POM-TC) and Hybrid Coordinate Ocean Model (HYCOM). HYCOM initial conditions are provided through Indian National Centre for Ocean Information Services (INCOIS) whereas POM-TC is initialized based on climatology.

It is run 4 times a day in cyclic mode with GSI based (hybrid-Ensemble Variation (EnVar)) assimilation (80 members) with 6 hourly cycles in cycling mode with full physics configuration. The Unified Post-Processor (UPP) coverts raw model outputs from all three domains into standard GRIB1/2 format. Moreover, Global Fluid Dynamics Laboratory (GFDL) tracker generates track and intensity information in a standard Automated Tropical Cyclone Forecasting System (ATCF) format processing all GRIB files with a specified time interval (3 or 6 hours) as per requirement.

The modeling system was fully operational and predicted all cyclones during the years. Whenever any low-pressure system intensified and became depression over both sub-basins of North Indian Ocean, the cyclic run of the modelling system had been initiated. The model utilized ocean initial state from the INCOIS Tendral Ocean Prediction System – Indian Ocean Model (ITOPSI) during each cycle to initialize the HYCOM ocean component. All available observed data including conventional and satellite observations were assimilated

into the regional GSI system to improve further the initial condition after the vortex initialization of the atmospheric first guess state of the model forecast from previous cycle (except first cycle).

The ocean model provides the SST field to the atmospheric component through coupler during the model integration to update the effect of mixing, cooling as well as advection effect on SST field, whereas the atmospheric component provides the heat fluxes, wind stress, precipitation and surface pressure fields to the ocean model through coupler. The coupled HWRF model uses GFDL vortex tracker and diagnostic software to provide the graphic and text information on track, intensity as well as structure of tropical cyclones for real time operational requirements. The HWRF physics scheme upgrades include updated Scale-Aware Simplified Arakawa-Schubert (SASAS) scheme, Ferrier-Aligo microphysics, GFS Hybrid-EDMF PBL, partial cloudiness for RRTMG scheme, and surface-exchange coefficients in the surface layer.

Within coupled framework of HWRF modeling system, the POM is initialized based on the climatological data whereas the HYCOM is initialized based on the ocean fields from Real-Time Ocean Forecast System (RTOF) of INCOIS, Hyderabad. The atmospheric component of HWRF is initialized based on the analysis and forecast from IMD-GFS (T1534L64) and associated GDAS analysis. The HWRF model uses 3D-EnVAR-GSI as its data assimilation component. The coupled HWRF model is run every 6 hours on real time basis in cyclic mode based on 00, 06, 12, 18 UTC initial conditions to provide track and intensity forecast along with surface wind, rain swaths and other diagnostic products for up to 126 hours.

The coupled HWRF system with both ocean models viz, POM-TC and HYCOM was operational simultaneously and model guidance products were provided from both the configurations. The coupled HWRF model uses TC Vital parameters generated by RSMC, New Delhi every six hour from Deep depression state till landfall of TC

1.3.7.2.3. High Resolution Rapid Refresh Modeling System (HRRR)

The High Resolution Rapid Refresh (HRRR) system based on Weather Research and Forecast (WRF-ARW) model with WRFDA (3DVAR-FGAT) data assimilation is operationalized in IMD in collaboration with Space Application Center (ISRO) from beginning of 2021. The HRRR is hourly updated atmospheric model with horizontal resolution of 2km. The model uses forecast of IMD-GFS (T1534L64) model as first guess and forecast as boundary during cold start and is then cycled providing hourly updates based on Radar Data assimilation. Using analysis and updated boundary conditions from the WRFDA, the HRRR is run to produce forecasts up to 12 hours and forecasts are made available after every two hours on NWP website of IMD.

The model is run in three different domains covering Indian mainland. The three domains are North-West domain, East & North-East domain and South-Peninsular domain. HRRR with hourly updates provide frequent and updated precipitation and reflectivity forecasts with respect to the TCs which could be very useful in planning effective and immediate disaster mitigation strategies in very short range.

1.3.7.2.4. Dynamical statistical models

The method comprises of five forecast components, namely (a) Cyclone Genesis Potential Parameter (GPP), (b) Multi-Model Ensemble (MME) technique for cyclone track prediction, (c) Cyclone intensity prediction, (d) Rapid intensification and (e) Predicting decaying intensity after the landfall.

a) Genesis Potential Parameter (GPP)

A cyclone genesis parameter, termed the genesis potential parameter (GPP), for the North Indian Sea is developed (Kotal et al, 2009). The parameter is defined as the product of four variables, namely relative vorticity at 850 hPa, middle tropospheric relative humidity, middle tropospheric instability, and the inverse of vertical wind shear. The parameter is operationally used for distinction between non-developing and developing systems at their early development stages. The composite GPP value is found to be around three to five times greater for developing systems (T 3.0) than for non-developing systems. The analysis of the parameter at early development stage of a cyclonic storm found to provide a useful predictive signal for intensification of the system.

The grid point analysis and forecast of the genesis parameter up to seven days is also generated on real time. Higher value of the GPP over a region indicates higher potential of genesis over the region. Region with GPP value equal or greater than 30 is found to be high potential zone for cyclogenesis. The analysis of the parameter and its effectiveness during cyclonic disturbances in 2025 affirm its usefulness as a predictive signal (4-5 days in advance) for cyclogenesis over the North Indian Ocean.

b) Multi-model ensemble (MME) technique

The multi model ensemble (MME) technique (Kotal and Roy Bhowmik, 2011) is based on a statistical linear regression approach. The predictors selected for the ensemble technique are forecasts latitude and longitude positions at 12-hour interval up to 120-hour of five operational NWP models. In the MME method, forecast latitude and longitude position of the member models are linearly regressed against the observed (track) latitude and longitude position for each forecast time at 12-hours intervals for the forecast up to 120-hour. The 12 hourly predicted cyclone tracks are then determined from the respective mean sea level pressure fields using a cyclone tracking software. Multiple linear regression technique is used to generate weights (regression coefficients) for each model for each forecast hour (12hr, 24hr, 36 hr, 48hr, 60hr, 72hr, 84hr, 96hr, 108hr and 120 hrs) based on the past data. These coefficients are then used as weights for the ensemble forecasts. 12-hourly forecast latitude (LATf) and longitude (LONf) positions are defined by multiple linear regression technique. A collective bias correction is applied in the MME by applying multiple linear regression based minimization principle for the member models GFS (IMD), GFS (NCEP), ECMWF, UKMO and JMA. ECMWF data are available at 24h intervals. Therefore, 12h, 36h, 60h, 84h, 108h forecast positions of ECMWF are computed based on linear interpolation. All these NWP products are routinely made available in real time on the IMD web site: www.rsmcnewdelhi.imd.gov.in.

New MME based on TC tracker: With the latest version of different models & EPS as well as different tracker used for tracking the centre of TC in models, the IMD has developed another MME for track, intensity & landfall forecasts since 2021. It performs better than the individual models.

c) Statistical Dynamical model for Cyclone Intensity Prediction (SCIP)

A statistical-dynamical model (SCIP) (Kotal et al, 2008) has been implemented for real time forecasting of 12 hourly intensity up to 120 hours. The model parameters are derived based on model analysis fields of past cyclones. The parameters selected as predictors are: Initial storm intensity, Intensity changes during past 12 hours, Storm motion speed, Initial

storm latitude position, Vertical wind shear averaged along the storm track, Vorticity at 850 hPa, Divergence at 200 hPa and Sea Surface Temperature (SST). For the real-time forecasting, model parameters are derived based on the forecast fields of IMD-GFS model. The method is found to be provided useful guidance for the operational cyclone forecasting.

The MME based all available NWP models on EPS is also developed by IMD since 2021 for intensity prediction.

d) Rapid Intensification (RI) Index

A rapid intensification index (RII) is developed for tropical cyclones over the Bay of Bengal (Kotal and Roy Bhowmik, 2013). The RII uses large-scale characteristics of tropical cyclones to estimate the probability of rapid intensification (RI) over the subsequent 24-h. The RI is defined as an increase of intensity 30 kt (15.4 ms-1) during 24-h. The RII technique is developed by combining threshold (index) values of the eight variables for which statistically significant differences are found between the RI and non-RI cases. The variables are: Storm latitude position, previous 12-h intensity change, initial storm intensity, vorticity at 850 hPa, divergence at 200 hPa, vertical wind shear, lower tropospheric relative humidity, and storm motion speed. The probability of RI is found to be increases from 0% to 100% when the total number of indices satisfied increases from zero to eight. The forecasts are made available in real time from 2013.

e) Decay of Intensity after the landfall

Tropical cyclones (TCs) are well known for their destructive potential and impact on human activities. The Super cyclone Odisha (1999) illustrated the need for the accurate prediction of inland effects of tropical cyclones. The super cyclone of Odisha maintained the intensity of cyclonic storm for about 30 hours after landfall. Because a dense population resides at or near the Indian coasts, the decay forecast has direct relevance to daily activities over a coastal zone (such as transportation, tourism, fishing, etc.) apart from disaster management. In view of this, the decay model (Roy Bhowmik et al. 2005) has been used for real time forecasting of decaying intensity (after landfall) of TCs.

1.5.4. Tropical Cyclone Ensemble Forecast based on Global Models Ensemble (TIGGE) Data

The THORPEX Interactive Grand Global Ensemble (TIGGE, Philippe Bougeault et al. 2010) is an implementation of ensemble forecasting for global weather forecasting and is part of THORPEX, an international research programme established in 2003 by the World Meteorological Organization (WMO) to accelerate improvements in the utility and accuracy of weather forecasts up to two weeks ahead. As part of WMO Program to provide a guidance of tropical cyclone (TC) forecasts in near real-time for the ESCAP/WMO Member Countries based on the TIGGE Cyclone XML (CXML) data, IMD implemented JMA supported software for real-time TC forecast over North Indian Ocean (NIO) in 2011. The Ensemble and deterministic forecast products from ECMWF (50+1 Members), NCEP (20+1 Members), UKMO (23+1 Members) and MSC (20+1 Members) are available near real-time for NIO region for named TCs. These Products includes: Deterministic and Ensemble TC track forecasts, Strike Probability Maps, Strike probability of cities within the range of 120 kms 4 days in advance. The JMA provided software to prepare Web page to provide guidance of tropical cyclone forecasts in near real-time for the ESCAP/WMO committee Members. The forecast products are made available in real time.

1.5.5. Global Ensemble Forecast System

The Ministry of Earth Sciences (MoES) has commissioned two very high resolution (12 km grid scale) state-of-the-art global Ensemble Prediction Systems (EPS) for generating operational 10-days probabilistic forecasts of weather since 2018. The EPS involves the generation of multiple forecasts using slightly varying initial conditions. The forecast products from these two prediction systems are available at the following links (http://nwp.imd.gov.in/gefspro.php) and http://www.ncmrwf.gov.in/ product_main.php). The frameworks of the new EPSs are among the best weather prediction systems in the world at present. Very few forecasting centres in the world use this high resolution for short-medium range probabilistic weather forecasts.

1.5.5.1. The Ensemble Mean and Spread

The ensemble spread is a measure of the difference between the members and is represented by the standard deviation (SD) with respect to the ensemble mean (EM). On average, small (high) spread indicates a high (low) forecast accuracy.

- The ensemble spread is flow-dependent and varies for different parameters.
- It usually increases with the forecast range, but there can be cases when the spread is larger at shorter forecast ranges than at longer ranges. This might happen when the initial days are characterized by strong synoptic systems with complex structures but are followed by large-scale "fair weather" high pressure systems.

1.5.6. Models run at NCMRWF

(a) Mithuna Forecast System (Mithuna-FS)

NCMRWF has recently upgraded its operational global forecasting system, moving from the atmosphere–land model NCUM-G to a fully coupled Earth system model known as Mithuna-FS. This model is India's first fully coupled numerical weather prediction system operational for routine short to medium-range forecasting, developed under the MOMENTUM, India-UK partnership. The new system incorporates dynamic exchange processes of heat, momentum, and moisture across the atmosphere, ocean, sea-ice, land components. Solar and terrestrial radiation govern the system's overall energy balance, while hydrological processes further intensify the coupling pathways between the atmosphere and the land surface. Mithuna-FS is operationalized since November, 2025 and routine short- to medium-range forecasts are now being delivered to IMD and other Government agencies, which will further strengthening national forecasting services. The Mithuna-FS suite encompasses modules for pre-processing, observation handling and monitoring, weakly coupled data assimilation, the coupled model components systems. Arunika, petascale high-performance computing (HPC) platform hosts an advanced software ecosystem built to support this modelling system.

(b) Weakly Coupled Data Assimilation (WCDA)

In a weakly coupled data assimilation (WCDA) system, Atmospheric, oceanic, land, and sea-ice components assimilate their respective observations independently using separate data assimilation systems. The updated component states are then combined within a coupled forecast model, where interactions among atmosphere, ocean, land, and sea ice occur only

during the model integration step. No cross-component error covariances are used during the assimilation. The atmospheric deterministic DA system employs a hybrid 4D-Var scheme that blends static and flow-dependent background-error covariances. The ensemble DA system uses a hybrid En-4DEnVar method, in which ensemble-derived covariances are incorporated directly within a four-dimensional variational framework. Ocean and sea-ice analyses are performed using NEMO v4, configured with the SI^3 sea-ice model. The system uses 75 vertical levels, a 20-minute time step, and 1/4° horizontal resolution on the ORCA025 tripolar grid. A 3D-Var FGAT scheme assimilates SST, SSH, T/S profiles, and Sea Ice Concentration, ensuring balanced updates of both oceanic and cryospheric states. The land surface and atmosphere are weakly coupled in the DA cycle: each system computes analysis increments independently but remains linked through the coupled model forecast. The JULES land-surface model, together with a simplified EnKF (sEnKF), enhances soil-moisture analyses and improves the representation of land–atmosphere energy and moisture exchanges.

(c) Mithuna FS: Deterministic

Mithuna-FS is based on the GC5 global coupled configuration (Xavier et al., 2025) comprising Global Atmospheric and Land system (GAL9) , Global Ocean and Sea (GOSI9) with the field exchanges passed through OASIS3 coupler. GOSI9 contains the NEMO 4.0 where Sea Ice-modelling Integrated Initiative (SI3) uses the same grid as the oceanic mesh where the transfer process is more robust and steady. The atmospheric and land component is using UM version 12.1 and the JULES version 7.1 respectively, and is set up with a horizontal resolution of 12 km and 70 vertical levels that span about 80 km. Major science advancement in the UM part is the modification in the mid-level convection to represent both surface-driven deep convection and elevated convection; bimodal cloud scheme and dust based heterogeneous ice nucleation thresholds. Whereas in the JULES, change in the tuning of the surface tile albedo values, and the changes in the soil water retention parameterization. The conductive coupling approach is replacing the default standard bulk formulation used in the NEMO.

(d) Mithuna FS: Ensemble

In the Mithuna-FS, forecast uncertainty is represented through ensemble-based methodologies, with the overall framework derived from the Met Office Global and Regional Ensemble Prediction System–Global. Recent system developments have transformed this framework into a fully coupled atmosphere–ocean ensemble configuration that employs weakly coupled data assimilation and stochastic physics perturbations. A hybrid ensemble–variational approach (En-4DEnVar) provides flow-dependent background-error covariances, leading to improved analysis accuracy.

The Mithuna-FS incorporates these advances by allowing each ensemble member to assimilate nearly all observations used in the deterministic system. Improvements in ensemble spread–skill relationships, particularly in the tropics, are achieved through advanced ensemble data assimilation techniques, including the use of multiple inflation schemes, spatial localisation, and perturbation of observations, which together enhance the representation of initial-condition uncertainty. Additional gains in ensemble spread and reliability are obtained through the application of stochastic physics and parameter- or tendency-perturbation schemes.

The current operational ensemble is integrated at N640L70 resolution, corresponding to an approximately 20-km horizontal grid spacing with 70 vertical levels extending up to a model top of about 80 km. Collectively, these developments enable the Mithuna-FS to generate dynamically consistent, weakly coupled initial states and to deliver robust probabilistic forecasts of high-impact monsoon weather. The system operates with a 44-member ensemble in each assimilation cycle, starting from background states at T–6 h. A mean update is first performed, after which ensemble perturbations are applied to represent initial-condition uncertainty. Each perturbed member undergoes analysis by assimilating atmospheric observations together with soil analysis and perturbations, as well as sea surface temperature (SST) analysis and SST perturbations. The resulting ensemble analyses are used to initialise the EPS forecasts, which consist of a combination of short-cycle members and long-cycle members, thereby enhancing ensemble spread and improving the reliability of probabilistic forecasts.

1.5.7. Models run at IITM Pune

Since 2018, Global Ensemble Forecast System (GEFS) T1534 (~12 km) is used for operational short-range probabilistic weather forecast system including cyclone prediction at IITM. It is based on Global Forecast System (GFS v14.1) which is a part of the 'Operational Model' developed at NCEP, USA in 2018. This is a spectral model with semi lagrangian dynamics and semi implicit time scheme. It has a horizontal resolution of 12.5 km. The total number of 21 Ensembles (20 perturbed forecasts + 1 control forecast) constitutes the ensemble system. These 20 ensembles analysis are generated by Ensemble Kalman Filter (EnKF) method from the forecast perturbation of the previous cycles four times a day (00, 06, 12 and 18 UTC) at all 64 model vertical levels. These analysis perturbations are added to the reconfigured analysis obtained from the hybrid four-dimensional Ensemble variational data assimilation system (GDAS-Hybrid4DEnsVar) as part of the suite. The 243 hour forecast of GEFS is routinely generated based on 00UTC and 12UTC initial conditions which include a control forecast starting from GDAS assimilation and 20 (20 perturbations) ensemble members with each perturbed initial conditions.

1.6 Bulletins and Products Generated by RSMC, New Delhi

RSMC, New Delhi prepares and disseminates the following bulletins:

1.6.1. Extended Range Outlook

IMD started issuing Extended Range Outlook for cyclogenesis during next two weeks every Thursday from 22nd April, 2018. It contains information about large scale features over the region, model guidance on probable cyclogenesis from various global/regional models, probability of cyclogenesis as LOW (0-33%), MODERATE (34-67%) and HIGH (68-100%) alongwith verification of forecast issued during last two weeks. The product is available on RSMC website at http://www.rsmcnewdelhi.imd.gov.in/images/bulletin/eroc.pdf and is also transmitted by email to WMO, WMO/ESCAP panel member countries and various scientists and researchers in the country. The ERF is generated based on consensus approach utilizing the forecast guidance from different deterministic and probabilistic NWP models, ERF models and the large scale processes like convectively coupled equatorial waves such as Maden Julian Oscillation (MJO), Equatorial Rossby waves, Kelvin waves, low background

waves. For details kindly refer SOP of cyclone warning services in India available on RSMC website at https://rsmcnewdelhi.imd.gov.in/report.php?internal_menu=NjE=).

1.6.2 Tropical Weather Outlook

Tropical Weather Outlook (TWO) is issued daily at 0600 UTC based on 0300 UTC observations in normal weather for use of the member countries of WMO/ESCAP Panel. This contains description of synoptic systems over NIO along with information on significant cloud systems as seen in satellite imageries. It also provides probabilistic genesis forecast (formation of depression) over Bay of Bengal and Arabian sea separately for day 1 (up to 24 hrs), day 2 (24 – 48 hrs), day 3 (48 – 72 hrs), day 4 (72-96 hrs), day 5 (96-120 hrs), day 6 (120-144 hrs) and day 7 (144-168 hrs). The forecast is issued in probabilistic terms like Nil, Low, Moderate and High probability corresponding to expected probability of occurrence of 00, 01 – 33, 34 – 67 and 68 – 100 %. It is based on the consensus developed from various NWP and dynamical statistical guidance coupled with guidance from observations and analyses. This forecast has been introduced since 1st June 2014 upto 72 hrs lead period. The lead period of cyclogenesis forecast has been extended to 120 hrs since 22nd April, 2018 and upto 168 hours since September, 2023. The area of genesis is also marked graphically.

The outlook is generated based on consensus approach utilizing the forecast guidance from different deterministic and probabilistic NWP models, the large scale processes like convectively coupled equatorial waves such as Maden Julian Oscillation (MJO), Equatorial Rossby waves, Kelvin waves, low background waves and the guidance on genesis potential parameters. For details kindly refer SOP of cyclone warning services in India available on RSMC website at https://rsmcnewdelhi.imd.gov.in/report.php?internal_menu=NjE=.

1.6.3 Pre-Genesis Forecast:

India Meteorological Department has commenced pre-genesis forecast of probable date, time and location of expected cyclogenesis (formation of depression) over the NIO along with 12 hourly forecast of track, intensity and structure upto next 72 hours, once daily from the stage of low pressure area on 17th March, 2022. Typical example of pre-genesis forecast issued during cyclone “MONTHA” is presented in Fig. 1.13.

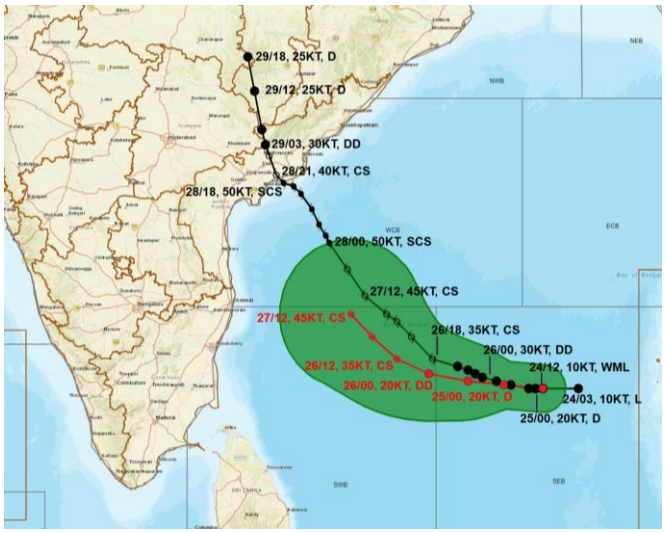


Fig. 1.13: Pre-genesis forecast issued at the stage of well marked low pressure area based on 1200 UTC of 24th October, 2025

The pre-genesis forecast is generated based on consensus approach utilizing the forecast guidance from different deterministic and probabilistic NWP models, and the large scale processes like convectively coupled equatorial waves such as Maden Julian Oscillation (MJO), Equatorial Rossby waves, Kelvin waves, low background waves and regional scale process as well as genesis potential parameters. For details kindly refer SOP of cyclone warning services in India.

1.6.4. Special Tropical Weather Outlook

The Special Tropical Weather Outlook is issued at +03 hours based on observations of 0000, 0300, 0600, 1200 & 1800 UTC observations when a tropical depression forms over NIO. These bulletins contain the current position and intensity, past movement, central pressure of the cyclone, description of satellite imageries, cloud imageries, expected direction and speed of movement, expected track and intensity of the system up to 72 hrs in case of depression and upto 120 hrs in case of a deep depression. It also includes the description of sea condition. It also includes discussion on various diagnostic and prognostic parameters. The 72 and 120 hours track and intensity forecasts are being issued from the stage of depression and deep depression respectively since 2009 and 2018. The track and intensity forecast are issued for +06, +12, +18, +24, +36, +48, +60, 120 hours or till the system is likely to weaken into a well marked low pressure area. IMD has initiated to give the quantitative forecast of track & intensity from depression stage for lead period of +12, +24, +48, +72 hours since April 2018. The time of issue of this bulletin is HH+03 hours. The cone of uncertainty in the track forecast is also included in the graphical presentation of the bulletin. (Fig.1.5). Tropical weather outlooks are transmitted to panel member countries through global telecommunication system (GTS) & e-mails and are also made available on real time basis through internet at IMD's website: **www.mausam.imd.gov.in and www.rsmcnewdelhi.imd.gov.in**. RSMC, New Delhi can also be contacted through e-mail (**cyclonewarningdivision@gmail.com**) for any real time information on cyclonic disturbances over NIO.

1.6.5 Tropical Cyclone Advisories

Tropical cyclone advisory bulletin is issued when a deep depression intensifies into a tropical cyclone (wind speed= 34 knots or more). It replaces the ‘special tropical weather outlook’ bulletin. Tropical cyclone advisories are issued at 3 hourly intervals based on 00, 03, 06, 09, 12, 15, 18 and 21 UTC observations. The time of issue is HH+03 hrs. These bulletins contain the current position and intensity, past movement, central pressure of the cyclone, description of satellite imageries, cloud imageries, expected direction and speed of movement, expected track and intensity of the system up to 120 hours like that in special tropical weather outlook. The expected point and time of landfall, forecast winds, squally weather and state of the Sea in and around the system are also mentioned. Storm surge guidance is provided in the bulletin as and when required. Tropical cyclone advisories are transmitted to panel member countries through e-mails & GTS and are also made available on real time basis through internet at IMD's website: **www.mausam.imd.gov.in** and **www.rsmcnewdelhi.imd.gov.in**. RSMC New Delhi introduced confidence level in current and forecast location & intensity as low, moderate and high wef post monsoon cyclone season 2025. Track and Intensity estimate is based on multiple data sources including satellite, scatterometer, multi-satellite based winds, radar, synoptic, guidance from other centres etc. Considering the variation in the estimate by different sources, probability or confidence in estimation of intensity and location is decided as given in Table 1.1 and Table 1.2 respectively.

Table 1.1: Confidence level for estimation of intensity

Range	Confidence Level
<10 kt	High
10-20 kt	Moderate
>20 kt	Low

Table 1.2: Confidence level for estimation of location corresponding to various lead period

Lead time (hr)	Confidence level		
	Low	Moderate	High
0	>0.5°	0.3° - 0.5°	0.3°
+24	>1.0°	0.5° - 1.0°	0.5°
+48	>1.5°	1.0° - 1.5°	1.0°
+72	>2.0°	1.5° - 2.0°	1.5°
+96	>2.5°	2.0° - 2.5°	2.0°
+120	>3.0	2.5° - 3.0°	2.5°
+144	>3.5°	3.0° - 3.5°	3.0°
+168	>4.5°	4.0° - 4.5°	4.0°

1.6.6 Storm Surge Guidance

RSMC New Delhi is providing storm surge guidance to the panel member countries since 2009 based on IIT Delhi Storm Surge model and. Recently INCOIS Hyderabad has developed an ADvanced CIRCulation (ADCIRC) Storm Surge and Coastal Inundation model which is running experimentally since 2013. In future it will be used as an input for providing storm surge guidance to member countries. RSMC New Delhi also commenced probabilistic storm surge guidance from Severe Cyclonic Storm “Remal” in May 2024 experimentally.

1.6.7. Severe Weather Forecasting Programme (SWFP):

Under WMO’s Severe Weather Forecasting Programme (SWFP), RSMC New Delhi provides severe weather guidance to 9 countries in South Asia including Thailand, Myanmar, Bangladesh, Bhutan, Nepal, India, Sri Lanka, Maldives and Pakistan through a dedicated web-portal and email. RSMC monitors and forecasts following weather parameters: (a) Heavy rain (due to tropical cyclone, thunderstorm, monsoon, etc.) / flooding; (b) Strong winds (due to tropical cyclone, thunderstorm, monsoon, etc.); (c) High waves; (d) Cyclonic disturbances; (e) Storm surge and (f) Flash Flood guidance

RSMC provides daily, the forecast for next 5 days of above referred parameters and following guidance products are generated: (i) Weather guidance in graphical format including 5 days forecast of heavy rainfall, wind, wave height, cyclonic disturbance and storm suge in graphical format (ii) Discussion including (a) weather inference, (b) satellite based inference of convective clouds over the region, (c) INSAT 3D and Hydro estimated quantitative precipitation estimate, (d) convection associated with cyclonic disturbances alongwith information about location and intensity in terms of T.No., (e) Broad scale features

including madden Julian Oscillation Index during next 5 days, discussion about heavy rainfall and strong winds in textual format for all 95 sub-divisions (iii) Risk guidance in graphical and tabular form for all 95 sub-divisions for heavy rainfall and strong winds (iv) Storm surge ≥ 1 m over and above astronomical tide.

1.6.8 Marine weather forecast bulletins

Under Global Maritime Distress and Safety System (GMDSS) Scheme, India has been designated as one of the 16 services providers in the world for issuing Sea area bulletins for vessels on high seas for broadcast through GMDSS for MET AREA VIII (N), which covers a large portion of NIO. As a routine, two GMDSS bulletins are issued at 0900 and 1800 UTC. During tropical cyclones/ depressions, additional bulletins (up to 4) are issued for GMDSS broadcast. In addition, sea area bulletin, coastal weather bulletins are also issued for broadcast through NAVTEX transmitting stations. Fleet Forecasts for Indian seas are also issued for Indian Navy twice a day with validity period of twelve hours.

Port Warnings & fishermen warnings are also issued for the entire Indian coast as and when the coast is likely to be affected due to disturbances in seas. IMD has initiated to issue the fishermen warning for entire BoB and AS since April, 2018. Further a graphics based fishermen warning is being generated for entire BoB and AS since 26th April 2019. Sample fishermen graphics is placed at Fig. 1.14.

The fishermen warnings for next 5 days based on multi-model ensemble and probability of exceedance of winds ≥ 45 kmph and 35 knots are available at www.rsmcnewdelhi.imd.gov.in.

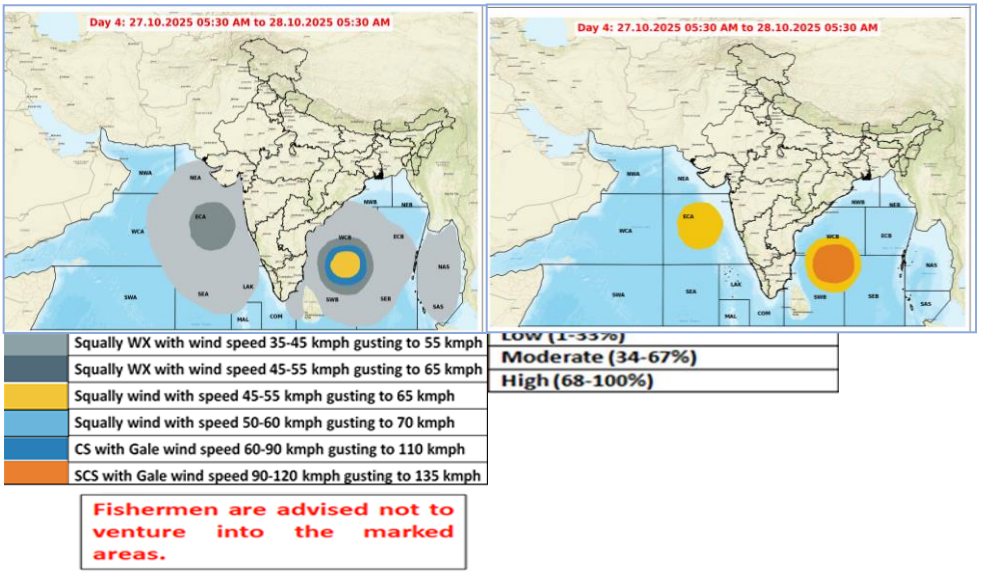


Fig. 1.14: Typical (a) fishermen warning graphics and probabilistic map for wind exceeding 45 kmph issued on 24th October, 2025 for 27th October during cyclone Montha

IMD has also commenced preparation of marine weather bulletins in graphical format using QGIS tool and these graphical products are also available over GIS platform since January, 2021 based on multi model ensemble guidance. During the cyclonic disturbance

period the frequency of these bulletins increase. Kindly refer SOP for detailed information available on RSMC website (www.rsmcnewdelhi.imd.gov.in).

1.6.9. Tropical Cyclone Advisories for Aviation

Tropical Cyclone Advisories for aviation are issued for international aviation as soon as any disturbance over the NIO attains or likely to attain the intensity of cyclonic storm (maximum sustained surface wind speed ≥ 34 knots) within next six hours. These bulletins are issued at six hourly intervals based on 00, 06, 12, 18 UTC synoptic charts and the time of issue is HH+03 hrs. These bulletins contain present location of cyclone in lat./long., maximum sustained surface wind (in knots), direction of past movement and estimated central pressure, change in intensity, forecast position as Lat./Long (in degree & minutes), and forecast winds in knots valid at HH+6, HH+12, HH+18 and HH+24 hrs. The tropical cyclone advisories are transmitted on real time basis through GTS & AFTN channels to designated International Airports of the region prescribed by ICAO and ftp to ADRR, Hong Kong (WMO's Aviation Disaster Risk Reduction) in coded form. It is also sent in graphics form in PNG format through GTS. The text and graphical bulletins are also uploaded on www.rsmcnewdelhi.imd.gov.in

1.6.10. National bulletin

These bulletins are issued from the stage of low pressure area as a "Special Message", once daily. In case of cyclones, IMD follows a 4 stage warning system with issue of (a) pre-cyclone watch at least 72 hours, (b) cyclone alert at least 48 hours, (c) cyclone warning at least 24 hours and (d) post landfall outlook for the interior districts issued 12 hours ahead of commencement of adverse weather over the coast. During the stage of depression/deep depression; it is issued 5 times daily based on 00, 03, 06, 12, and 18 UTC observations. When the system intensifies into a cyclonic storm over NIO, these bulletins are issued every three hourly based on 00, 03, 06, 09, 12, 15, 18 and 21 UTC (every three hourly interval) at +03HH. This bulletin contains present status of the system i.e. the location, intensity; past movement and forecast track & intensity for next 120 hours or till the system weakens into a low pressure area, likely landfall point & time and likely adverse weather including heavy rain, gale wind & storm surge. Expected damage and action suggested are also included in these bulletins. This bulletin is completely meant for national users and these are disseminated through various modes of communication including Email, Telephone/FAX, All India Radio, Doordarshan (National TV), SMS and Print & electronic media. It is also posted on cyclone page of IMD website and RSMC website. These are also posted on social networking sites like facebook, tweeter and whatsapp.

1.6.11. Cone of uncertainty forecast

The Cone of uncertainty (COU) represents the uncertainty in forecast centre of a CD/TC's and is made by drawing a set of circles centered at each forecast point—06, 12, 18, 24, 36, 48, 60, 72, 84, 96, 108 and 120 hours for a five-day forecast. IMD introduced COU forecast upto a lead period of 72 hours in 2009 from Cyclone "WARD". The lead period was further extended to 120 hours in 2013 from Cyclone "VIYARU". COU values were revised in 2014 from cyclone "Hudhud" based on the errors during 2009-13. From cyclone FANI, 2019, the COU values have been revised based on the errors during 2014-18. Thereafter, again, the COU values have been revised from post monsoon season 2025 based on the

operational errors during 2020-24. The standard errors (nm) as radius of the circle around the forecast position (lat/long) so as to construct the cone of uncertainty in the track forecast for 00, +06, +12, +18, +24, +36, +48, +60, +72, +84, +96, +108 and +120 hrs lead period have been fixed as 10, 20, 25, 35, 40, 50, 60, 70, 85, 100, 115, 130 and 145 nm since April, 2025. Typical observed and forecast track alongwith cone of uncertainty demonstrating accuracy in track forecast during Severe Cyclonic Storm "MONTHA" is presented in **Fig. 1.15**. This product is uploaded on various websites of IMD viz. www.rsmcnewdelhi.imd.gov.in and www.mausam.imd.gov.in in .png format and appended with the national and tropical cyclone advisory bulletins. Since, severe cyclonic storm "Nisarga" in June, 2020, this product was also made available on GIS based platform at www.rsmcnewdelhi.imd.gov.in

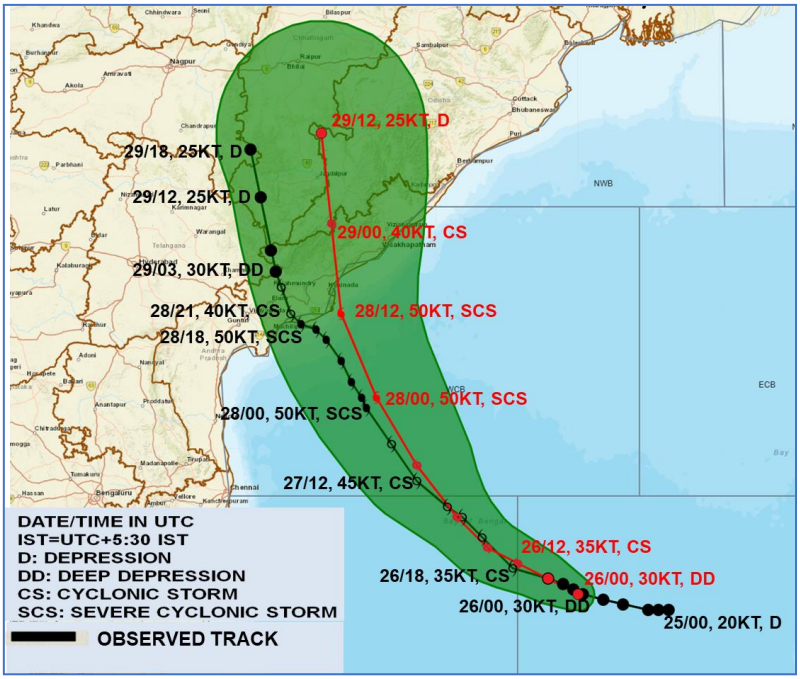


Fig.1.15: Observed track and forecast based on 25th Oct./ 0000 UTC (0530 IST) demonstrating accuracy in track & intensity forecast

1.6.12. Wind forecast for different quadrants

The forecast of the radius of maximum sustained wind in four quadrants of a cyclone commenced with effect from the cyclone, GIRI during October 2010. In this forecast, the radius of 28, 34, 50 and 64 knot winds are given for various forecast periods like +06, +12, +18, +24, +36, +48, +60, … 120 hrs. A typical graphical presentation of this forecast is shown in Fig.1.16. This product is uploaded on various websites of IMD viz. www.rsmcnewdelhi.imd.gov.in and www.mausam.imd.gov.in in PNG format and appended with the national and tropical cyclone advisory bulletins. Since, severe cyclonic storm "Nisarga" in June, 2020, this product was also made available on GIS based platform at www.rsmcnewdelhi.imd.gov.in. It is also uploaded on RSMC, New Delhi website in textual form.

1.6.13 Hourly Update

On the day of landfall IMD issues hourly updates on the landfalling cyclone over the Indian coast since October, 2014. It contains information about the centre, it's distance &

direction from the station, landfall point and time, current maximum sustained wind speed (MSW), MSW at the time of landfall. These bulletins are available at http://www.rsmcnewdelhi.imd.gov.in/images/bulletin/hourly.pdf on the day of landfall.

1.6.14 TC Vital

The TC Vital is issued by RSMC New Delhi to various NWP Centres in coded form for their use in creating the synthetic vortex in NWP models and running storm surge and coastal inundation model. It is issued 4 times a day based on 00, 06, 12 and 18 UTC. This bulletin contains the information on location (Latitude/Longitude), intensity (MSW and estimated central pressure), movement (Speed/Direction), size, the radius of maximum wind and wind radii of 34kts wind in 4 geographical quadrants namely NE, NW,SE and SW quadrants etc. This bulletin has been introduced in 2012.

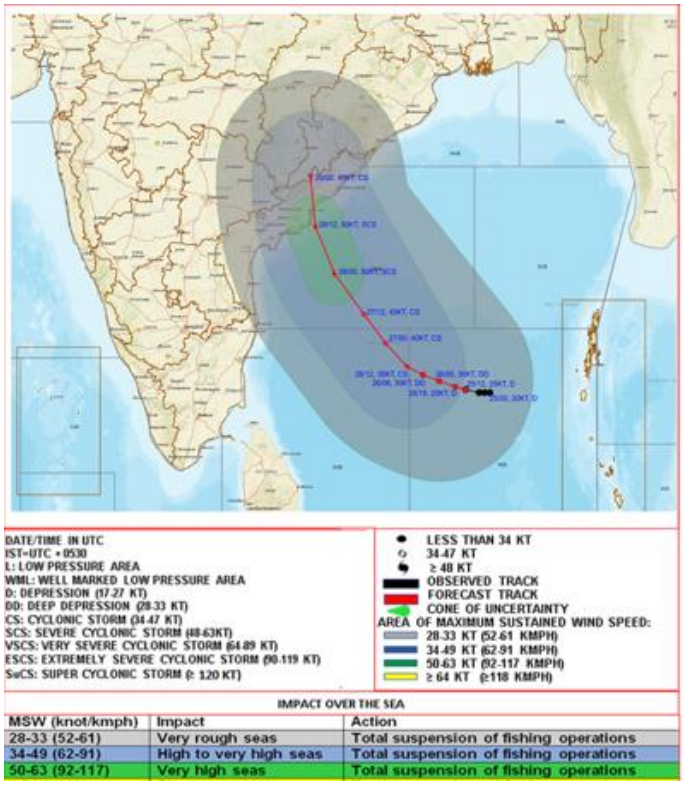


Fig. 1.16: Observed and forecast track alongwith quadrant wind distribution based on 1730 hrs IST/1200 UTC of 25th October during cyclone Montha

1.6.15. Customised Location Specific Forecast for offshore/onshore industries

IMD commenced customised location specific forecast for offshore/ onshore industries since post-monsoon season 2021 (Fig. 1.17). The customised bulletins are issued with commencement of track and intensity forecast. In addition to the track, intensity, wave height forecast, these bulletins also share specific information about the time when the system will come closest to a location, minimum distance & direction and expected intensity at that time alongwith wave height and associated uncertainties in path & intensity. These bulletins are shared with specific users by email. Currently, IMD is preparing customised location specific forecast for about 500 locations of various users including offshore/onshore industries, Indian Coast Guard, Indian Air Force, Ports, Nuclear Power Corporation of India Limited etc.

1.7 Associated weather warnings

1.7.1. Heavy rainfall warnings

Heavy rainfall warning is issued in each cyclone forecast commencing from pre-genesis, pre-cyclone watch, cyclone alert, cyclone warning and post landfall outlook. It has been made mandatory to provide 3-hourly observations and warnings information to disaster management authorities and other state users through WhatsApp group, website, E-mail and all other possible means of communication.

TABLE 4: CYCLONIC DISTURBANCE FORECAST FOR BAY OF BENGAL & MAJOR AREAS OF E&P OPERATIONS BASED ON 0530 hrs IST of 30th November,2025

SI	DESCRIPTION OF SITE NAME(LAT°N /LON°E)	LOCATION		CURRENT LOCATION FROM CENTRE OF CYCLONIC DISTURABANCE		FORECAST PARAMETERS WHEN THE SITE WOULD BE NEAREST TO THE CYCLONE PATH							
		LAT (°N)	LON (°E)	DISTANCE (NM)	DIRECTION	DATE/ TIME(IST) OF OCCURRENCE	DISTANCE OF SITE FROM PATH	DIRECTION OF SITE FROM PATH	UNCERTAINTY IN DISTANCE OVER PATH(NM)	MSW OVER SITE(KTS)	UNCERTAINTY IN MSW OVER SITE(KT)	SIGNIFICANT WAVE HEIGHT (m)	STATE OF SEA
BAY OF BENGAL (PY-1 BLOCK IN THE CAUVERY BASIN OF TAMIL NADU)													
11.	PY-1(A) (11.52,79.88)	11.1	80.6	49	WNW	30.11.25/1130	36	W	20	40	5	2.5-4.0	Rough
12.	PY-1(B) (11.56,79.92)	11.1	80.6	48	NW	30.11.25/1130	34	W	20	40	5	2.5-4.0	Rough
13.	PY-1(C) (11.5,80.0)	11.1	80.6	42	NW	30.11.25/1130	30	WSW	20	40	5	2.5-4.0	Rough
14.	PY-1(D) (11.45,79.95)	11.1	80.6	43	WNW	30.11.25/1130	33	WSW	20	40	5	2.5-4.0	Rough

ZONE	PARAMETERS
GREEN	NORMAL SITUATION, NO FORECAST OF CYCLONE
YELLOW	(1) THE STORM CENTRE WITHIN 800 NM FROM LOCATION AND (2) THE FORECAST TRACK IS FORECAST TO BE WITHIN 300 NM FROM LOCATION AND (3) SUSTAINED WIND SPEED ALONG THE PATH IS FORECAST TO EXCEED 28 KTS
ORANGE	(1) THE STORM CENTRE WITHIN 600 NM FROM LOCATION AND (2) THE FORECAST TRACK IS FORECAST TO BE WITHIN 200 NM FROM LOCATION AND (3) SUSTAINED WIND SPEED ALONG THE PATH IS FORECAST TO EXCEED 50 KTS
RED	(1) THE STORM CENTRE WITHIN 300 NM FROM LOCATION AND (2) THE FORECAST TRACK IS FORECAST TO BE WITHIN 150 NM FROM LOCATION AND (3) SUSTAINED WIND SPEED ALONG THE PATH IS FORECAST TO EXCEED 65 KTS

Fig. 1.17: Sample customised location specific forecast for offshore industries

1.7.2. Wind warnings:

Warnings alongwith impact associated with squally weather and gale winds in association with cyclonic storms and their remnants are issued over the sea and land area as well till it becomes less marked in textual and graphical format.

1.7.3. Storm Surge warnings:

Storm surge warnings are issued both in textual and graphical format, on issue of track and landfall forecast. Storm surge warning is also issued when there is no landfall, but cyclone is expected to lie very close to the coast about 0.5^0.

1.8. Impact based forecast and risk based warnings

India Meteorological Department introduced impact based forecasts (IBF) & warnings for cyclonic storms since 1990 based on historical damage. Recently, since 2014, IMD introduced colour coded IBF for various severe weather events as per WMO guidelines.

Web Based Dynamic Composite Risk Atlas (Web-DCRA) & DSS Tool

Web-DCRA&DSS Tool for Cyclone impacts forecasting for the area falling within 10 m elevation above mean sea level in 13 Coastal States/UTs of the Country has been developed under National Cyclone Risk Mitigation Project (NCRMP) Phase II and is installed/hosted at IMD, HQ, New Delhi. The responsibility for operating the DSS Tool at central level has been entrusted to IMD, being Nodal Agency for cyclone warning, while outputs of Web-DCRA & DSS Tool is being accessed by States through State specific credentials and utilized by Disaster Management Authorities in all 13 coastal States/UTs for mitigation planning and decision making during cyclonic event. The Web-DCRA & DSS Tool has been operationalized during the cyclone 'Biparjoy' in 2023.

The outputs of Web-DCRA & DSS Tool are probabilistic and real-time hazard layer of cyclonic wind, storm surge and cyclone induced rainfall flooding, which can be used by Disaster Management Authorities of the 13 cyclone-prone States and Union Territories (UTs) of India in advance mitigation planning as well as dynamic response during a real time cyclonic event. Using this Tool, dynamic and impact-based cyclone warnings will be release by IMD aiming to minimize economic losses and damage to property due to the intense weather system. The Offline version of Web-DCRA has been installed in State Disaster Management Authority (SDMA) for routine updation of exposure database by the coastal States.

1.9. Cyclone Warning Dissemination System

Cyclone warnings are disseminated to various users through telephone, fax, email SMS, Global Telecommunication System (GTS), All India Radio, FM & community radio, Television and other print & electronic media, press conference & press release. All cyclone warnings and advisories are also made available on the IMD website at **https://rsmcnewdelhi.imd.gov.in**.

India Meteorological Department has taken various initiatives in recent years for improvement in the dissemination of weather forecast and warning services based on latest tools and technologies. Since 2009, IMD has started SMS based weather and alert dissemination system through AMSS (Transmet) at RTH New Delhi.

To further enhance this initiative, India Meteorological Department has taken the leverage of Digital India Programme to utilize "Mobile Seva" of Department of Electronics and Information Technology (DeitY), Ministry of Communication and Information Technology; Govt. of India for SMS based Warnings /Weather information dissemination for a wide range of users. The SMS based cyclone alert to the registered users including public was inaugurated on 25th December 2014. Global Maritime Distress and Safety System (GMDSS) message is made available on RSMC New Delhi website, as well as transmitted through GTS and International Maritime Satellite (INMARSAT).

New IMD website dedicated to general public (**https://mausam.imd.gov.in**) was launched by Hon'ble Minister of Earth Sciences, Dr Harsh Vardhan on 27th July, 2019. Cyclone related bulletins are uploaded on this site since July, 2019.

IMD has also started issuing of NAVTEX bulletins for the coastal region along east as well as the west coast of India for the operation of lightships and fishermen from 30th March 2016, for quick dissemination of warning against impending disaster from approaching cyclones. This is a direct broadcast service of cyclone warning in the regional languages meant for the areas affected or likely to be affected by the cyclone.

In addition, the SMS-based alert/warnings are issued to registered farmers through Kisan portal of Govt. of India (Ministry of Agriculture) and to registered fishermen through Indian National Centre for Ocean Information Sciences (INCOIS), Hyderabad also.

Since 2019, the India Meteorological Department (IMD) has been issuing cyclone warnings through the UMANG mobile application. Since July 2020, a dedicated mobile application, MAUSAM, has also been made available to the public for disseminating weather warnings and alerts. In addition, IMD has initiated the dissemination of weather information using the Common Alerting Protocol (CAP) for cyclone warnings. IMD's CAP feeds are automatically aggregated to the WMO Alert Hub at https://alert-hub.org. These alerts are also disseminated to Global Multi-Hazard Alert System (**GMAS**) portal (https://gmas.asia/), Google , AccuWeather, the Weather Company. Notably, since Super Cyclone Amphan in 2020, cyclone warnings have been disseminated through the CAP framework. These information are also being disseminated through GAGAN and NavIC, SACHET Mobile app, web portal and browser based notifications. IMD has also commenced sharing of cyclone bulletins through WhatsApp with 13 WMO/ESCAP panel member countries in 2023. Application Programming Interface (API) has been developed for various products like heavy rainfall, cyclones, rainfall, thunder storms, heat wave etc in 2021. It is used by various stake holders within the country and outside including Global Multi-hazard Alert System (GMAS) of WMO, Google, Apple, windy etc. and various state governments. Public can also report their observations (in text and image format) along with their location and time of the events through Crowd source web interface launched in 2021. This feature is available in the "Public Observation" section of Mausam website of IMD (https://city.imd.gov.in/citywx/crowd/enter_th_datag.php) and MAUSAM mobile App. IMD is also sharing cyclone warnings through different social media platforms like facebook, twitter, YouTube etc, which includes weather briefing videos and posts.

Cyclone warning information are being disseminated through AFTN (Aeronautical Fixed Telecommunication Network) for aviation safety.

1.10. Tropical Cyclone Forecasting Programme (TCFP) on Landfalling Tropical Cyclones over the Bay of Bengal

A Forecast Demonstration Project (FDP) on landfalling tropical cyclones over the Bay of Bengal was taken up in 2008. It helps us in monitoring and prediction of a tropical cyclone. The project is operated during 15 October to 30th November every year. The demonstration project has been renamed as Tropical Cyclone Forecasting Programme (TCFP) in 2022. During the year 2025, the TCFP campaign commenced on 15th October and was extended upto 15th December 2025. Like previous years (2008-2021), several national institutions participated for joint observational, communicational & NWP activities. There was an improved observational campaign with the observation from Buoys, Scatterometer based satellite and microwave imageries products. The daily reports were prepared during this period to find out the characteristics of genesis, intensification, and movement of the systems as well as environmental features over the NIO. During the period intense observation period was declared for various coastal states of India along the east & west coasts and for Oman, Yemen & Bangladesh in association with depressions/deep depressions and tropical cyclone. All the bulletins issued during the period have been archived and are available on the RSMC, New Delhi website. The detailed report on implementation of TCFP are available at RSMC, New Delhi website.

CHAPTER-II

CYCLONIC ACTIVITIES OVER NORTH INDIAN OCEAN DURING 2025

The salient features of the cyclonic disturbances (CDs) over the north Indian Ocean (NIO) during the year 2025, the operational forecast performance of India Meteorological Department (IMD) and new initiatives during the year are presented below:

2.1. Salient features of CDs over the RSMC region

Following CDs developed over the RSMC region (Bay of Bengal, Arabian Sea and Land region) during 2025:

1. Depression over the Arabian Sea (24–25 May, 2025)
2. Deep Depression over Northwest Bay of Bengal off West Bengal–Bangladesh Coasts (29–30 May, 2025)
3. Depression over Southeast Gangetic West Bengal and Adjoining Bangladesh (14–15 July, 2025)
4. Depression over Central Parts of North Rajasthan (15 July, 2025)
5. Depression over Southeast Uttar Pradesh (17–19 July, 2025)
6. Depression over Northwest Bay of Bengal (25–27 July, 2025)
7. Depression over Northwest and Adjoining Westcentral Bay of Bengal (18–19 August, 2025)
8. Land Deep Depression over Southwest Rajasthan and Neighbourhood (06–10 September, 2025)
9. Depression over Northwest and Adjoining Westcentral Bay of Bengal (26–28 September, 2025)
10. Deep Depression over Westcentral Bay of Bengal (01–03 October, 2025)
11. Severe Cyclonic Storm SHAKHTI over Northeast Arabian Sea (01–07 October, 2025)
12. Depression over Southeast Arabian Sea (22–31 October, 2025)
13. Severe Cyclonic Storm MONTHA over Westcentral Bay of Bengal (25–29 October, 2025)
14. Cyclonic Storm “SENYAR” over the Strait of Malacca (25-27 November, 2025)
15. Cyclone “DITWAH” over Bay of Bengal (27th November – 03 December 2025)

Observed tracks of the CDs during 2025 are presented in **Fig. 2.1.1.**

- Annual activity: Year 2025 witnessed the formation of 15 cyclonic disturbances (CDs) (maximum sustained wind speed (MSW) ≥ 17 knots) i.e. depressions and cyclones over the north Indian Ocean (NIO) including 7 over the Bay of Bengal (BoB) and 3 over the Arabian Sea (AS) and 4 over land against the normal of 11.2 CDs per year over the NIO based on the data of 1965-2024. Thus, the activity of formation of CDs was above normal.
- Category-wise activity: There were 11 depressions/deep depressions (MSW: 17-33 knots) against a normal of 6.5 per year. There were 4 cyclones (MSW:≥34 knots) against a normal of 4.6 per year. It included 2 cyclonic storms (MSW:34-47 knots) and 2 severe cyclonic storms (MSW:48-63 knots) Overall, there were above normal number of depressions/ deep depressions during 2025. It was mainly due to an increased number of CDs during the monsoon season which was an above normal monsoon rainfall season.
- Basin-wise activity: There were 3 CDs over AS against normal of 2.3, 8 CDs over BoB against normal of 7.8 and 4 CDs over land against normal of 1.1. Hence higher number of

CDs in 2025 was mainly due to land depressions/deep depressions during monsoon season 2025.

- Season-wise activity: There were 2 CDs during pre-monsoon season (March-May) against normal of 1.4, 7 CDs during monsoon season (June-Sep) against normal of 4.9 and 6 CDs during post-monsoon season (Oct-Dec) against normal of 4.8. Thus, the above normal genesis of CDs during 2025 was mainly during monsoon and post-monsoon seasons.
- Tracks/Paths of cyclones (Straight/recurving): All 4 cyclones (Shakhti, Montha, Senyar and Ditwah) had recurving tracks.
- Landfall of cyclones: Out of 4 cyclones, 3 crossed the coast as cyclones against normal of 3.2 per year. Shakhti dissipated over sea, Montha crossed Andhra Pradesh coast (India) as a severe cyclonic storm, Senyar crossed Indonesia coast as a cyclonic storm and Ditwah moved across Sri Lanka as a cyclonic storm. However, only 1 cyclone (Montha) crossed India coast against the normal of 2 per year.

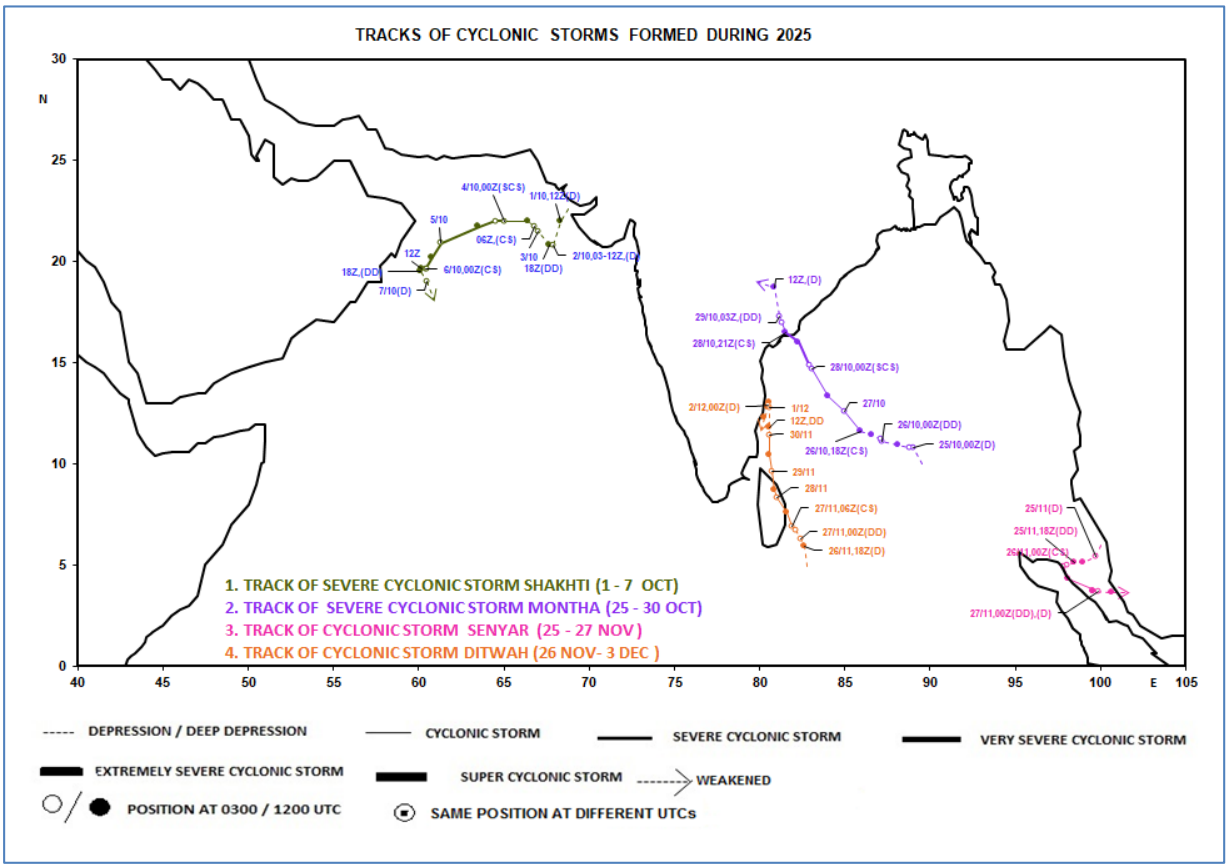


Fig 2.1.1: Observed Tracks of all cyclonic disturbances during 2025

Table 2.1.1 Some Characteristic features of cyclonic disturbances formed over north Indian Ocean and adjoining region during 2025

S No.	Cyclonic storm/ Depression	Date, Time& Place of genesis (Lat.°N/ Long°E)	Date, Time (UTC) Place (Lat./Long.) of Landfall	Estimated lowest central pressure, Time & Date (UTC) & (Lat°N/ Long°E)	Estimated Maximum wind speed (kt), Date & Time	Max T. No. Attained
1.	Depression over eastcentral Arabian Sea and adjoining south Konkan (24-25 May, 2025)	0000 UTC of 24th May, 2025 over eastcentral Arabian Sea and adjoining south Konkan (17.0/73.0)	crossed south Konkan coast near Ratnagiri between 1130 and 1230 hrs IST (0600 and 0700 UTC) of 24th May	998 hPa at 0000 UTC of 24th May, 2025 (17.0/73.0)	20kt at 0000 UTC of 24th May, 2025 (17.0/73.0)	T1.5
2.	Deep Depression Over Northwest Bay of Bengal off West Bengal – Bangladesh Coasts (29th - 30th May, 2025	0000 UTC of 29th May, 2025 over Bay of Bengal (20.8/88.3)	Weakened into a well-marked low-pressure area over Meghalaya and neigbourhood	986hpa at 0300 UC of 29th May, 2025 (21.3/88.3)	30 kts at 0300 UC of 29th May, 2025 (21.3/88.3)	T2.0
4.	Depression over southeast Gangetic West Bengal and adjoining Bangladesh (14th - 15th July, 2025)	0000 UTC of 14th July, 2025 over southwest Bangladesh and adjoining Gangetic West Bengal (23.0/88.8)	Weakened into a well-marked low-pressure area over north Jharkhand and adjoining south Bihar	998 hPa at 0000 UTC of 14th July, 2025 (23.0/88.8)	20 kts at 0000 UTC of 14th July, 2025 (23.0/88.8)	-
5.	Depression over North Rajasthan during 15th July-16th July 2025	0300 UTC of 15th July, 2025 over central part of northern Rajasthan (27.4/75.4)	Weakened into a well-marked low-pressure area over northwest Rajasthan	998 hPa at 0300 UTC of 15th July, 2025 (27.4/75.4)	20 kts at 0300 UTC of 15th July, 2025 (27.4/75.4)	-

6.	Depression over Southeast Uttar Pradesh during 17th July – 20th July, 2025	0000 UTC of 17th July, 2025 over Southeast Uttar Pradesh (25.2/81.8)	Weakened into a well-marked low-pressure area over west Rajasthan and adjoining Pakistan	993 hPa at 0000 UTC of 17th July, 2025 (25.2/81.8)	25 kts at 0000 UTC of 17th July, 2025 (25.2/81.8)	-
7.	Depression over Northwest Bay of Bengal (25th July-27th July 2025)	0000 UTC of 25th July, 2025 over Northwest Bay of Bengal and adjoining areas of coastal West Bengal and Bangladesh (21.4/89.5)	Weakened into a Well Marked Low Pressure Area Over Northwest Madhya Pradesh and neighbourhood	988 hPa at 0000 UTC of 25th July, 2025 (21.4/89.5)	25 kts at 0000 UTC of 25th July, 2025 (21.4/89.5)	-
8.	Depression over Northwest Bay of Bengal during 18th - 19th August 2025	1200 UTC of 18th Aug, 2025 over northwest and adjoining westcentral BoB & north Andhra Pradesh - south Odisha coasts (18.9/85.0)	Weakened into a well-marked low-pressure area over central parts of Chhattisgarh & neighbourhood	994 hPa at 1200 UTC of 18th Aug, 2025 (18.9/85.0)	20 kt at 1200 UTC of 18th Aug, 2025 (18.9/85.0)	T1.5
9.	Deep Depression over north Gujarat and adjoining southwest Rajasthan (06th - 10th September, 2025)	1800 UTC of 06th September, 2025 over Southwest Rajasthan and neighbourhood (25.0/72.5)	Weakened into a well-marked low pressure area over northwest Arabian Sea and adjoining southwest Pakistan	995 hPa at 1200 UTC on 9th September, 2025. (24.5/71.2)	30 knots at 1200 UTC on 9th September, 2025. (24.5/71.2)	T1.5
10.	Depression over northwest and adjoining westcentral Bay of Bengal off south Odisha-	1800 UTC of 26th September, 2025 northwest BoB	Weakened into a well-marked low-pressure area over west Vidarbha and adjoining north	996 hPa at 1200 UTC on 26th September, 2025.	25 knots at 1200 UTC on 9th September, 2025.	T1.5

	north Andhra Pradesh coasts during 26th - 28th September, 2025	(19.3/86.1)	Madhya Maharashtra	(19.3/86.1)	(19.3/86.1)	
11	Deep Depression over Westcentral Bay of Bengal (01st - 03rd October 2025)	0600 UTC of 1st October, 2025 over Westcentral Bay of Bengal (15.8/86.5)	Weakened into a well-marked low-pressure area over north Chhattisgarh & adjoining areas of north interior Odisha & Jharkhand	995 hPa at 0300 UTC on 2nd October, 2025. (18.0/85.6)	30 knots at 1800 UTC of 1st October, 2025 (16.8/86.0)	T2.0
12	Severe Cyclonic Storm “Shakthi” over northeast Arabian Sea (01Oct – 07th October, 2025)	1200 UTC of 1st November, 2025 over northeast Arabian Sea (22.0/68.3)	Weakened into a well-marked low-pressure area over southwest Arabian Sea on 7th October.	986 hPa at 0300 UTC on 5th October, 2025. (20.9/61.3)	60 knots at 0300 UTC on 5th October, 2025. (20.9/61.3)	T3.5
13	Severe cyclonic storm “MONTHA” over Southeast Bay of Bengal (25th – 30th) October, 2025	0300 UTC) of 25th Nov over Strait of Malacca	Well Marked Low Pressure Area over east Vidarbha and adjoining south Chhattisgarh at 0000 UTC of 30th October 2025	990 hPa at 0000 UTC on 28th October, 2025 (4.7/83)	50 Knots at 0000 UTC on 28th October, 2025	T3.0

14	Cyclonic Storm "SENYAR" over the Strait of Malacca (25-27 November, 2025)	1200 UTC of 20th December, 2024 Over westcentral Bay of Bengal (13.7/83.5)	Weakened into a well marked low pressure area over Malacca Strait and adjoining coastal areas of Malaysia in the midnight (2330 hrs IST/ 1800 UTC) of 27th Nov	999 hPa at 0000 UTC on 26th November, 2025 (5.0/98.0)	40 Knots at 0000 UTC on 26th November, 2025 (5.0/98.0)	T2.5
15	Cyclone "DITWAH" over Bay of Bengal (27th November – 03 December 2025)	1800 UTC) of 26th November2025, depression over southwest BoB and adjoining Sri Lanka	Weakened into a Well Marked Low Pressure Area over North Tamil Nadu-Puducherry coasts and neighbourhood	1000 hPa at 0300 UTC on 29th November, 2025 (9.6/80.7)	40 Knots at 0300 UTC on 29th November, 2025 (9.6/80.7)	T2.5

Table 2.1.2 Statistical data relating to cyclonic disturbances over the north Indian Ocean during 2025

A) Monthly frequencies of cyclonic disturbances (C I.≥1.5)

↔ Peak intensity of the system over NIO (BoB & AS), ⊕: Land Depression

S.No	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.	D					↔		↔ ⊕ ⊕ ⊕	↔	↔ ⊕	↔		
2.	DD					↔					↔		
3.	CS											↔ ↔	
4.	SCS										↔ ↔		

5.	VSCS												
6.	ESCS												
7	SuCS												

B) Life time of cyclonic disturbances during 2025 at different stages of intensity

i. For NIO Region (BoB & AS)

S.No.	Type	Life Time in (Days)
1	D	16 days 12 hours
2.	DD	5 days 12 hours
3.	CS	7 days 0 hour
4.	SCS	2 days 18 hours
	Total Life Time in (Days)	31 days 18 hours

ii. For Bay of Bengal Region

S.No.	Type	Life Time in (Days)
1	D	4 days 21 hours
2.	DD	4 days 15 hours
3.	CS	5 days 12 hours
4.	SCS	0 day 18 hours
	Total Life Time in (Days)	15 days 18 hours

iii. For Arabian Sea Region

S.No.	Type	Life Time in (Days)
1	D	11 days 15 hours
2.	DD	0 day 21 hours
3.	CS	1 days 12 hours
4.	SCS	2 days 0 hour
	Total Life Time in (Days)	16 days 0 hour

iv. For Land Region

S.No.	Type	Life Time in (Days)
1	D	7 days 12 hours
2	DD	1 days 12 hours
	Total Life Time in(Days)	9 days 0 hour

C) Frequency distribution of cyclonic disturbances with different intensities based on satellite assessment over NIO (BoB & AS)

CI No (≥)	**≥1.5**	**≥2.0**	**≥2.5**	**≥3.0**	**≥3.5**	**≥4.0**	**≥4.5**	**≥5.0**	**≥5.5**	**≥6.0**
No of Disturbances	11	6	4	3	1	0	0	0	0	0

D) Basin-wise distribution of cyclonic disturbances

Basin	Number of cyclonic disturbances
Bay of Bengal	8
Arabian Sea	3
Land depression	4

Table 2.1.3 Cyclonic disturbances formed over the north Indian Ocean and land areas of India during 1997-2025

Year	Basin	D	DD	CS	SCS	VSCS	ESCS	SuCS	Total
1997	BOB	1	4	1	1	1	0	0	8
	ARB	1	0	0	0	0	0	0	1
	Land	0	0	0	0	0	0	0	0
	Total								**9**
1998	BOB	0	3	0	1	2	0	0	6
	ARB	0	1	1	1	1	0	0	4
	Land	1	0	0	0	0	0	0	1
	Total								**11**
1999	BOB	2	2	1	0	1	0	1	7
	ARB	0	0	0	0	1	0	0	1
	Land	1	0	0	0	0	0	0	1
	Total								**9**
2000	BOB	1	1	2	0	2	0	0	6
	ARB	0	0	0	0	0	0	0	0
	Land	1	0	0	0	0	0	0	1
	Total								**7**
2001	BOB	2	0	1	0	0	0	0	3
	ARB	0	0	2	0	1	0	0	3
	Land	0	0	0	0	0	0	0	0
	Total								**6**
2002	BOB	1	1	2	1	0	0	0	5
	ARB	0	0	0	0	0	0	0	1
	Land	0	0	0	0	0	0	0	0
	Total								**6**
2003	BOB	2	2	0	1	1	0	0	6
	ARB	0	0	0	1	0	0	0	1
	Land	0	0	0	0	0	0	0	0
	Total								**7**
2004	BOB	2	0	0	0	1	0	0	3
	ARB	0	2	0	3	0	0	0	5
	Land	2	0	0	0	0	0	0	2
	Total								**10**
2005	BOB	2	3	4	0	0	0	0	9
	ARB	2	0	0	0	0	0	0	2
	Land	1	0	0	0	0	0	0	1
	Total								**12**

2006	BOB	5	2	1	0	1	0	0	9
	ARB	0	1	0	1	0	0	0	2
	Land	1	0	0	0	0	0	0	1
	Total								**12**
2007	BOB	3	4	1	0	1	0	0	9
	ARB	0	1	1	0	0	0	1	3
	Land	0	0	0	0	0	0	0	0
	Total								**12**
2008	BOB	1	2	3	0	1	0	0	7
	ARB	1	1	0	0	0	0	0	2
	Land	1	0	0	0	0	0	0	1
	Total								**10**
2009	BOB	0	2	2	1	0	0	0	5
	ARB	2	0	1	0	0	0	0	3
	Land	0	0	0	0	0	0	0	0
	Total								**8**
2010	BOB	2	1	0	2	1	0	0	6
	ARB	0	0-	1	0	1	0	0	2
	Land	0	0	0	0	0	0	0	0
	Total								**8**
2011	BOB	2	2	0	0	1	0	0	5
	ARB	1	2	1		0	0	0	4
	Land	1	0	0	0	0	0	0	1
	Total								**10**
2012	BOB	0	2	1	0	0	0	0	3
	ARB	0	1	1	0	0	0	0	2
	LAND	0	0	0	0	0	0	0	0
	Total								**5**
2013	BOB	3	0	1	1	3	0	0	8
	ARB	0	1	0	0	0	0	0	1
	Land	1	0	0	0	0	0	0	1
	Total								**10**
2014	BOB	2	2	0	0	1	0	0	5
	ARB	0	0	1	0	1	0	0	2
	Land	1	0	0	0	0	0	0	1
	Total								**8**
2015	BOB	1	1	1	0	0	0	0	3
	ARB		2	1	0	0	2	0	5
	Land	2	2		0	0	0	0	4
	Total								**12**
2016	BOB	1	2	3	0	1	0	0	7
	ARB	2	0	0	0	0	0	0	2
	Land	1	0	0	0	0	0	0	1
	Total								**10**
2017	BOB	4	1	1	1	1	0	0	8
	ARB	0	0	0	0	0	0	0	0

	Land	2	0	0	0	0	0	0	2
	Total								**10**
2018	BOB	3	2	1	2	1	0	0	9
	ARB	1	0	0	0	1	2	0	4
	Land	1	0	0	0	0	0	0	1
	Total								**14**
2019	BOB	0	1	1	0	1	1	0	4
	ARB	2	1	1	0	2	1	1	8
	Land	0	0	0	0	0	0	0	0
	Total								**12**
2020	BOB	1	1	1	0	1	0	1	5
	ARB	2	0	0	1	1	0	0	4
	Land	0	0	0	0	0	0	0	0
	Total								**9**
2021	BOB	3	1	2	0	1	0	0	7
	ARB	1	0	0	1	0	1	0	3
	Land	0	0	0	0	0	0	0	0
	Total								**10**
2022	BOB	4	3	1	2	0	0	0	10
	ARB	2	1	0	0	0	0	0	3
	Land	2	0	0	0	0	0	0	2
	Total								**15**
2023	BOB	1	1	1	1	1	1	0	6
	ARB	1	0	0	0	0	2	0	3
	Land	0	0	0	0	0	0	0	0
	Total								**9**
2024	BOB	4	2	1	2	0	0	0	9
	ARB	1	0	1	0	0	0	0	2
	Land	1	1	0	0	0	0	0	2
	Total								**13**
2025	BOB	3	2	2	1	0	0	0	8
	ARB	2	0	0	1	0	0	0	3
	Land	3	1	0	0	0	0	0	4
	Total								**15**

Table 2.1.4 Average translational speed of Tropical cyclones over the NIO during 2025

TC Name	Basin	Period	Average Translational Speed (kmph)		
			6 Hr	12 Hr	24 Hr
SHAKHTI	AS	01-07 October, 2025	9.9(23)	9.8(22)	9.4(20)
MONTHA	BoB	25-29 October, 2025	12.5(19)	12.4(18)	12.4(16)
SENYAR	BoB	25-27 November, 2025	10.5(9)	9.9(8)	8.3(6)
DITWAH	BoB	27 November – 03 December, 2025	6.2(22)	6.0(21)	5.9(19)
Annual Average Translational Speed (kmph)			**9.5**	**9.3**	**9.0**

Table 2.1.5 Velocity Flux of Tropical cyclones over the NIO during 2025

TC Name	Velocity Flux (10^2 kt)	Accumulated Cyclone Energy (10^4 kt^2)	Power Dissipation Index (10^6 kt^3)
SHAKHTI	6.8	3.4	1.74
MONTHA	4.4	1.93	0.87
SENYAR	1.5	0.57	0.21
DITWAH	0.48	1.74	0.64
Total	**13.18**	**7.64**	**3.46**

2.2 Depression over the Arabian Sea (24th-25th May, 2025)

2.2.1 Life History:

- An upper air cyclonic circulation extending upto mid-tropospheric level lay over Eastcentral Arabian Sea (AS) off North Karnataka-Goa coasts at 0530 hrs IST/0000 UTC of 21st May 2025.
- Under its influence, a low-pressure area formed over Eastcentral AS off south Konkan-Goa coasts at 0530 hrs IST/0000 UTC on 22nd May.
- It lay as a well-marked low-pressure area over Eastcentral AS off south Konkan coast at 0530 hrs IST/ 0000 UTC of 23rd May.
- It concentrated into a depression over eastcentral AS and adjoining south Konkan at 0530 hrs IST/0000 UTC of 24th May.
- Thereafter, it slowly moved nearly eastwards and crossed south Konkan coast near Ratnagiri between 1130 and 1230 hrs IST (0600 and 0700 UTC) of 24th May.
- It then moved east-northeastwards and weakened into a well-marked low-pressure area over south Madhya Maharashtra and adjoining areas of Marathwada & North Interior Karnataka at 0530 hrs IST/ 0000 UTC of 25th May 2025
- The observed track of the depression is presented in **Fig.2.2.1**. The best track parameters of the system are presented in **Table 2.2.1.**

Table 2.2.1: Best track positions and other parameters of the Depression over Eastcentral Arabian Sea and adjoining south Konkan coast during 24th May – 25th May, 2025

Date	Time (UTC)	Lat. (^{0}N)	Long.(^{0}E)	ECP (hpa)	ΔP (hPa)	C.I. No.	MSW (kt)	Category
24.05.2025	0000	17.0	73.0	998	3	1.5	25	D
	0300	17.0	73.2	998	3	1.5	25	D
	0600	17.0	73.3	998	3	1.5	25	D
		Crossed South Konkan Coast near Ratnagiri between 0600-0700 UTC as a depression with maximum sustained wind speed of						
	1200	17.2	74.3	998	4	-	25	D
	1800	17.4	75.3	998	4	-	20	D
25.05.2025	0000	Weakened into a well-marked low-pressure area over south Madhya Maharashtra and adjoining areas of Marathwada & North Interior Karnataka.						

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

2.2.2 Salient features:

- It developed during onset phase of southwest monsoon season 2025 and contributed to early advance of southwest Monsoon over Kerala on 24th May against normal date of 1st June.
- Active monsoon conditions alongwith favourable combination of equatorial waves including Madden Julian Oscillation (MJO), Kelvin wave (KW) and Equatorial Rossby wave (ERW) helped in genesis of this system.

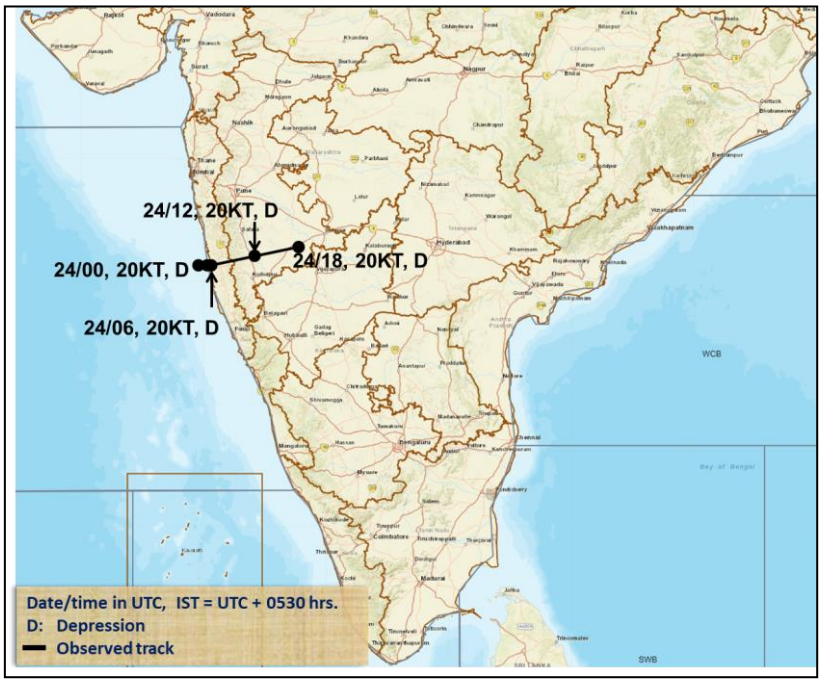


Fig.2.2.1: Track of Depression over eastcentral Arabian Sea and adjoining south Konkan during 24th – 25th May, 2025

- Based on data during 1965-2024, there have been 18 depressions and cyclones over AS in the month of May. Out of these, there were 8 severe cyclones, 6 cyclonic storms and 4 depressions. Last such activity in the month of May was observed in 2021 with the development of extremely severe cyclonic storm (Fig.2.2.2).
- With the advance of southwest monsoon, the system didn't move northwestwards. It rather moved eastwards.

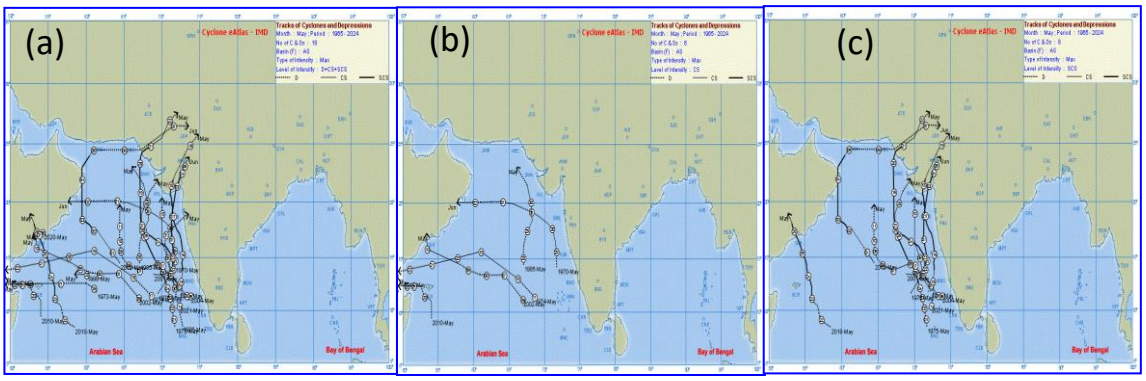


Fig.2.2.2: Tracks of (a) all cyclonic disturbances (MSW≥ 17 kt, (b) all cyclones (MSW: 34-47 kt and (c) all severe cyclones developing over AS during 1965-2024.

2.2.3 Monitoring of Depression

India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean (NIO) and the cyclone was monitored since 15th May, about 9 days prior to formation of depression on 24th May. First information about the system was released in the weekly extended range outlook issued by IMD on 15th May, indicating formation of depression over eastcentral AS during middle of week 2 (23.05.2025-29.05.2025) with low probability (1-33%). Anticipatory actions for the

marine, scientific and disaster management communities were also issued at this stage. The updated extended range outlook issued on 22nd May August, further reiterated the forecast and indicated formation of a depression over eastcentral AS with high confidence (68-100%). Actually, the depression formed over eastcentral AS on 24th May.

The depression was monitored with the help of available satellite observations from INSAT 3D and 3DR, SCAT SAT, ASCAT, microwave imageries and available ships, buoy observations and coastal observations in the region. Various global models and dynamical-statistical models run by Ministry of Earth Sciences (MoES) institutions including IMD, NCMRWF, IITM & INCOIS and guidance from models from various international agencies under bilateral arrangement were utilized to predict the genesis, track and intensity of the cyclone as well as associated severe weather. The forecasts were mainly based on multi-model ensemble technique developed by IMD further modulated by observations and forecasters intervention at IMD. An indigenously developed digitized forecasting system of IMD was utilized for analysis and comparison of various observations and numerical weather prediction models guidance, decision making process and warning products generation.

The detailed satellite features during the life cycle of depression over eastcentral Arabian Sea are discussed herewith. The visible, IR, enhanced colored and enhanced IR imageries during life cycle of depression are presented in Fig.2.2. 3. Doppler weather Radar, Goa also monitored the system. Typical imagery is presented in Fig.2.2.4.

At 0300 UTC of 22nd May, the system lay as a low-pressure area over eastcentral Arabian Sea off South Konkan-Goa coasts. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over eastcentral Arabian Sea and south Konkan. Minimum cloud top temperature was -60^{0}C to -85^{0}C. Scattered low and medium clouds with embedded moderate to intense convection lay over westcentral Arabian Sea, south Arabian Sea, Lakshadweep Islands, Maldives & Comorin area.

At 0300 UTC of 23rd May, the system lay as a well-marked low-pressure area over eastcentral Arabian Sea off Konkan coast. As per satellite imagery at 0300 UTC, the vortex lay over eastcentral Arabian Sea off south Konkan coast & neighbourhood centered near 17.2N/72.5E and associated intensity was characterised as T1.0. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over eastcentral Arabian Sea & Konkan and adjoining Madhya Maharashtra & Goa. Minimum cloud top temperature was -60^{0}C to -80^{0}C. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over south & central Arabian Sea. Scattered low and medium clouds with embedded moderate to intense convection lay over Lakshadweep Islands, north Maldives & Comorin area.

At 0300 UTC of 24th May, a depression formed over the eastcentral Arabian Sea near 17.2^0 N & longitude 73.0^0 E. As per INSAT 3D (S) imagery at 0000 UTC, the system was centered over east-central Arabian Sea off Konkan coast & neighbourhood near 17.2^{0}N/73.0^{0}E. The clouds were organised in shear pattern with convective clouds sheared towards northwest of system centre and the associated intensity was T1.5. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over eastcentral Arabian Sea and adjoining Konkan, Goa & Karnataka coasts. Minimum cloud top temperature was -60^{0}C to -90^{0}C. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over south & central Arabian Sea off Konkan, Goa, Karnataka coasts and Lakshadweep Islands area.

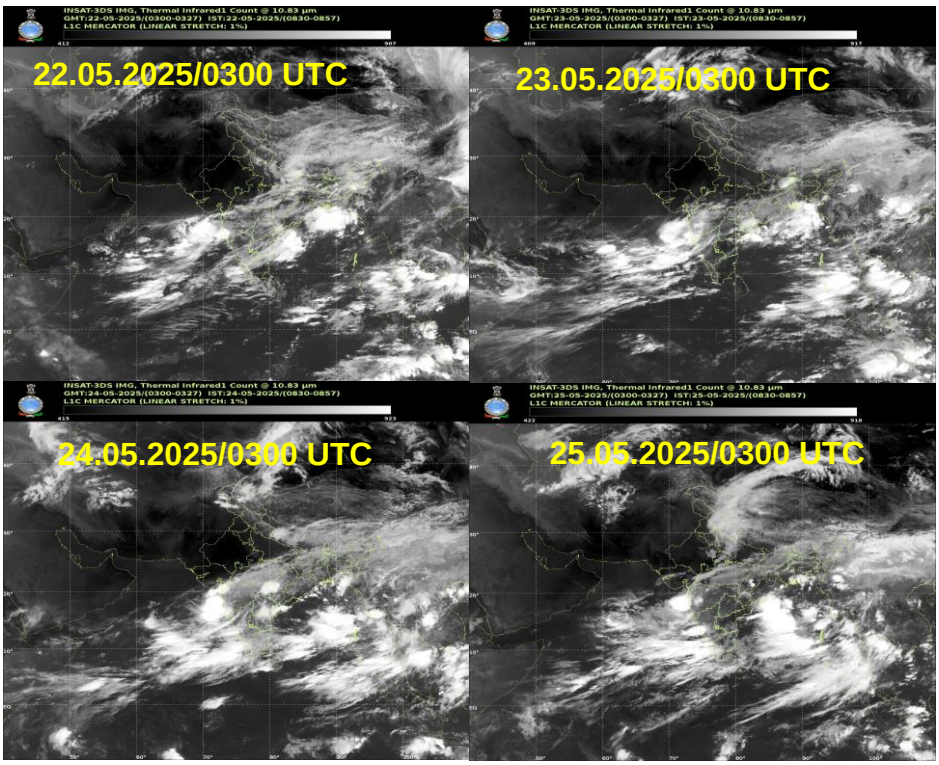


Fig.2.2.3(a): Typical INSAT 3DS infra-red imageries during 22nd to 25th May, 2025 in connection with Depression over eastcentral Arabian Sea

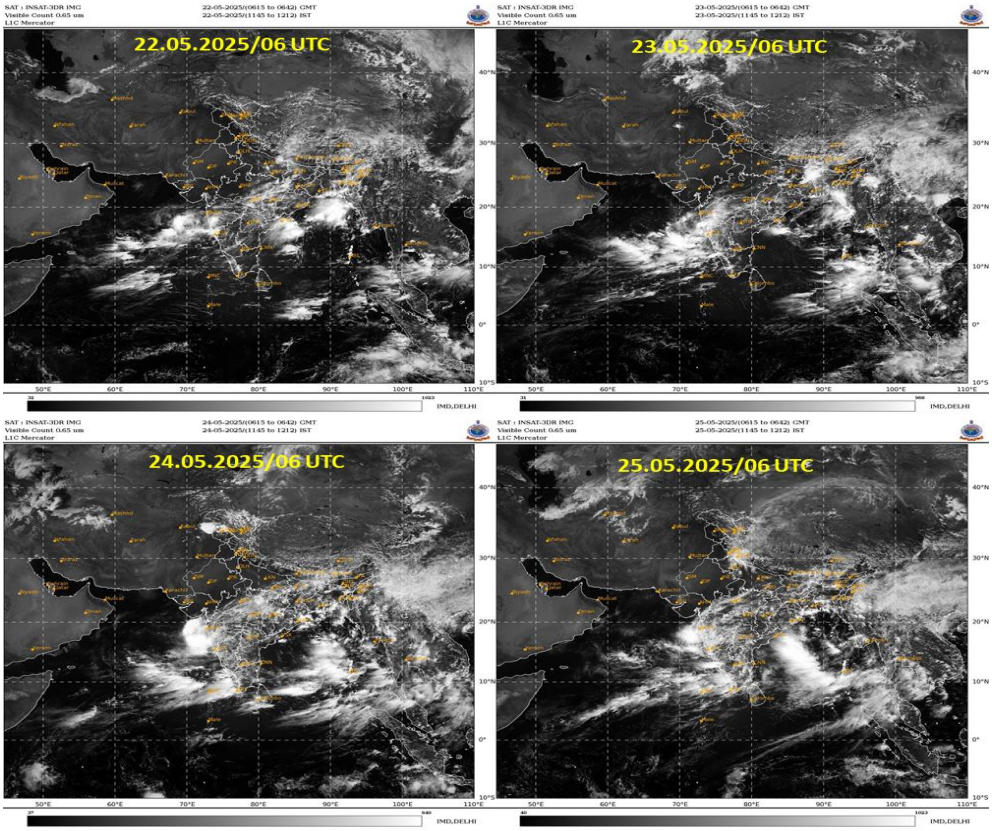


Fig.2.2.3(b): Typical INSAT 3DS visible imageries during 22nd to 25th May, 2025 in connection with Depression over eastcentral Arabian Sea

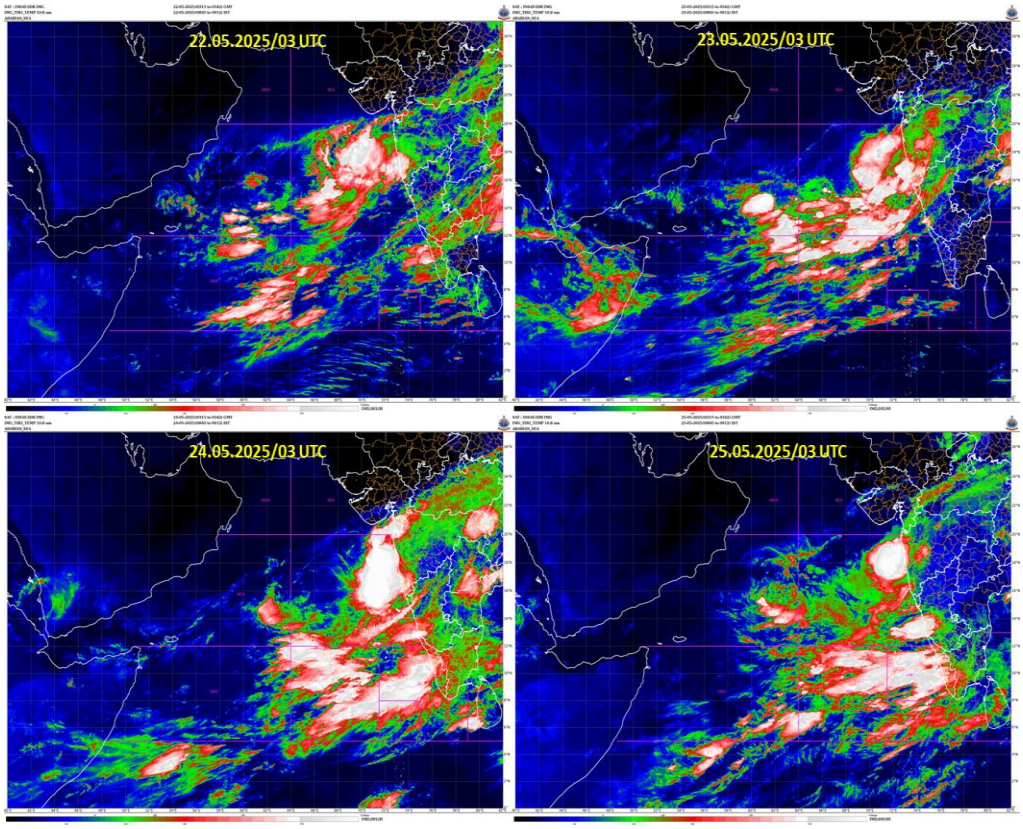


Fig.2.2.3(c): Typical INSAT 3DS enhanced colored imageries during 22nd to 25th May, 2025 in connection with Depression over eastcentral Arabian Sea

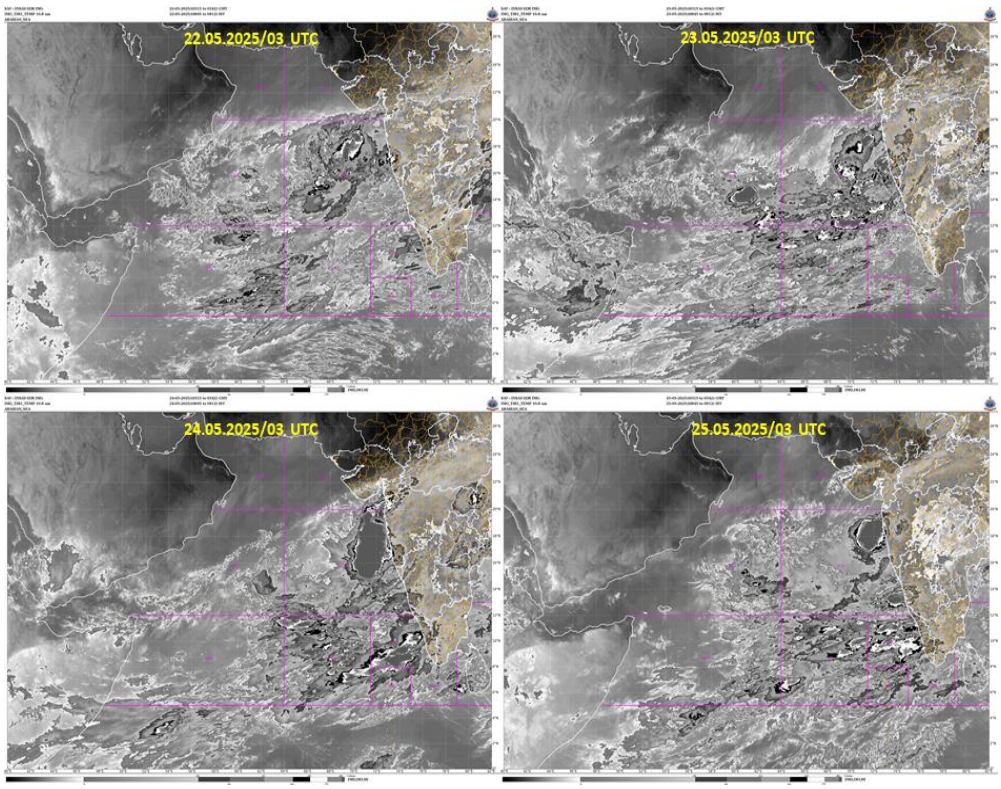


Fig.2.2.3(d): Typical INSAT 3DS enhanced IR BD curve imageries during 22nd to 25th May, 2025 in connection with Depression over eastcentral Arabian Sea

The Doppler Weather Radar, Goa captured the system on 24th May. Typical radar imagery is presented in Fig.2.2.4.

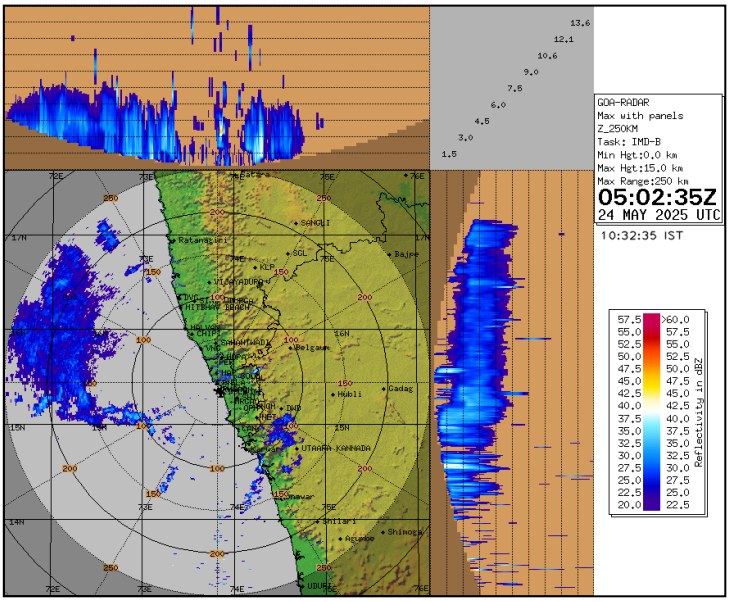


Fig.2.2.4: Maximum reflectivity imageries from Doppler Weather Radar Goa on 24th May.

2.2.4 Genesis, Intensification and Weakening:

An upper air cyclonic circulation lay over Eastcentral AS off North Karnataka-Goa coasts at 0530 hrs IST/0000 UTC of 21st May 2025. On 22nd May, the Madden Julian Oscillation (MJO) index was in phase 4 with amplitude close to 1. It was likely to continue in same phase during next 3 days. Thereafter, it was expected to move across phase 5 and 6 for subsequent 4 to 5 days. Sea Surface Temperature was 30^0C - 32^0C over entire AS. The vertical wind shear was low to moderate. The cloud features indicated moderate poleward outflow. Equatorial waves including Rossby wave and Kelvin wave with strong westerly wind anomaly over south AS (5 to 7 mps) and easterly wind anomaly over eastcentral AS (5 to 7 mps) were prevailing over the region. Under these favourable environment conditions, a low-pressure area formed over eastcentral AS off south Konkan-Goa coasts at 0530 hrs IST/0000 UTC on 22nd May.

On 23rd May, the system lay in a moderately favourable environment with low to moderate vertical wind shear, poleward outflow and warm sea conditions. Further equatorial waves including Rossby wave and Kelvin wave with strong westerly wind anomaly over south Arabian Sea (5 to 7 mps) and easterly wind anomaly over eastcentral AS (5 to 7 mps) provided a supportive environment. However, the proximity with land region, further slowed down the development of the system. Under these favourable conditions, the well-marked low-pressure area formed over eastcentral AS at 0300 UTC of 23rd May.

On 24th May, favourable environmental conditions prevailed. The mid-level vertical wind shear was low to moderate. There was strong surge in advancing monsoon current and both poleward & equatorward outflow. The sea surface temperature was 30-

32^0C. The low-level relative vorticity was positive around 70-80 $X10^{-6}s^{-1}$ at 850 hPa level with vertical extension upto 500 hPa. The low-level convergence was $20X10^{-5}s^{-1}$ and upper-level divergence was $30X10^{-5}s^{-1}$ to the southwest of system. The equatorial waves also provided supportive environment. Under these conditions, a depression formed over the eastcentral AS off south Konkan coast at 0000 UTC of 24th May. On 24th, the system was steered eastwards, under the influence of westerly winds in lower and middle tropospheric levels. The composite wind analysis of various levels also indicated a westerly trough passing to the north of the system area. As a result of all these, the depression over eastcentral AS moved nearly eastwards during its life cycle. Further as the system formed in southwest monsoon flow, it supported eastwards movement. It may be mentioned here that southwest monsoon set in over Kerala on 24th May and advanced upto 15^0N by 25th May, 2025.

Due to warm moist air incursion from the southeast AS, after landfall it maintained its intensity of depression for another 18 hours and thereafter it weakened into a well-marked low-pressure area over south Madhya Maharashtra and adjoining areas of Marathwada & North Interior Karnataka at 0000 UTC of 25th May.

2.2.5 Model Guidance:

IMD maintained a round the clock watch and the system was monitored since 15th May. However, till 22nd May, the models indicated development of a cyclonic storm and nearly northwards movement initially followed by northwestwards movement and then northeastwards movement. There was large variation in prediction of landfall point and time of landfall. On 22nd May, the guidance from various numerical models including IMD GFS, ECMWF and NCEP GFS indicated nearly northwards movement along the coast and intensification into depression by 24th May. However, there was large divergence among various models wrt further movement and intensification with GFS group indicating higher intensification and ECMWF indicating marginal intensification upto depression stage.

On 23rd May, compared to previous runs, the models completely withdrew likely development of a cyclonic storm over the Arabian Sea and indicated nearly northeastwards movement against earlier projections of initial northwards movement followed by northwestwards movement & then northeastwards recurvature.

On 24th May, in contrast to earlier predictions by various numerical models about north-northeastwards movement, the system exhibited eastwards movement. Thus, the models couldn't capture the steering flow and hence the track of the system. Even after landfall, most of the models indicated emergence of its remnant cyclonic circulation into westcentral Bay of Bengal around 27th May. However, it was not realised. The forecast was mainly based on synoptic features and model diagnosis and prognosis.

The IMD GFS analysis fields of mean sea level pressure, 10m winds and winds at 850, 500 & 200 hPa wrt genesis, location and intensity during 22nd -25th May are presented in Fig.2.2.5.

IMD GFS analysis field based on 0000 UTC of 22nd May, indicated a Low-Pressure Area over eastcentral AS off south Konkan-Goa coast. The associated cyclonic circulation extended upto 500 hpa tilting southwards with height. Actually, a low-pressure area lay over eastcentral AS of south Konkan-Goa coast at 00 UTC of 22nd May.

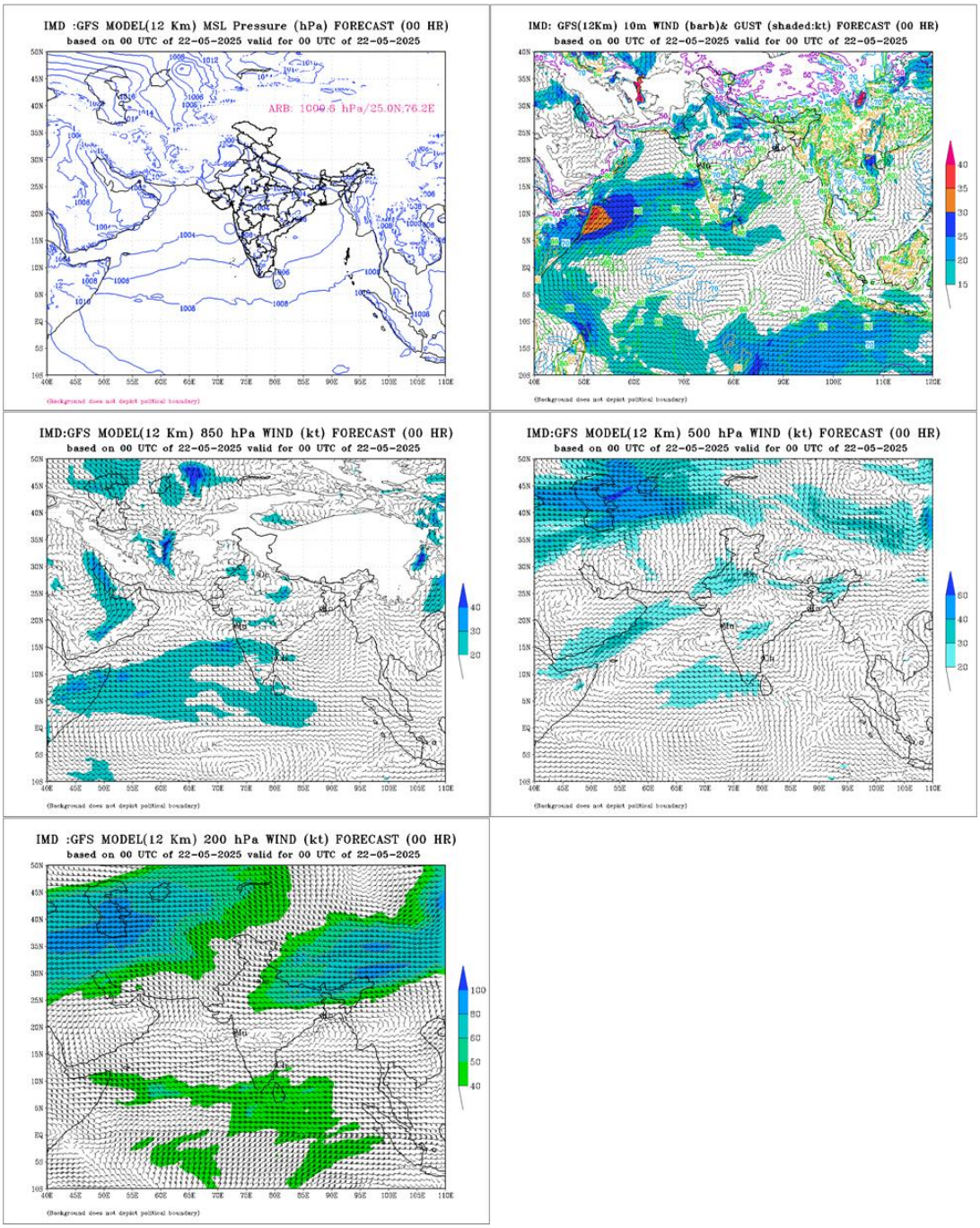


Fig.2.2.5(a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 22nd May 2025

At 0000 UTC of 23rd model indicated Low Pressure area over south Konkan coast with vertical extention upto 850 hpa. However, the system lay as a Well marked low pressure area over eastcentral AS of south Konkan coast at 0000 UTC 23rd May. Thus, the model was under estimating the intensity of the system.

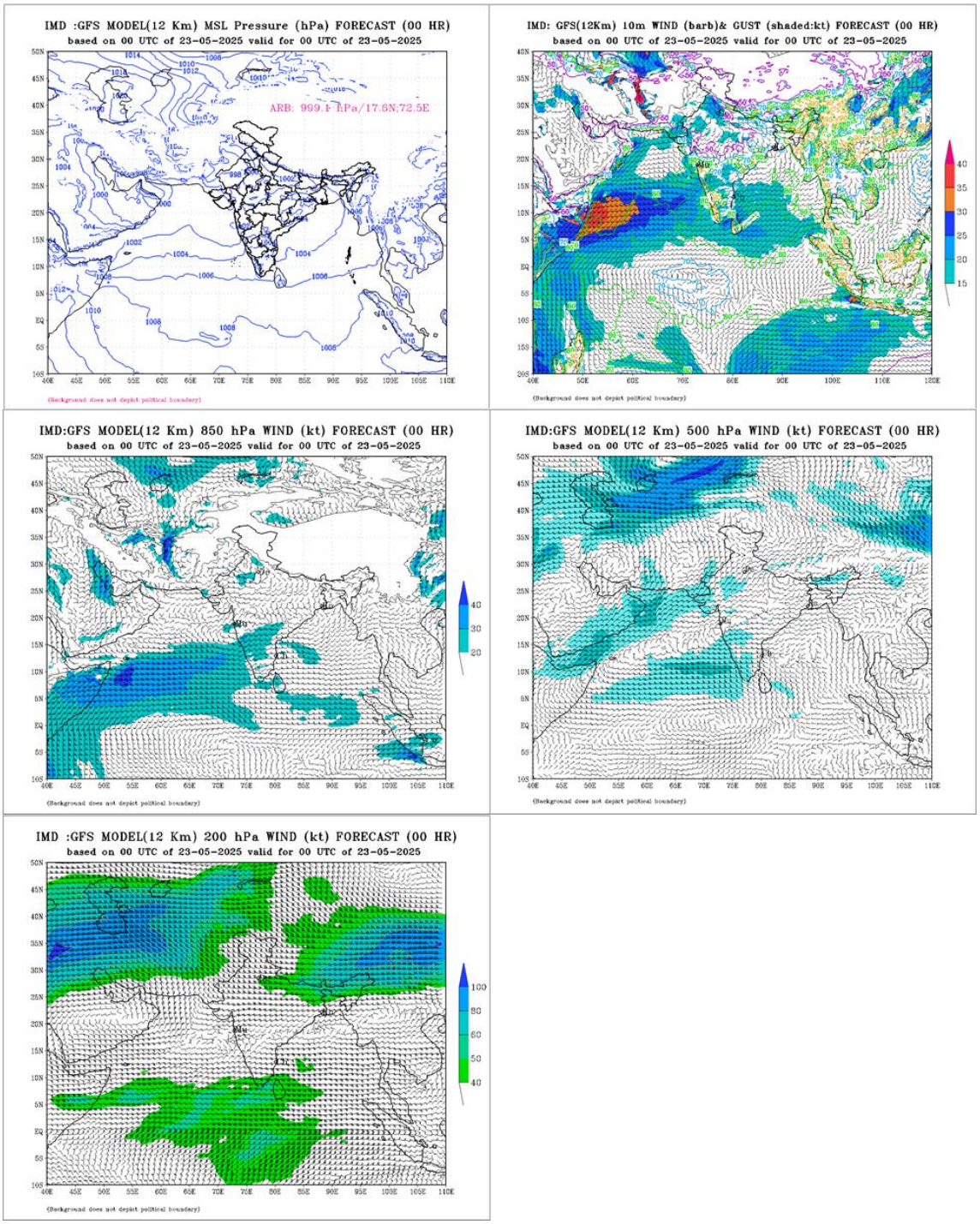


Fig.2.2.5(b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 23rd May 2025

At 0000 UTC of 24th IMD GFS indicated an extended trough over Maharashtra and adjoining west Madhya Pradesh. Actually, the system lay as a depression over east central AS and adjoining south Konkan coast.

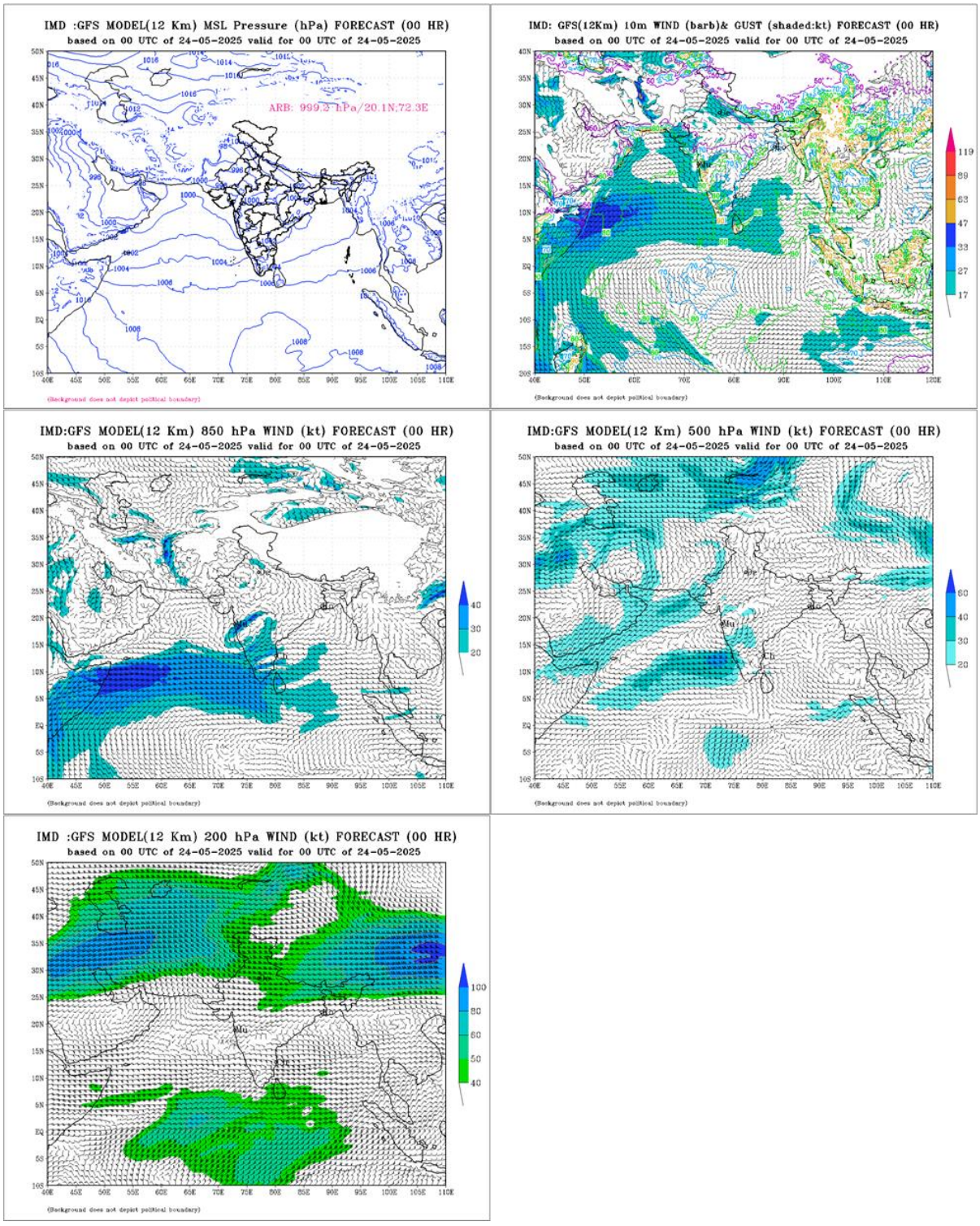


Fig.2.2.5(c): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 24th May 2025

At 0000 UTC of 25th the model was indicating a cyclonic circulation over Madhya Maharashtra tilting southwestwards with height upto mid tropospheric levels. However, the system lay as a well-marked low pressure over south Madhya Maharashtra and adjoining areas at 0000 UTC of 25th.

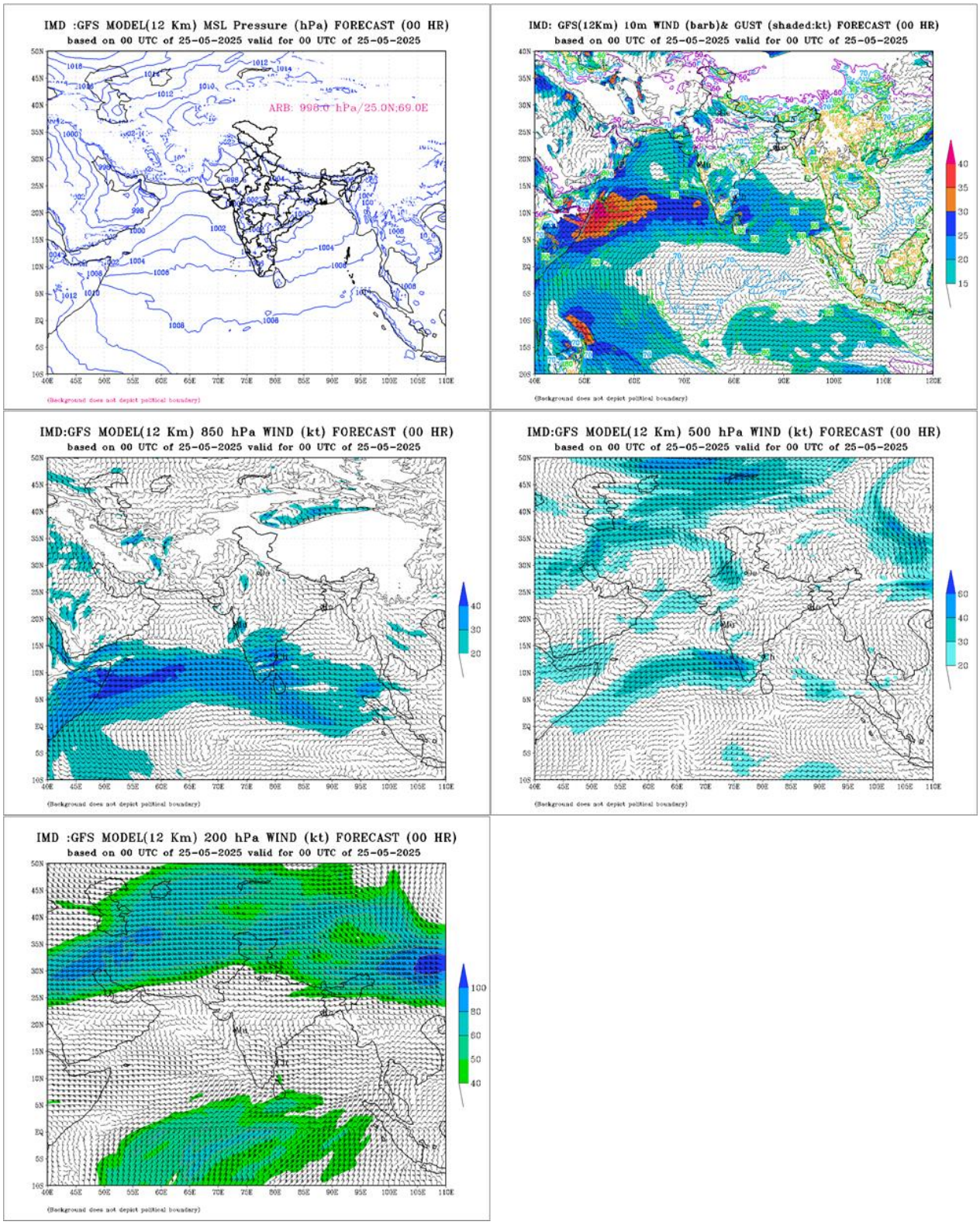


Fig.2.2.5(d): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 25th May 2025

Thus, overall IMD GFS could not capture the intensity and the track of the system correctly.

2.2.6 Realized Weather

Realized Rainfall

The depression caused rainfall at most places with heavy to very heavy rainfall at a few places over Konkan & Goa, Madhya Maharashtra, Coastal Karnataka and South Interior Karnataka during 22nd – 26th May and over Kerala & Mahe during 25th & 26th May. It also brought extremely heavy rainfall at isolated places over Konkan & Goa during 22nd to 26th May. The station-wise realised heavy rainfall maps during 22nd -26th May are presented in Fig.2.2.6.

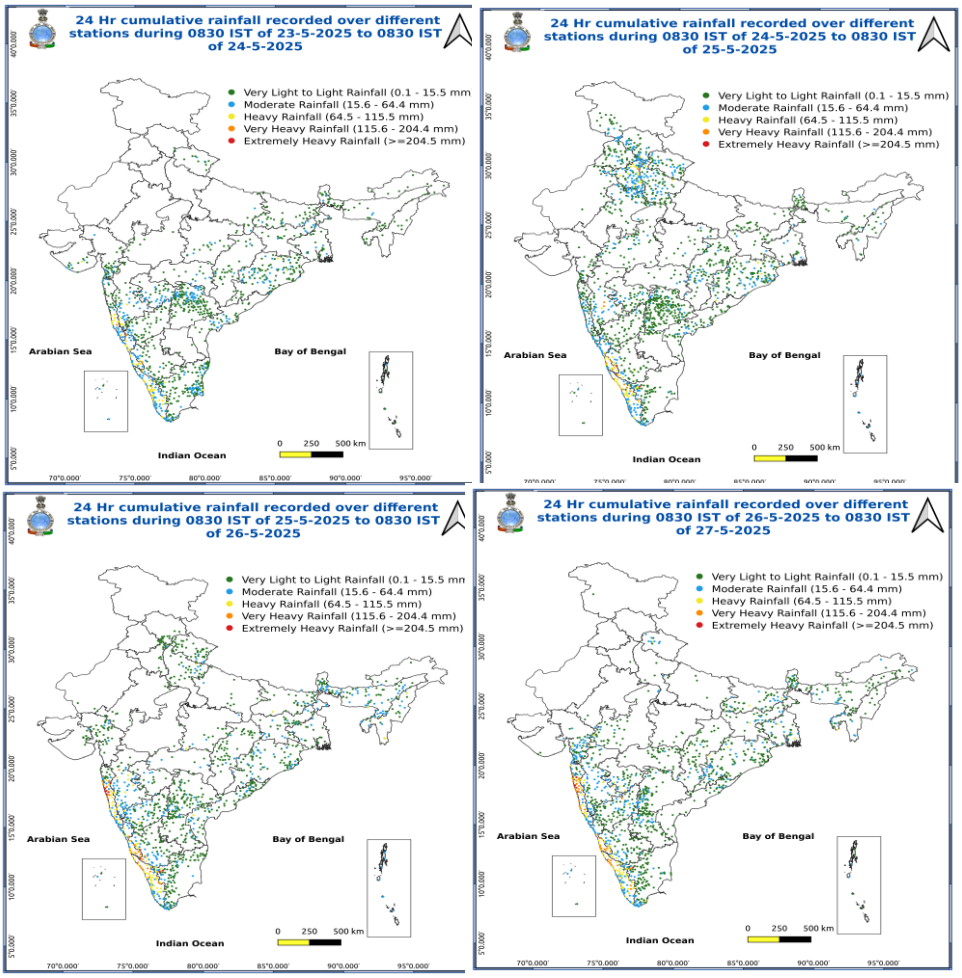


Fig.2.2.6: Station wise rainfall data plots of realized 24-hour accumulated rainfall from 24th to 26th May, 2025**.**

24 hours cumulative realised heavy rainfall (≥7cm) reported by different stations ending at 0300 UTC of date.

23rd May

Konkan & Goa: Guhagarh 28; Ponda, Wakwali, Sangameshwar Devrukh & Lanja 16 Each; Margao & Mulde 12 each; Kudal, Kankavli, Dapoli, Devgad, Ratnagiri & Chiplun 11 each; Sawantwadi 10; Canacona & Vaibhavwadi 9 each; Khed & Mapusa 8 each; Pernem, Panjim, Poladpur & Rajapur 7 each

Madhya Maharashtra: Mahabaleshwar 10; Wai 8; Satara, Chandgad & Radhanagari 7 each

Coastal Karnataka: Castle Rock 13; Kadra 12; Gokarna, Karwar & Karkala 9 each; Ankola & Kumta 8 each

South Interior Karnataka: Kottigehara 7

24th May

Konkan & Goa: Kankavli 13; Devgad 10; Rajapur, Sangameshwar Devrukh & Ratnagiri 9 each; Vaibhavwadi, Lanja & Ponda 8 each; Rameshwar 7

Madhya Maharashtra: Gaganbawada 10; Radhanagari 9; Phaltan 8; Shahuwadi & Gargoti 7 each

Coastal Karnataka: Castle Rock 16; Belthangadi & Manki 9 each; Kadra, Mangaluru & Gersoppa 8 each; Kundapur, Mani, Kumta, Dharmasthala, Gokarna & Ankola 7 each

South Interior Karnataka: Kottigehara 16; Bhagamandala10; Kalasa 7

25th May

Madhya Maharashtra: Daund 16; Baramati 13; Phaltan 7

Coastal Karnataka: Udupi 14; Puttur 13; Siddapura 11; Belthangadi & Kundapur 10 each; Dharmasthala, Karkala & Uppinangadi 9 each; Gersoppa & Kota 8 each, Mani 7

South Interior Karnataka: Kottigehara 21; Agumbe 19; Bhagamandala 17; Sringeri 10; Ponnampet 9; Napoklu, Koppa, Kalasa & Hunchadakatte 7 each

Kerala & Mahe: Nilambur 16; Vyttiri 15; Karipur, Urumi, Kannur, Mannarkkad & Chemberi 13 each; Kanjirapuzha 12; Ayyankunnu & Irikkur 11 each; Quilandi & Alwaye 10 each; Munnar, Angadipuram, Taliparamba, Cheruvanchery & Alathur 9 each; Kunnamkulam, Peringome, Muliyar, Peechi, Malampuzha, Kozhikode, Ottapalam, Palemad, Palakkad, Vadakkancherry, Kannur & Thritla 8 each; Tellichery, Kochi, Vilangankunnu, Piravam, Mahe, Vellanikkara, Sholayar, Pattembi, Varkala, Enamakkal, Vadakara, Chittur, Vaikkom & Chimoni 7 each

26th May

Konkan & Goa: Murud 37; Harnai & Shriwardhan 31 each; Mhasla 30; Mandangad 21; Tala & Matheran 18 each; Roha 17; Alibag 15; Colaba & Wakwali 13 each; Guhagarh & Dapoli 12 each; Ratnagiri & Chiplun 11 each; Sudhagad, Sangameshwar Devrukh, Mahad & Lanja 10 each; Poladpur 9; Khed, Panvel & Rameshwar 8 each; Kudal, Pernem, Mulde, Kankavli, Vaibhavwadi, Dodamarg & Ponda 7 each

Madhya Maharashtra: Lonavala 24; Sinnar 15; Karjat & Chas 10 each; Phaltan, Mahabaleshwar & Shahuwadi 9 each; Rahuri & Gaganbawada 8 each; Junnar 7

Coastal Karnataka: Mulki 20; Puttur 17; Sulya & Dharmasthala 13 each; Gersoppa, Mangaluru, Uppinangad & Mangaluru 12 each; Mani 10; Karkala & Panambur 8 each; Kadra, Honavar & Kota 7 each

North Interior Karnataka: Nippani 9; Annigere 7

South Interior Karnataka: Bhagamandala 23; Kottigehara 22; Napoklu 16; Agumbe & Somwarpet 12 each; Ponnampet 11; Kalasa 9; Kushalnagar 8; Kammardi, Bandipura, Jayapura & Sringeri 7 each

Kerala & Mahe: Urumi 21; Ayyankunnu 20; Vyttiri & Vellathooval 19 each; Vadakara & Taliparamba 17 each; Nilambur & Cheruvanchery 15 each; Peechi, Quilandi, Idamalayar Dam & Tellichery 14 each; Karapuzha & Vadakara 13 each; Parumbikulam, Mangalam Dam,

Chimoni & Thritla 12 each; Chalakudi, Manantoddy, Vellanikkara, Kozhikode, Kannur, Mahe, Sholayar, Angadipuram, Pattembi & Kannur 11 each; Muliyar, Idukki, Kollamkode, Kollengode, Kuppady, Peermade, Kudulu, Hosdurg, Thodupuzha & Kannur 10 each; Karipur 9, Mannarkkad, Kanjirappally, Vilangankunnu, Mannarkkad, Ottapalam, Palemad, Myladumpara, Ottapalam, Manjeri, Peringome & Vilangad 9 each; Poonjar, Irinjalakuda, Kannur, Vaikkom, Athirappalli, Malampuzha, Enamakkal & Palakkad 8 each; Kabanigiri, Ponnani, Perumpavur, Kanjirapuzha, Vaikom, Alwaye, Kochi, Vannamada, Palluruthy, Chittur, Mavelikara, Aluva, Choondy, Vadakkancherry, Ernakulam 7 each

27th May

Gujarat Region: Hansot 8

Konkan & Goa: Mhasla 28; Murud 25; Panvel 25; Dapoli 24; Devgad 18; Rameshwar, Tala & Shriwardhan 17 each; Alibag, Colaba, Pen & Guhagarh 16 each; Wakwali & Matheran 15 each; Santacruz & Mangaon 14 each; Roha, Kankavli & Mandangad 13 each; Khalapur, Ratnagiri, Poladpur & Harnai 12 each; Karjat, Sudhagad, Uran, Chiplun & Mulde 10 each; Rajapur, Kudal & Malvan 9 each; Mahad & Dahanu 8 each; Mapusa, Sawantwadi, Pernem, Ambernath & Vaibhavwadi 7 each

Madhya Maharashtra: Vadgaon 10; Karjat 8; Lonavala, Barshi & Paud Mulshi 7 each

Marathwada: Washi 10; Lohara 8; Umarga 7

Coastal Karnataka: Mulki 19; Mani 18; Uppinangadi & Panambur 17 each; Karkala 15; Manki 14; Kota & Puttur 13 each; Mangaluru & Belthangadi 12 each; Mangaluru 11; Kundapur & Udupi 9 each; Siddapura & Dharmasthala 8 each

North Interior Karnataka: Afzalpur 16; Shahpur & Ganagapura 8 each; Balaganur 7

South Interior Karnataka: Bhagamandala & Agumbe 11 each; Napoklu 10; Kottigehara, Somwarpet & Ponnampet 9 each; Kalasa 8

Kerala & Mahe: Ayyankunnu & Tellichery 17 each; Peermade & Vyttiri 16 each; Vellathooval, Chemberi & Vadakara 15 each; Peringome, Kannur & Kannur 13 each; Irikkur, Venkurinji, Taliparamba, Idukki, Kannur & Mahe 12 each; Padannakkad, Hosdurg, Munnar, Vaikkom, Palakkad, Angadipuram & Kozhikode 11 each; Malampuzha & Kudulu 10 each; Quilandi, Vaikom, Ernakulam, Cheruvanchery & Muliyar 9 each; Cherthala, Neyyattinkara, Mattanchery, Kanjirappally, Chalakudi, Mannarkkad, Athirappalli & Mannarkkad 8 each; Parumbikulam, Ottapalam, Thennala, Kochi, Palluruthy, Myladumpara, Pattembi, Kollam, Karipur, Manjeri, Vellanikkara, Manantoddy, Kumarakam, Pampadumpara, Thritla, Nilambur, Kuppady, Konni, Kollamkode, Ulanad, Peechi, Kanjirapuzha 7 each.

2.3 Deep Depression over Northwest Bay of Bengal off West Bengal-Bangladesh Coasts (29th - 30th May, 2025)

2.3.1 Life History:

- A Low-Pressure Area formed over Northwest Bay of Bengal (BoB) off Odisha coast in the morning (0830 hours IST/0300 UTC) of 27th May 2025.
- It lay as a Well-Marked Low-Pressure Area over the same region in the early morning (0530 hours IST/0000 UTC) of 28th May 2025.
- It concentrated into a depression in the early morning (0530 hours IST/0000 UTC) of 29th May 2025 over northwest BoB off West Bengal and adjoining Bangladesh coasts.
- It moved nearly northwards and intensified into a deep depression over the same region in the morning (0830 hrs IST/0000 UTC) of 29th May 2025.
- Continuing to move nearly northwards, it crossed West Bengal – Bangladesh coasts between Sagar Island & Khepupara (Bangladesh) close to Raidighi (West Bengal) during noon (1030-1130 hrs IST/0500-0600 UTC) of 29th May 2025.
- Thereafter, it moved nearly north-northeastwards across Gangetic West Bengal and western parts of Bangladesh and weakened into a depression over Bangladesh in the early morning (0530 hrs IST/0000 UTC) of 30th May 2025.
- Continuing to move further north-northeastwards across north Bangladesh, it weakened into a well-marked low-pressure area over Meghalaya in the evening (1730 hours IST/1200 UTC) of 30th May 2025.
- It weakened further into a low-pressure area over northeast Assam and neighbourhood in the early morning (0530 hrs IST/0000 UTC) of 31st May 2025 and became less marked thereafter.
- However, the associated upper air cyclonic circulation lay over Arunachal Pradesh and neighbourhood in the morning (0830hrs IST/0300 UTC) of 31st May, 2025.
- The observed track of the deep depression is presented in **Fig.2.3.1**. The best track parameters of the system are presented in **Table 2.3.1**.

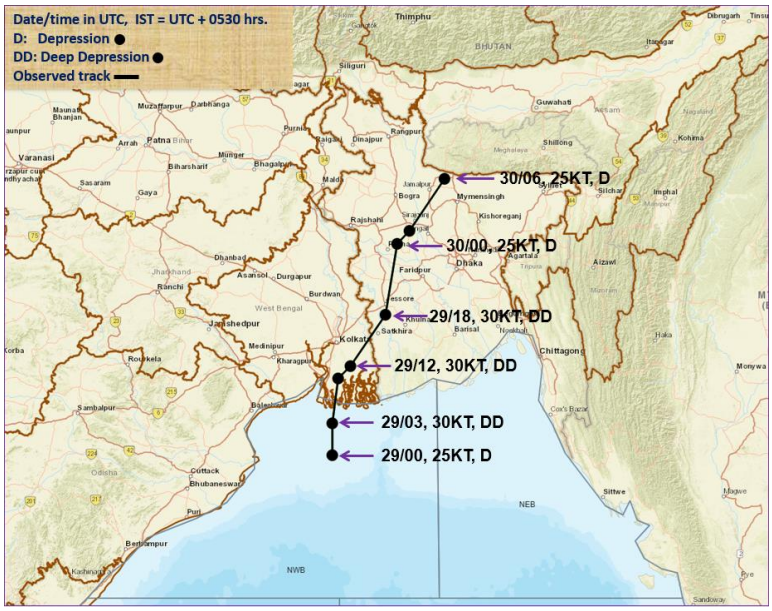


Fig.2.3.1: Observed track of the Deep Depression over Northwest Bay of Bengal off West Bengal-Bangladesh coasts during 29th May – 30th May, 2025

Table 2.3.1: Best track positions and other parameters of the Deep Depression Over Northwest Bay of Bengal off West Bengal-Bangladesh Coasts during 29th May – 30th May, 2025

Date	Time (UTC)	Lat. (^{0}N)	Long.(^{0}E)	ECP (hpa)	ΔP (hPa)	C.I. No.	MSW (kt)	Category
29.05.2025	0000	20.8	88.3	988	4	1.5	25	D
	0300	21.3	88.3	986	5	2.0	30	DD
	Crossed West Bengal – Bangladesh coasts between Sagar Island & Khepupara (Bangladesh) close to Raidighi (West Bengal) during 0500-0600 UTC as a deep depression with maximum sustained wind speed of 30 kt							
	0600	22.0	88.4	986	5	-	30	DD
	1200	22.2	88.6	987	5	-	30	DD
	1800	23.0	89.2	988	5	-	30	DD
30.05.2025	0000	24.1	89.4	990	4	-	25	D
	0300	24.3	89.6	992	3	-	20	D
	0600	25.1	90.2	992	3	-	20	D
	1200	Weakened into a well-marked low-pressure area over Meghalaya and neigbourhood						

kt: Knots 1 kt=1.85 kmph, D: Depression, DD: Deep Depression

2.3.2 Salient features;

- It developed during the onset phase of southwest monsoon season and helped in early advance of southwest monsoon over Kerala on 24th May against normal of 1st June.
- Last such activity was observed in 2024 with the formation of severe cyclonic storm Remal over central BoB on 24th May, 2024 which supported early advance of southwest monsoon over Kerala.

2.3.3 Monitoring of Depression

India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean and the cyclone was monitored since 22nd May, about 7 days prior to formation of depression on 29th May. First information about the system was released in the weekly extended range outlook issued by IMD on 22nd May, indicating formation of depression over westcentral and adjoining North Bay of Bengal during 28th-29th May with low probability (1-33%). Anticipatory actions for the marine, scientific and disaster management communities were also issued at this stage. Actually, the depression formed over northwest Bay of Bengal off West Bengal-Bangladesh coasts on 29th May.

The depression was monitored with the help of available satellite observations from INSAT 3DR & INSAT 3DS, SCATSAT, ASCAT, microwave imageries, Doppler Weather Radar at Kolkata, Mohanbari & Agartala and available ships, buoy observations and coastal observations in the region. Various global models and dynamical-statistical models run by the Ministry of Earth Sciences (MoES) institutions including IMD, NCMRWF, IITM & INCOIS and guidance from various international modeling agencies

under bilateral arrangement were utilized to predict the genesis, track and intensity of the deep depression as well as associated adverse weather. The forecasts were mainly based on multi-model ensemble technique developed by IMD further modulated by observations and forecaster's intervention at IMD. An indigenously developed digitized forecasting system of IMD was utilized for analysis and comparison of various observations and numerical weather prediction model's guidance, decision making process and warning products generation. Typical satellite-based products utilised for monitoring the system are presented in **Fig.2.3.2**.

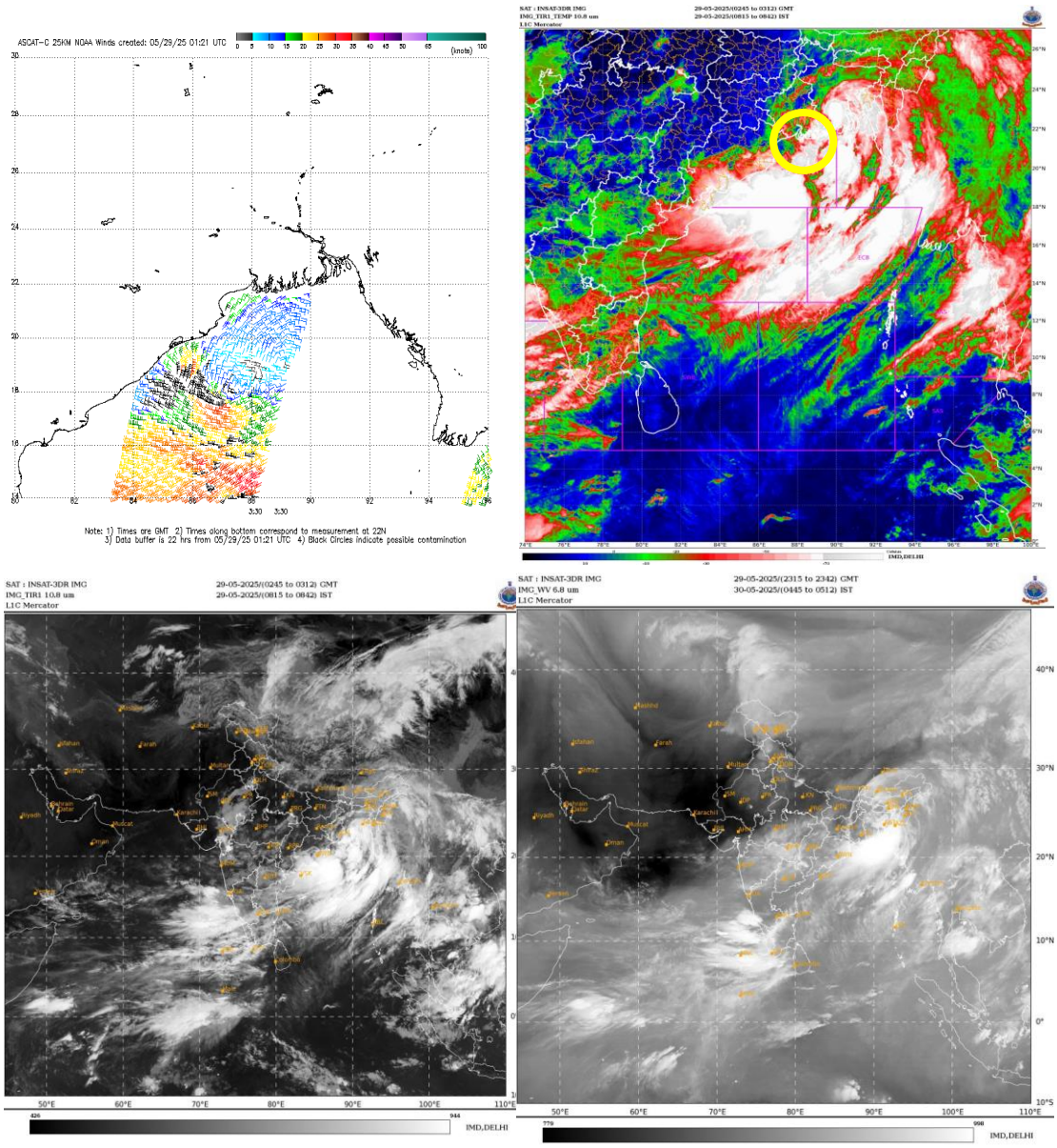


Fig.2.3.2: Typical ASCAT and INSAT 3DR Imageries on 29th May, 2025 of deep depression over Northwest Bay of Bengal off West Bengal-Bangladesh coasts.

2.3.4.1 Satellite Features:

As per satellite imagery at 0300 UTC, a low level cyclonic circulation (LLCC) lay over northwest BoB off Odisha-Andhra Pradesh coasts & neighbourhood. Associated intense to very intense convection lay over coastal Andhra Pradesh and Odisha. (Minimum cloud top temperature (CTT) -75°C to -85°C) and moderate to intense convection lay over Chhattisgarh, Jharkhand, Gangetic West Bengal and Bangladesh. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over BoB and Andaman Sea.

At 0300 UTC of 29th May, the depression lay over northwest BoB off Gangetic West Bengal and adjoining Bangladesh coasts. Intensity of the system was characterized as T2.0. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over north and central BoB, southwest & east Odisha, south Gangetic West Bengal, south Bangladesh. Minimum CTT was -75°C to -90°C and moderate to intense convection lay over north coastal Andhra Pradesh, Mizoram, Tripura, north Gangetic West Bengal and North Bangladesh. Minimum CTT was -50°C to -70°C. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over north & central BoB, north Andaman Sea and Gulf of Martaban. Scattered low and medium clouds with embedded isolated moderate to intense convection lay over south BoB & south Andaman Sea.

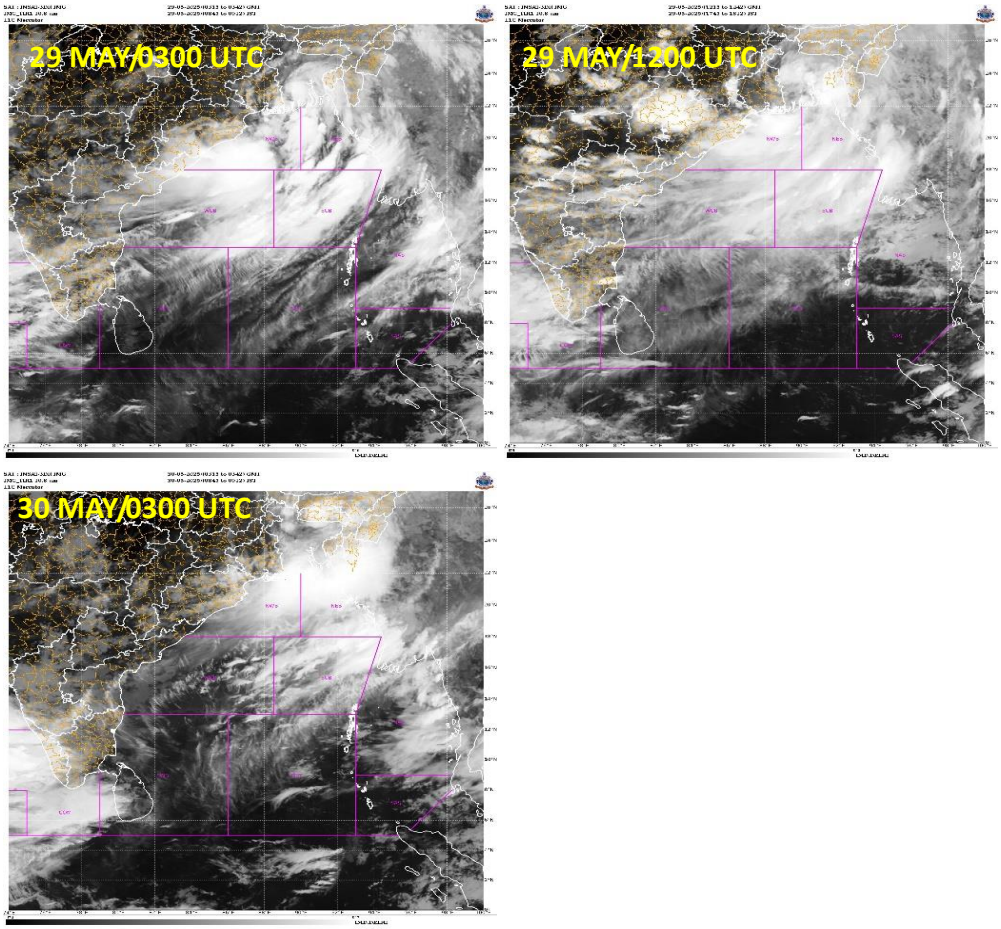


Fig.2.3.3(a): INSAT-3DS IR imageries during life cycle of Deep Depression of Bay of Bengal (29th-30th May, 2025).

At 0300 UTC of 30th May, associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over north and central BoB, Bangladesh and Manipur, Mizoram and Tripura. Minimum CTT was -75°C to -90°C. Moderate to intense convection lay over Odisha, Gangetic West Bengal and Northeastern states. Minimum cloud top temperature is -50°C to -70°C. INSAT 3DS Imagery during 29th to 30th May, 2025 are presented in **Fig 2.3.3.**

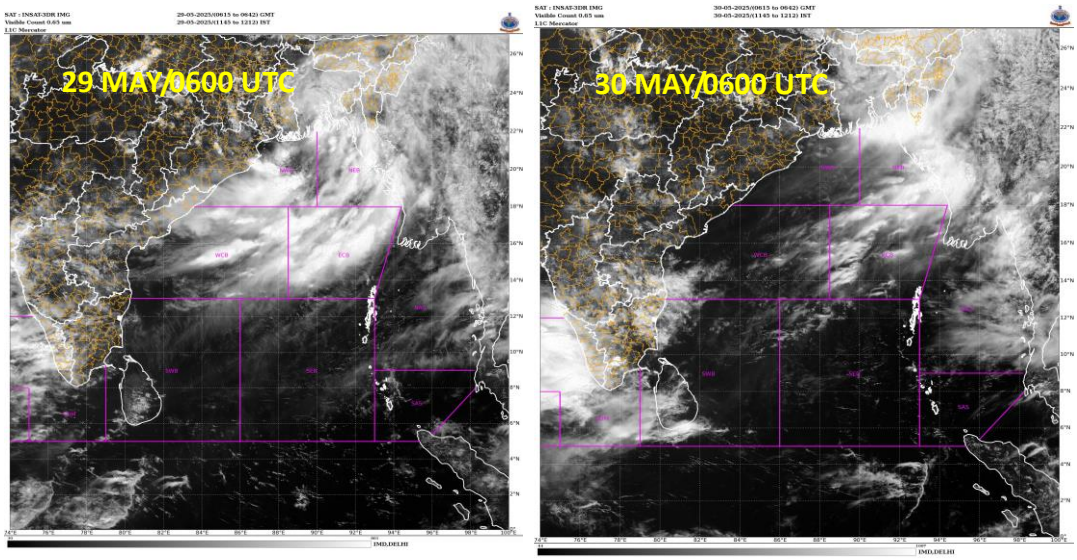


Fig.2.3.3(b): INSAT-3DS Visible imageries during life cycle of Depression of Bay of Bengal (29th -30th May, 2025)

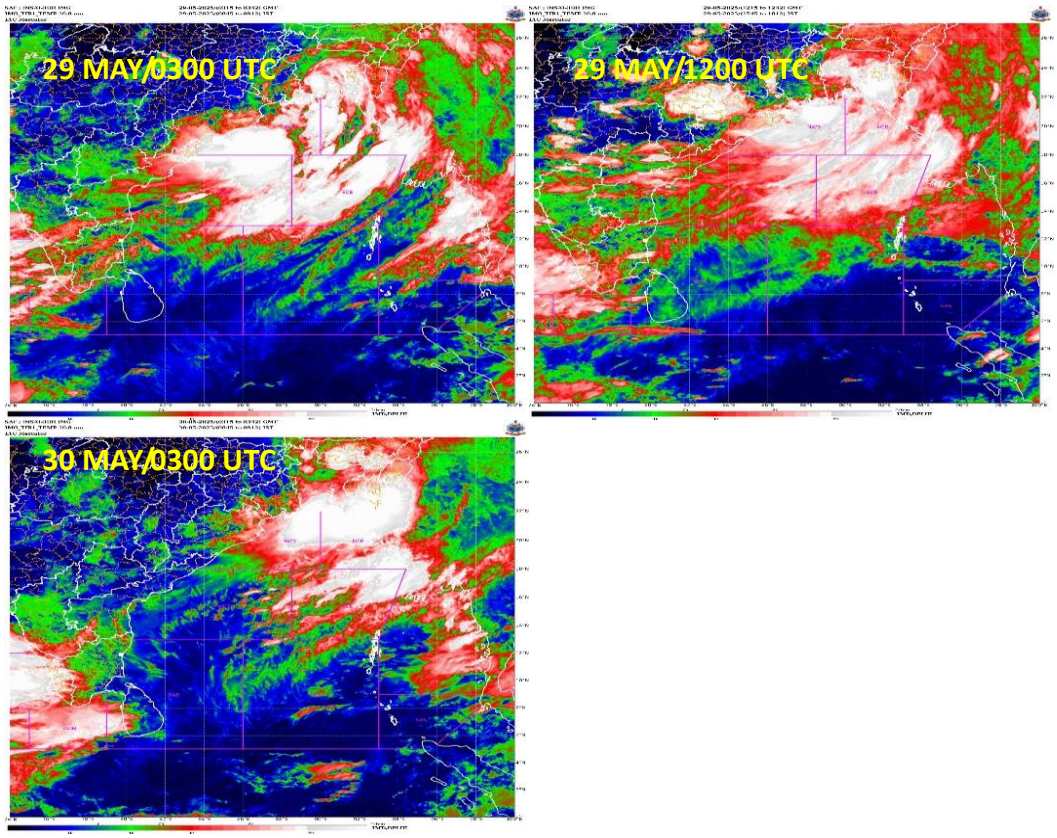


Fig.2.3.3(c): INSAT-3DS enhanced colour imageries during life cycle of Depression of Bay of Bengal (29th -30th May, 2025)

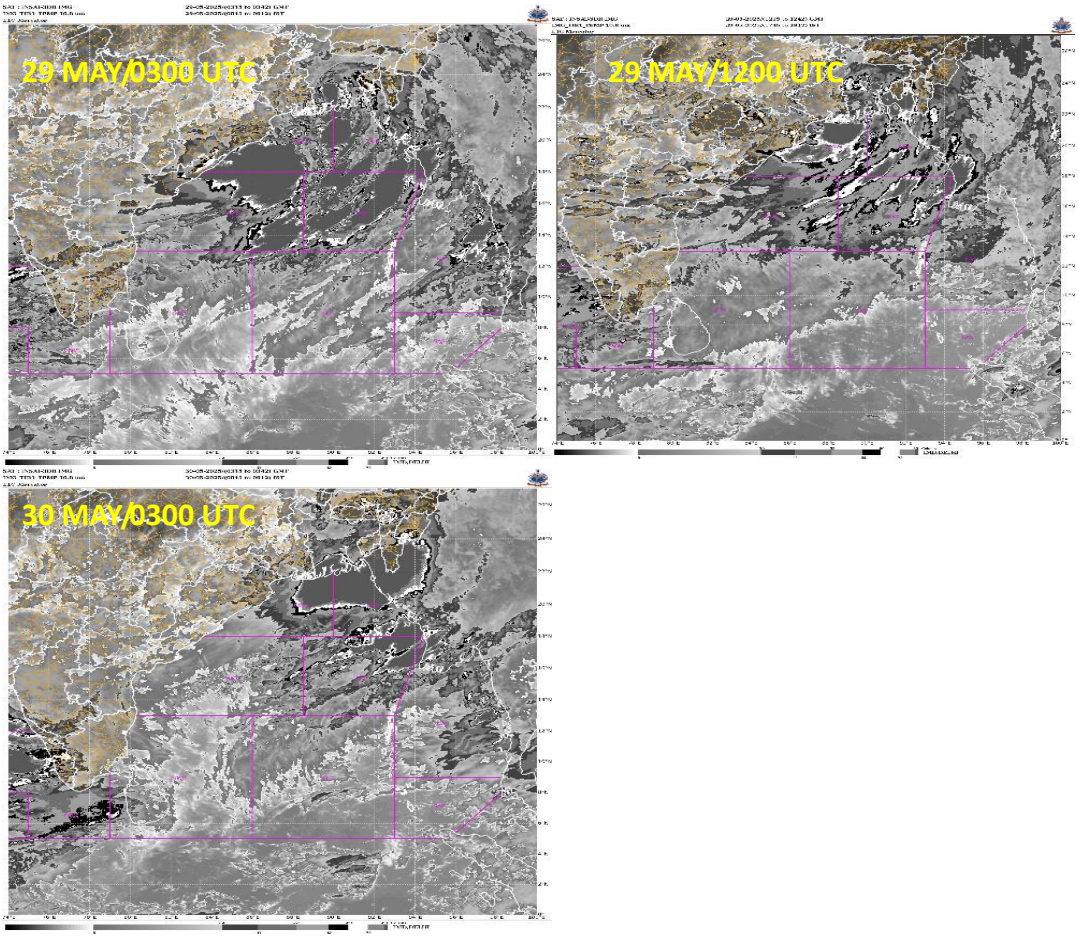


Fig.2.3.3(d): INSAT-3DS BD imageries during life cycle of Depression of Bay of Bengal (29th -30th May, 2025)

2.3.4.2 Radar Features:

The system was captured by Doppler weather radar at Kolkata on 29th May. Typical maximum reflectivity imageries from radar indicating intense convection over Bangladesh are presented in Fig.2.3. 4(a).

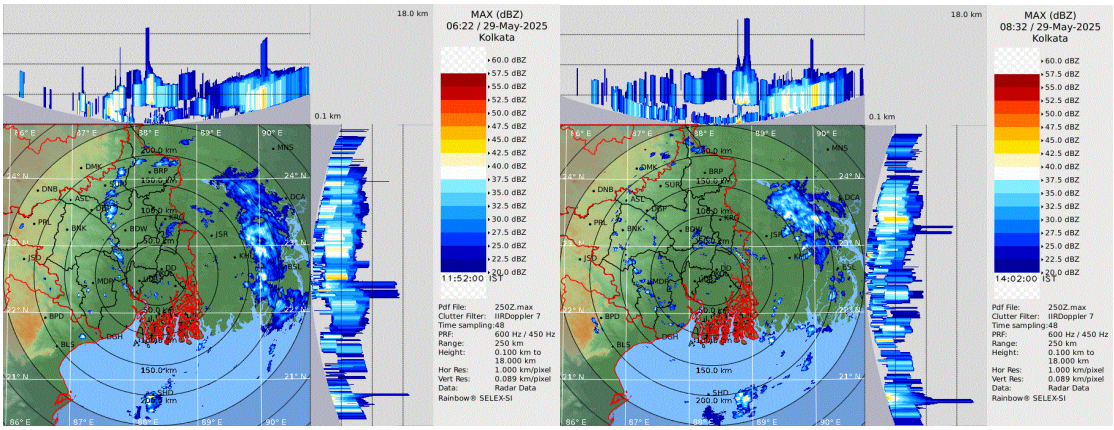


Fig.2.3.4(a): Maximum Reflectivity (dBZ) observations by Doppler Weather Radar (DWR) at Kolkata

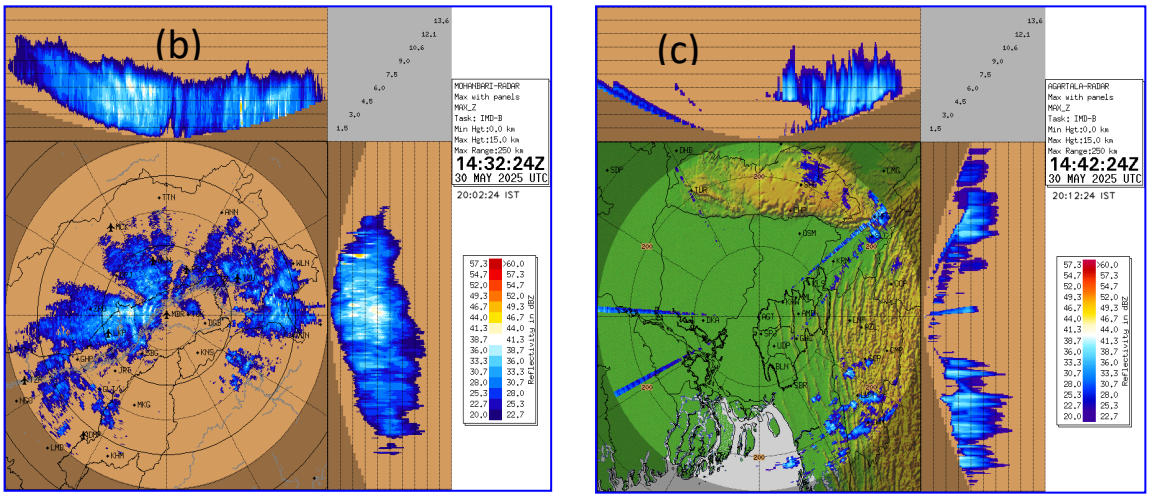


Fig.2.3.4: Maximum Reflectivity (dBZ) imageries from DWR at (b) Mohanbari and (c) Agartala

2.3.5 Genesis, Intensification and Weakening:

On 27th May, the Sea Surface Temperature (SST) was 30-32^{0}C over the entire BoB. Madden Julian Oscillation (MJO) was in phase 5 with amplitude more than 1. The guidance from NCICS model indicated strong westerly wind anomaly (5-7 mps) over the south BoB and strong easterly wind anomaly (5-7 mps) over north BoB till 31st May. The Equatorial Rossby wave (ERW) was likely to move westwards across south BoB, peninsular India and central Arabian Sea (AS) for next 4-5 days. The Kelvin wave was also seen moving eastwards across northern plains of India and north BoB during the same period. Along with the large-scale environmental features, the moderate vertical wind shear (VWS) of horizontal wind over north and adjoining central BoB also supported development of low-pressure system over the Northwest BoB off Odisha coast at 0830 hrs IST/0300 UTC of 27th May 2025.

On 28th May the VWS was moderate (5-10) over the system area. Low level relative vorticity was 100 X10^{-6}s^{-1} over north BoB, low level convergence was 30X10^{-6}s^{-1} over northeast BoB off Bangladesh & Myanmar coasts, upper-level divergence was around of 30X10^{-6}s^{-1} over eastentral BoB. As per total precipitable water content, there was warm air over the entire region extending upti Gangetic West Bengal and Bangladesh. Under these favourable conditions, the low-pressure area over northwest BoB off Odisha coast lay as a well marked low pressure area at 0530 hrs IST/0000 UTC of 28th May. The large-scale environmental features along with various dynamical parameters were supportive for further intensification of well-marked low-pressure system over the region. However, the moderate to strong shear over the region due to advancement of the southwest monsoon was limiting the intensification.

At 0000 UTC of 29th May, the SST was 30-32^{0}C over entire BoB. The MJO was in phase 5 with amplitude more than 1. The guidance from NCICS model indicated strong westerly wind anomaly (5-7 mps) over the south BoB and strong easterly wind anomaly (5-7 mps) over north BoB till 30th May. The ERW was likely to move westwards across peninsular India and central AS for next 3 days. The Kelvin waves were also likely to move eastwards across north BoB during the same period. The VWS was moderate (5-10 kt) over the system. Low level relative vorticity had increased and was 150 X10^{-6}s^{-1} to northeast of

system centre. Low level convergence increased and was $50X10^{-6}s^{-1}$ over northeast BoB and upper-level divergence was around $30X10^{-5}s^{-1}$ over northeast BoB. The total precipitable water imagery indicated warm moist air over the entire region extending over Gangetic West Bengal and Bangladesh. Under these favourable features the well-marked low-pressure system over northwest BoB intensified into a depression at 0530 hrs IST/0000 UTC of 29th May.

At 0300 UTC of 29th May, low level relative vorticity was $150\ X10^{-6}s^{-1}$ near system centre with vertical extension upto 200 hPa. Low level convergence was around $40X10^{-6}s^{-1}$ to the northeast of system centre and upper-level divergence was the same and was around $30X10^{-6}s^{-1}$ to the southwest of system centre. The total precipitable water imagery indicated warm moist air over the entire region extending over Gangetic West Bengal and Bangladesh. The upper tropospheric ridge was located near 21^0N. The system was lying very close to the north of the ridge. Under these favourable features the depression over northwest BoB moved nearly northwards along the ridge and intensified into a deep depression at 0830 hrs IST/0300 UTC of 29th May over northwest BoB off West Bengal-Bangladesh coasts.

At 0000 UTC of 30th May, MJO was in phase 5 with amplitude close to 1. The mid-level VWS was high (25 kt) around the system centre and 5-10 knots to the southeast of the system centre. Low level relative vorticity was about $150\ X10^{-6}s^{-1}$ to the southwest of system centre. Low level convergence was around $40X10^{-6}s^{-1}$ to the southeast of system centre and upper-level divergence was about $30X10^{-6}s^{-1}$ to the southeast of system centre. The total precipitable water imagery indicated warm moist air over the entire region extending upto coastal areas of Gangetic West Bengal and Bangladesh. The continuous land interaction and high vertical wind shear resulted in gradual weakening of the system at 0530 hrs IST/0000 UTC of 30th May, However, due to moist environment and local geography of the region (deltaic region), the depression maintained its intensity for 12 hours.

At 0600 UTC of 30th May, the MJO continued in phase 5 with amplitude close to 1. The mid-level vertical wind shear was moderate (10-20 kt) to the east of the system area. Low level relative vorticity decreased and was about $100\ X10^{-6}\ s^{-1}$ to the southeast of system centre. Low level convergence was around $50X10^{-6}\ s^{-1}$ to the southeast of system centre and upper level divergence was about $30X10^{-6}\ s^{-1}$ to the northeast of system centre. The total precipitable water imagery indicates warm moist air incursion over the entire region extending upto coastal areas of Gangetic West Bengal, Bangladesh and northeastern states. There would be orography enhancement of rainfall over the region due to southerly & southeasterly winds interaction with Garo Khasi Jaintia Hills & eastern Himalayas. Warm and moist air continued from northeast and eastcentral Bay of Bengal towards the system centre. It was expected to continue so for next 12 hours.

Under these features, the system maintained it's intensity for some more time and weakened into a well marked low pressure area over Meghalaya and neighbourhood at 1200 UTC of 30th May due to interaction with orography.

2.3.6 Model Guidance:

IMD maintained a round the clock watch over the Bay of Bengal and the system was continuously monitored since 22nd May. The analysis fields of IMD GFS ae presented in Fig.2.3. 5. At 0000 UTC of 27th, the analysis fields of IMD GFS indicated a well marked low pressure area over northwest BoB with vertical extension upto 500 hPa tilting southwestwards. Actually, it lay as a low-pressure area over northwest BoB off

Odisha coast at 0300 UTC of 23rd. The model under-estimated the intensity of the system on 27th May, however the location was correctly predicted.

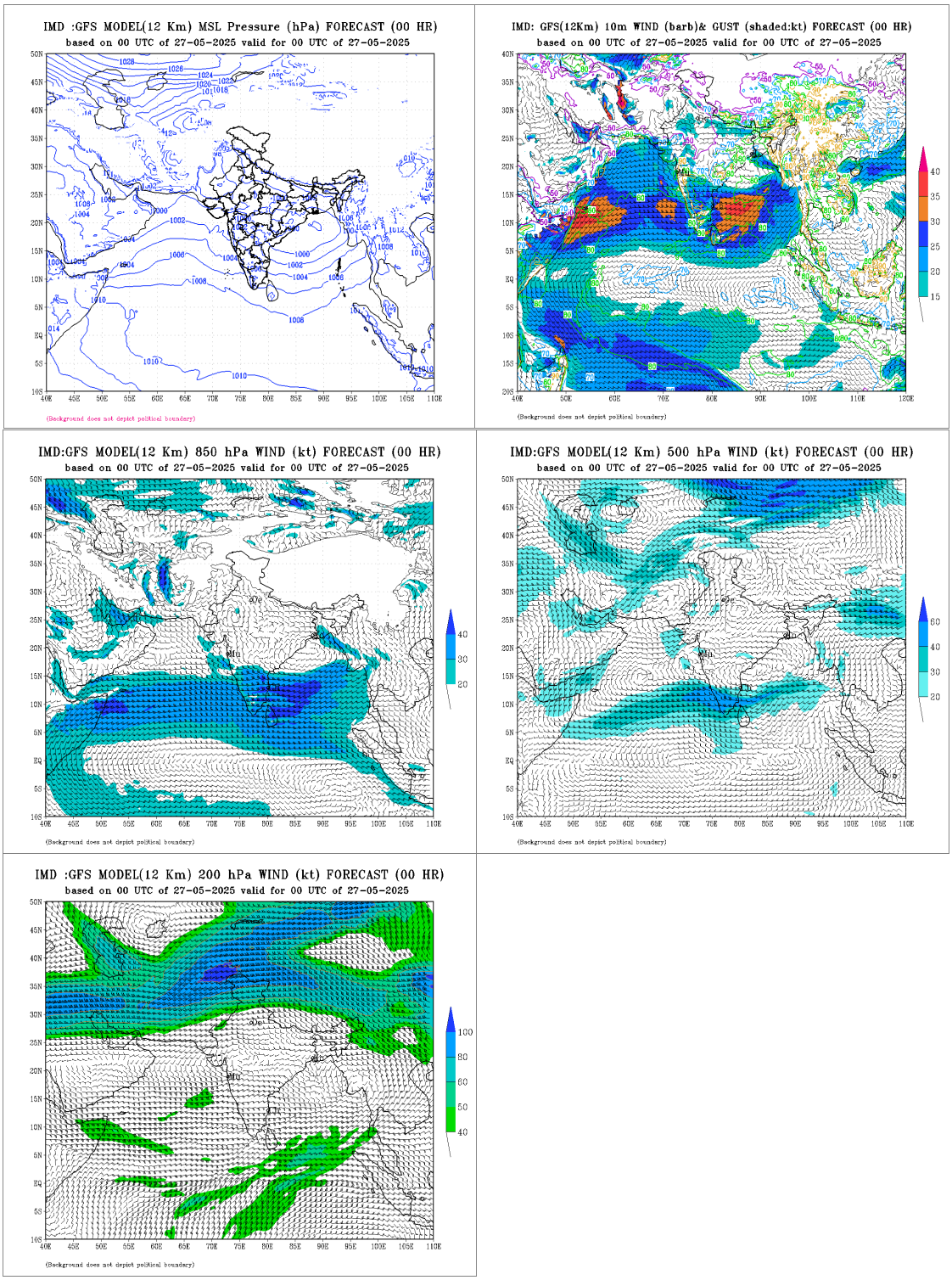


Fig.2.3.5(a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 27th May 2025.

At 0000 UTC of 28th, the model analysis fields indicated a well marked low pressure area over northwest BoB off Odisha, West Bengal coasts with vertical extension upto

500hPa tilting southwest wards with height. Actually, on 28th May/0000 UTC, it lay a well marked low pressure area over northwest BoB of Odisha and west Bengal coasts. Thus, the model correctly captured the location and intensity of the system.

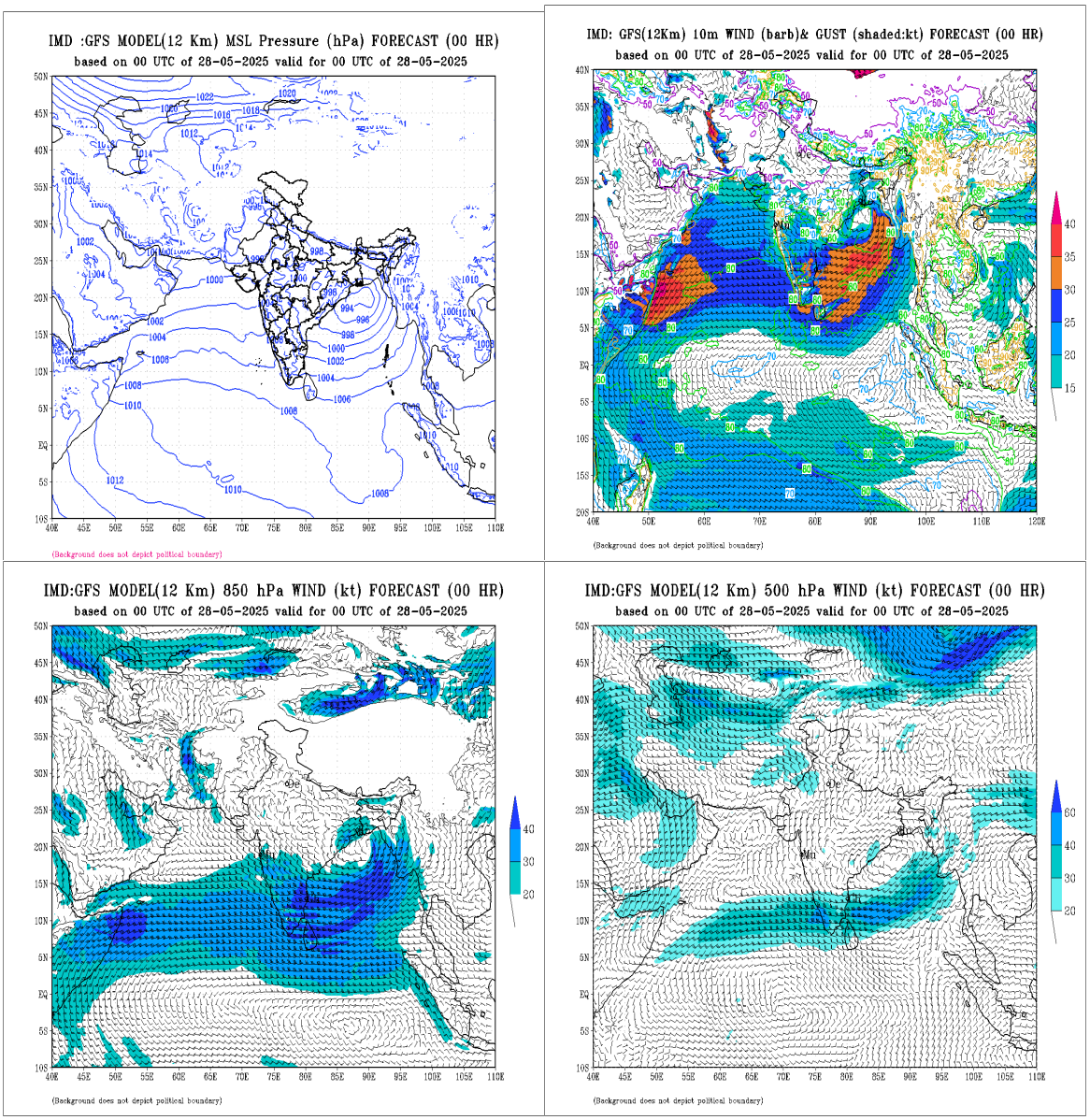


Fig.2.3.5(b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 28th May 2025.

At 0000 UTC of 29th, IMD GFS analysis fields indicated a deep depression over northwest BoB off West Bengal, Bangladesh coasts near 20^0N/89.6^0E with vertical extension upto 500hPa and no tilting. Actually at 0000 UTC of 29th, the system lay as a depression over northwest BoB off est Bengal coast near 20.8^0N, 88.3^0E.

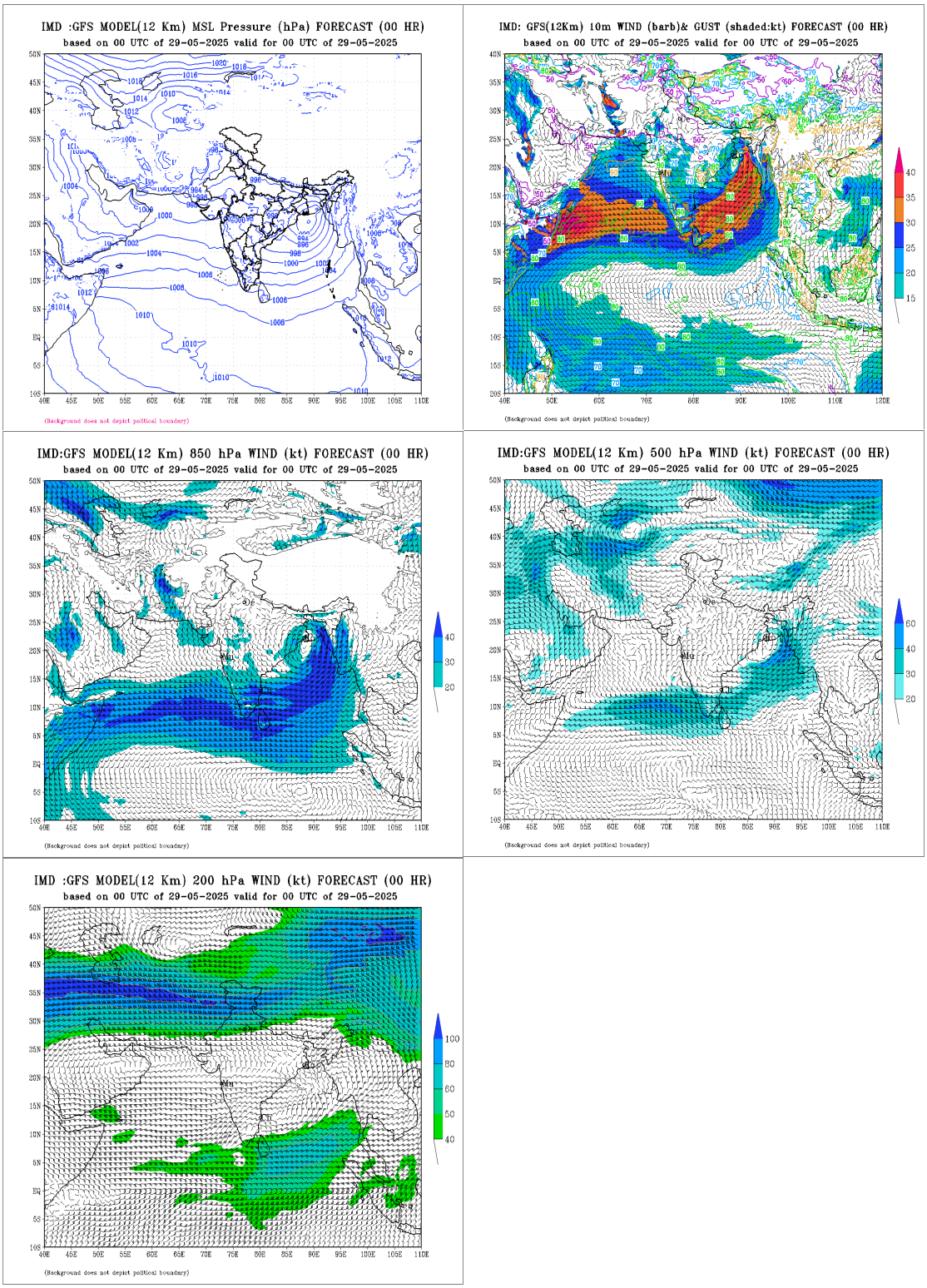


Fig.2.3.5(c): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 29th May 2025

At 0000 UTC of 30th, the IMD GFS analysis field indicated a deep depression over central parts of Bangladesh near 24.8^{0}N/90.2^{0}E with vertical extension upto 500hPa and no tilting. Actually, the system lay as a depression over central parts of Bangladesh near 24.1^{0}N/89.4^{0}E. Thus, IMD GFS correctly captured the location and intensity of the system during its life period.

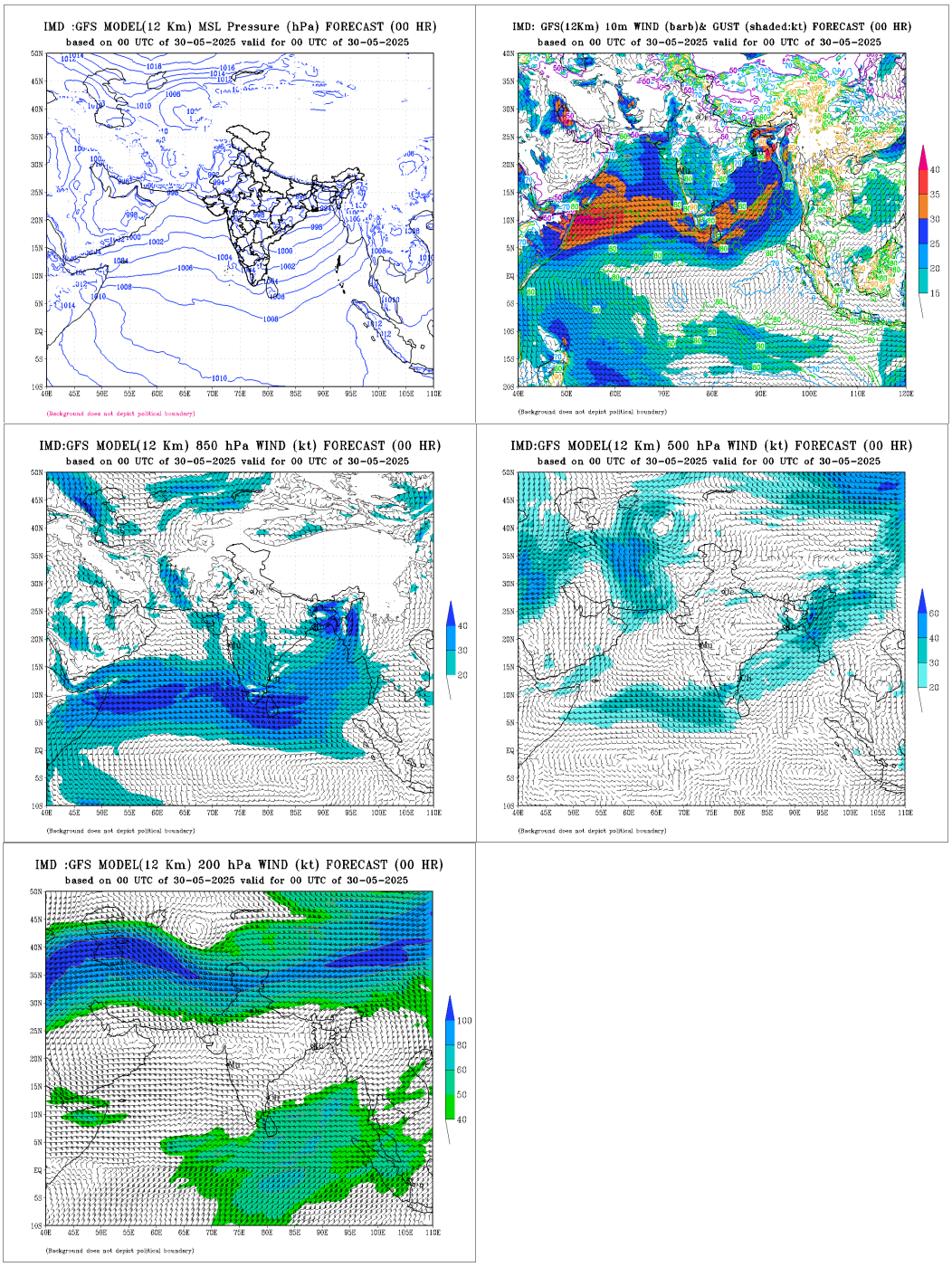


Fig.2.3.5(d): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 30th May 2025

2.3.7 Realised Weather:

2.3.7.1 Realised Rainfall

Rainfall associated with the depression based on IMD-NCMRWF satellite gauge merged data and state-wise point rainfall data are depicted in Fig 2.3.6(a) and (b).

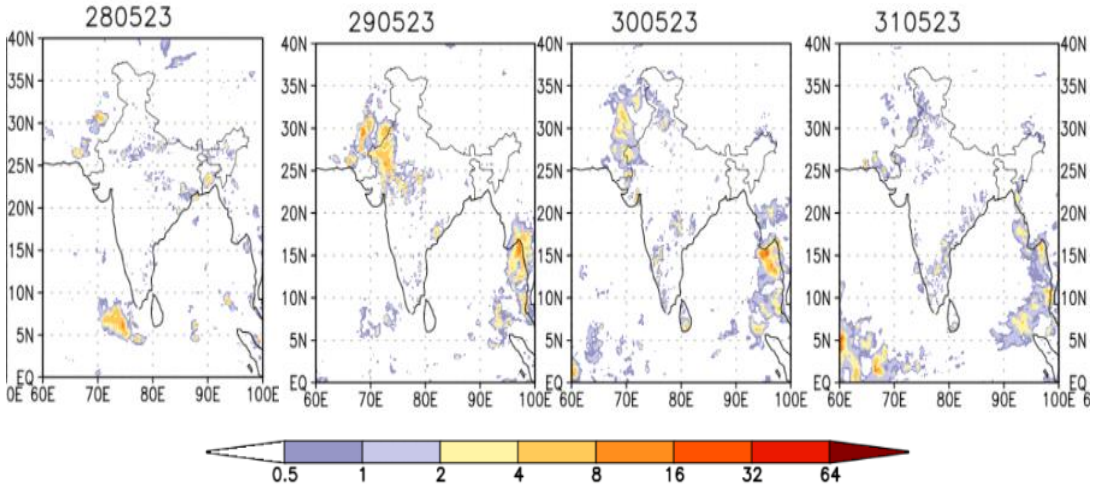


Fig.2.3.6(a): NCMRWF-IMD satellite gauge merged data plots of realized 24 hours accumulated rainfall from 28th May to 31st May, 2025.

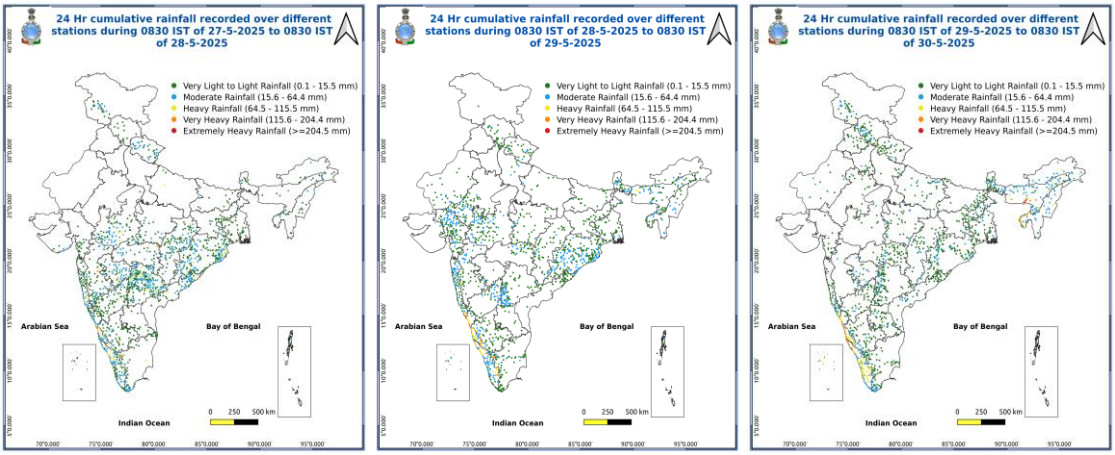


Fig.2.3.6(b): State-wise Point rainfall data plots of realized 24 hours accumulated rainfall from 28th May to 30st May, 2025.

The system caused vigorous rainfall activity over the northeastern states of India during 28th-30th leading to damage to life and property.

24 hours cumulative heavy rainfall (≥ 7cm) ending at 0830 hours IST of date is presented below and in Fig.2.3.11.

29th May:

- **Odisha**: Lanjigarh 10; Chilika 8; Krishnaprasad, Ganjam, Begunia, Angul 7 each;
- **Assam & Meghalaya**: Kokrajhar, Dhupdhara 8 each; Gharmura, Bahalpur 7 each;
- **Nagaland, Manipur, Mizoram & Tripura**: Chandel 8;
- **Sub Himalayan West Bengal & Sikkim**: Lava 7;

30th May:

- **Assam & Meghalaya**: Cherrapunji 38; Mawsynram 26; Mawphlang 25; Cherrapunji 22; Williamnagar 17; Mawkyrwat, Resubelpara 15 each; Jowai, Bhaghmara, Umrangso 14 each; Shillong 13; Williamnagar, Khliehriat 12 each;

- **Nagaland, Manipur, Mizoram & Tripura**: Sonamura 17; Jirania 16; Arundhutinagar, Sonamura 14 each; Teliamura, Agartala, Khowai, Agartala, Khowai 12 each; Sabroom, Budhjongnagar 11 each; Bishalgarh, Amarpur, Belonia, Sabroom, Gandachara, Belonia, Bagafa 9 each;
- **Arunachal Pradesh**: Bomdila 10; Daparijo, Daporizo, Hawai 8 each;
- **Sub Himalayan West Bengal & Sikkim**: Kalimpong 8;

31st May:

- **Assam & Meghalaya**: Cherrapunji 47; Mawsynram 40; Khliehriat 30; Mawkyrwat 29; Mawphlang 21; Chauldhowaghat 18; N.lakhimpur, Tezpur 17 Each; Majbat, Khanapara, Mazbat 16 each; Shella, Amraghat 15 each; Jowai, Badatighat, Chandrapur, Khetri, Sonapur 13 Each; Bihpuria, Numaligarh, Barpathar, Guwahati, Panbari 12 Each; Guwahati, Dhemaji, Byrnihat, Sualkuchi, Laharighat, Guwahati 11 Each; Shillong, Goibargaon, Barapani, Jia Bharali, Guwahati, Neamatighat, Nongstein, Majuli, Udaipur, Kalakshetra 10 Each; Shillong, Dholai, Khowang, Baithalangso, Bhumuraguri, Tangla, Hangrabari 9 Each; Dharamtul, Jiagaon, Lakhipur, Tamulpur, Dhupdhara, Hazo, Bajali, Dhekiajuli, Silchar 8 Each; B P Ghat, Matijuri, Kheronighat, A P Ghat, Margherita, Golaghat, Tamulpur, Ranganadi 7 Each;
- **Sub Himalayan West Bengal & Sikkim**: Sevoke, Buxaduar, Hasimara 23 Each; Beech, Hilla 17; Chengmari 16; Banarhat, Kurti 15 Each; Neora, Ghatia, Gurjongjhora, Soongachi, Nagrakata, Dima 14 Each; Ghish, Indong, Jiti, Bhutanghat 13 Each; Zurrantee, Nagarkata 12 Each; Gajoldoba, Aibheel, Gandrapara, Leesh 11 Each; Bhatkawa, Chel, Oodlabari 10 Each; Singhik, Baradighi, Kumlai, Washabari, Fagu, Mangan, Dalgaon 9 Each; Shipgyar, Batabari, Chalouni, Damdim, Gairkata, Saraswatipur 8 Each; Bagdogra, Murti, Baintgoorie, Kailashpur, Newlands 7 Each;
- **Nagaland, Manipur, Mizoram & Tripura**: Saiha 22; Senapati 15; Champai 14; Lawngtlai 12; Aizawl, Zunheboto 9 Each; Wokha, Ukhrul 8 Each; Chottabekra, Kiphire, Kolasib 7 Each;
- **Arunachal Pradesh**: Tezu, Bomdila 18 Each; Basar 16; Yazali 15; Naharlagun, Tezu 14 Each; Miao, Ziro, Hawai 13 Each; Pasighat 12; Daporizo, Passighat 11 Each; Roing, Seppa 10 Each; Tuting, Daparijo, Kibithu 9 Each; Bomdila 8; Tuting, Namsai 7 Each;

2.3.7.2 Realised gale/squally wind in past 24 hours ending at 0300 UTC of date

29th May:

Assam & Meghalaya: Gossaigaon 68, Kokrajhar 47, Dhubri 45, Goalpara 43,

Gangetic West Bengal: Amta 46; Canning 41; Raidighi 39; Digha, Diamond Harbour 37; Sonarpur 35; Jagatballavpur, Berhampore, Kalyani, Purulia, Alipore 33; Dum Dum 31; Durgapur & Nimpith 30 each

Mizoram: Saiha 42

Odisha: Ranital, Mayurbhanj 43

Sub-Himalayan West Bengal & Sikkim: Dhupguri 41; Mal 33; Ramshai & Malda 30 each;

30th May:

Assam & Meghalaya: Kamrup 93, Goalpara 88, Bongaigaon 81, Morigaon 65, Dibrugarh 60;

Nagaland, Manipur, Mizoram & Tripura: Saiha 72;
Gangetic West Bengal: Barrackpore 56, Berhampore 48, Amta 39, Kolkata Airport 33, Canning 33;
Odisha: Gunupur 56, Mayurbhanj 39, Cuttack 33, Jagatsinghpur 35;
Sub-Himalaya West Bengal & Sikkim: Jalpaiguri 41, Dhupguri 41, Dinhata 39, Malda 37;

2.3.8 Damage report:

The deep depression over the Bay of Bengal and its remnant led to catastrophic flooding and landslides across Northeast India, causing at least 32 deaths and widespread destruction. Guwahati experienced record-breaking rainfall, resulting in fatal mudslides and urban flooding. Arunachal Pradesh reported multiple fatalities due to vehicles being swept away and drowning incidents. Mizoram faced unprecedented rainfall leading to landslides and infrastructure damage. Manipur, Tripura, and Meghalaya also suffered significant disruptions and fatalities. Emergency services were mobilized, and authorities assessed damage to seek central assistance for relief and reconstruction efforts. Damage photographs are presented in Fig.2.37.

Fig 2.3.7: Deep depression leaves trails of destruction over Northeastern states of India (a) Commuters stranded on BCT road in Arunachal Pradesh. (The Arunachal Times) (b) Incessant rainfall since May 29 triggered landslides in several parts of Sikkim's Mangan district (PTI 02 June) (c) In Meghalaya, 10 districts have been affected by flash floods and landslides. Photo Credit: ANI 02 June (d) Residents commute in cycle rickshaws through a flooded road in Guwahati, Assam, India, May 31, 2025. Photo Credit: ANI 01 June.

2.4. Depression over southeast Gangetic West Bengal and adjoining Bangladesh (14th-15th July, 2025)

2.4.1 Life History:

- Under the influence of an upper air cyclonic circulation that had formed over northwest Bay of Bengal adjoining West Bengal and north Odisha coasts, a Low-Pressure Area formed over the same region in the evening (1730 hours IST/1200 UTC) of 13th July 2025.
- It lay as a Well-Marked Low-Pressure Area over southwest Bangladesh and adjoining Gangetic West Bengal in the early morning (0530 hours IST/0000 UTC) of 14th July 2025.
- It concentrated into a Depression over the same region in the forenoon (1130 hours IST/0600 UTC) of 14th July 2025 and lay centred near Lat. 23.0°N and Long. 88.8°E, about 70 km northeast of Kolkata and 100 km east-southeast of Burdwan.
- Moving west-northwestwards, it lay centred as a Depression over southeast Gangetic West Bengal and adjoining Bangladesh in the evening (1730 hours IST/1200 UTC) of 14th July 2025 near Lat. 23.3°N and Long. 88.4°E, about 90 km north of Kolkata and 50 km east of Burdwan.
- Continuing its west-northwestward movement, it lay centred over central parts of Gangetic West Bengal in the late night (2330 hours IST/1800 UTC) of 14th July 2025 near Lat. 23.5°N and Long. 88.0°E, about 110 km north-northwest of Kolkata, 30 km north-northeast of Burdwan and 160 km east of Dhanbad.
- It moved further west-northwestwards and lay centred over Jharkhand and neighbourhood in the early morning (0530 hours IST/0000 UTC) of 15th July 2025 near Lat. 24.0°N and Long. 86.7°E, about 40 km northeast of Dhanbad, 140 km east of Hazaribagh, and 200 km east-southeast of Gaya.
- It weakened into a Well-Marked Low-Pressure Area over north Jharkhand and adjoining south Bihar in the morning (0830 hours IST/0300 UTC) of 15th July 2025.
- The observed track of the depression was presented in Fig.2.4.1. The best track parameters of the system were presented in Table 2.4.1.

Table 2.4.1: Best track positions and other parameters of the Depression over southeast Gangetic West Bengal and adjoining Bangladesh during 14th–15th July, 2025

Date	Time (UTC)	Lat.	Long.	C.I. No.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure Drop at the Centre (hPa)	Grade
14.07.2025	0600	23.0	88.8	-	998	20	3	D
	1200	23.3	88.4	-	998	20	3	D
	1800	23.5	88.0	-	998	20	3	D
15.07.2025	0000	24.0	86.7	-	998	20	3	D
	0300	Weakened into a well-marked low-pressure area over north Jharkhand and adjoining south Bihar						

kt: Knots 1 kt=1.85 kmph, D: Depression

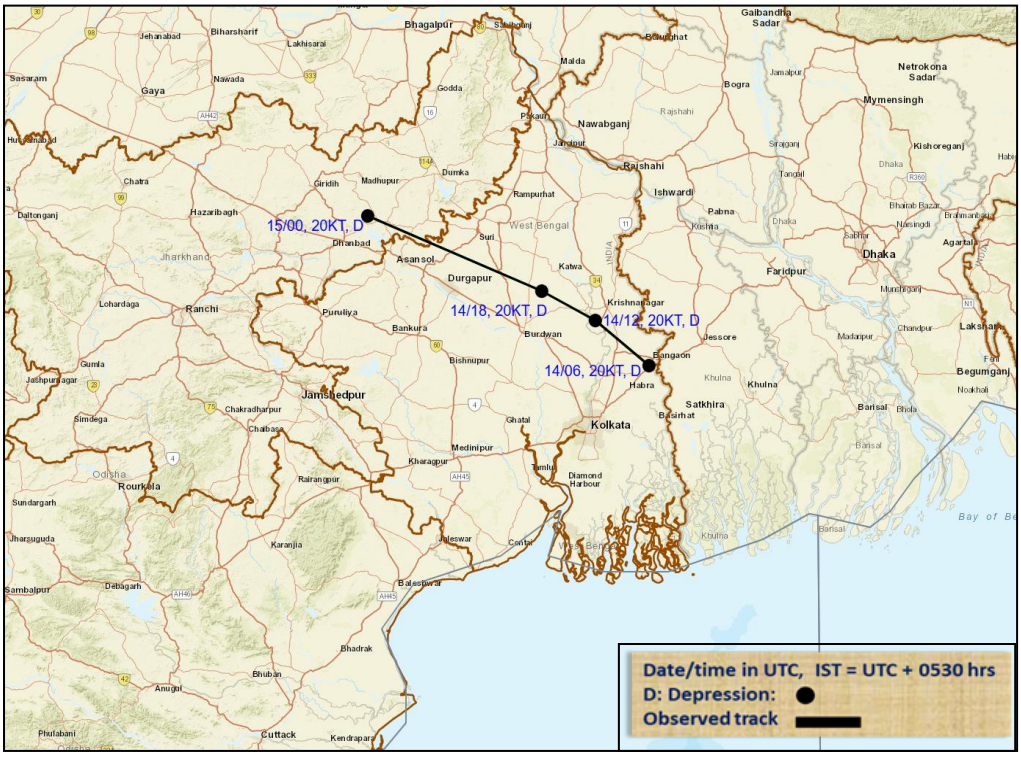


Fig.2.4.1: Observed track of the Depression over southeast Gangetic West Bengal and adjoining Bangladesh during 14th July – 15th July, 2025

2.4.2 Monitoring of Depression

The India Meteorological Department (IMD) maintained round-the-clock surveillance over the north Indian Ocean, continuously monitoring the weather system since July 10, 2025. The first indication of its development was highlighted in the weekly Extended Range Outlook issued on July 10, which suggested the likely formation of an upper-air cyclonic circulation over the North Bay of Bengal and adjoining coastal areas of West Bengal and Bangladesh around July 13. The outlook also indicated that the system might move slowly west-northwestwards across Gangetic West Bengal, north Odisha, adjoining Jharkhand, and south Chhattisgarh over the next 2–3 days, with a low probability of significant intensification.

Based on this forecast, anticipatory guidance for marine interests, scientific institutions, and disaster management authorities was issued in advance. As expected, a Low-Pressure Area formed over the northwest Bay of Bengal off the West Bengal–Bangladesh coasts on the evening of July 13, 2025, influenced by the anticipated upper-air cyclonic circulation. This system later concentrated into a Depression on July 14.

The IMD monitored the depression using available satellite observations from INSAT 3D and 3DR, RADAR and microwave imageries, and land observations in the region. Various global models and dynamical-statistical models—run by Ministry of Earth Sciences (MoES) institutions, including IMD, NCMRWF, IITM, and INCOIS—were utilized to predict the system's genesis, track, intensity, and associated severe weather. Guidance from international agencies under bilateral arrangements was also used.

The forecasts were primarily based on a multi-model ensemble technique developed by the IMD, which was further modulated by observations and forecaster intervention. The

department utilized an indigenously developed digitized forecasting system for analyzing and comparing observations and numerical weather prediction model guidance, supporting the decision-making process and generating warning products.

Satellite-based products utilised for monitoring the system are presented in **Fig.2.4.1**

2.4.3.1 Satellite Features:

According to INSAT-3D/3DS imagery from 0300 UTC on July 14, 2025, scattered to broken low and medium clouds were observed over Odisha, Gangetic West Bengal, south Bangladesh, and the adjoining north Bay of Bengal. This system included areas of intense to very intense convection, with minimum cloud top temperatures ranging from -70°C to -90°C.

Further analysis of the system over southeast Gangetic West Bengal and adjoining Bangladesh revealed the following conditions:

Low-level vorticity: Approximately 100×10^{-6} s^{-1} to the south of the system's center.

Low-level convergence: About 5×10^{-6} s^{-1}, also located to the south of the center.

Upper-level divergence: Around 10×10^{-6} s^{-1}, positioned to the southwest.

Wind shear: Low, in the range of 5–10 knots over the system area.

In association with the separate system over northeast Rajasthan and adjoining northwest Madhya Pradesh, different atmospheric conditions were noted:

Low-level vorticity: Positive and exceeding 100×10^{-6} s^{-1} over the system center.

Low-level convergence: Ranged from 10 to 15×10^{-6} s^{-1} and was oriented north–south.

Upper-level divergence: About 5 to 10×10^{-6} s^{-1} located to the northwest of the system center.

Wind shear: Relatively high, ranging between 20–25 knots to the northwest of the system center.

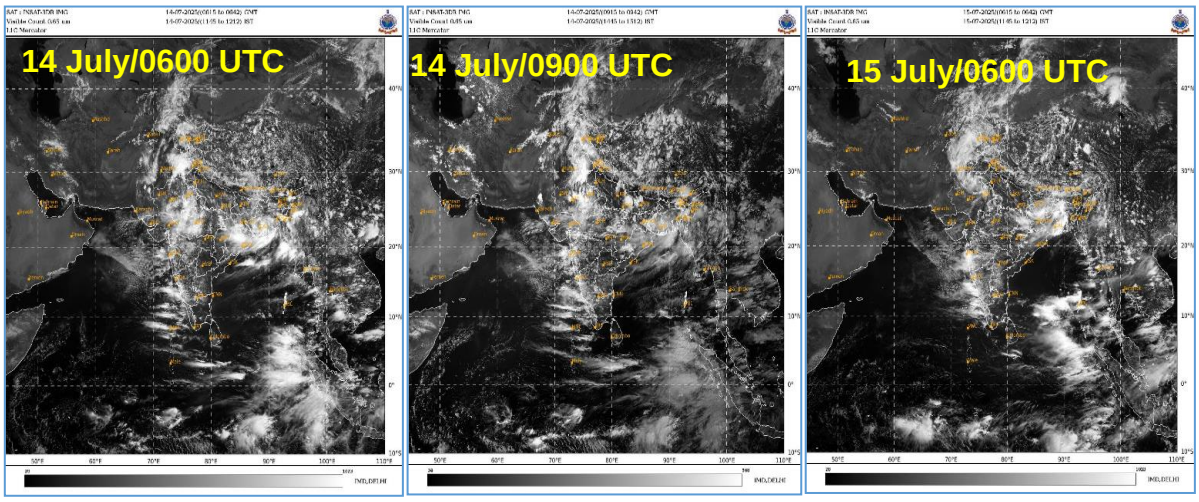


Fig. 2.4.2(a): INSAT-3D Visible imageries during life cycle of Depression over southeast Gangetic West Bengal and adjoining Bangladesh during 14th July – 15th July, 2025.

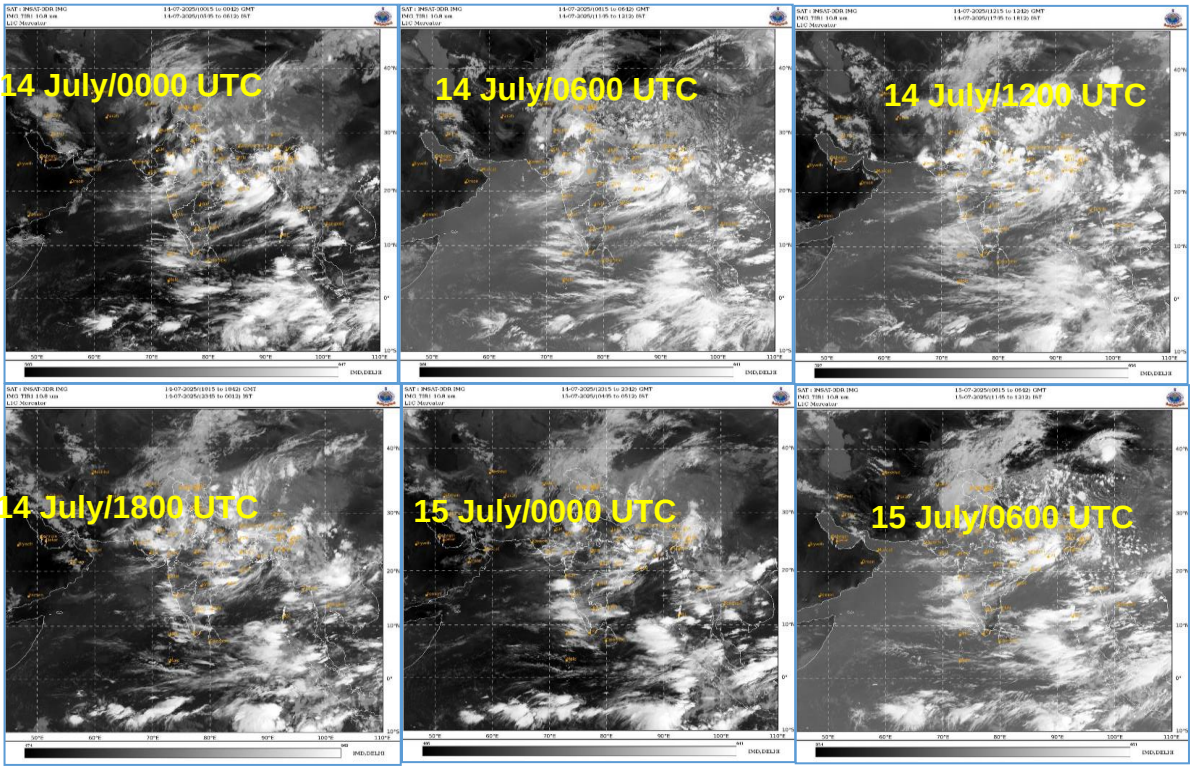


Fig.2.4.2(b): INSAT-3S IR imageries during life cycle of Depression over southeast Gangetic West Bengal and adjoining Bangladesh during 14th–15th July, 2025.

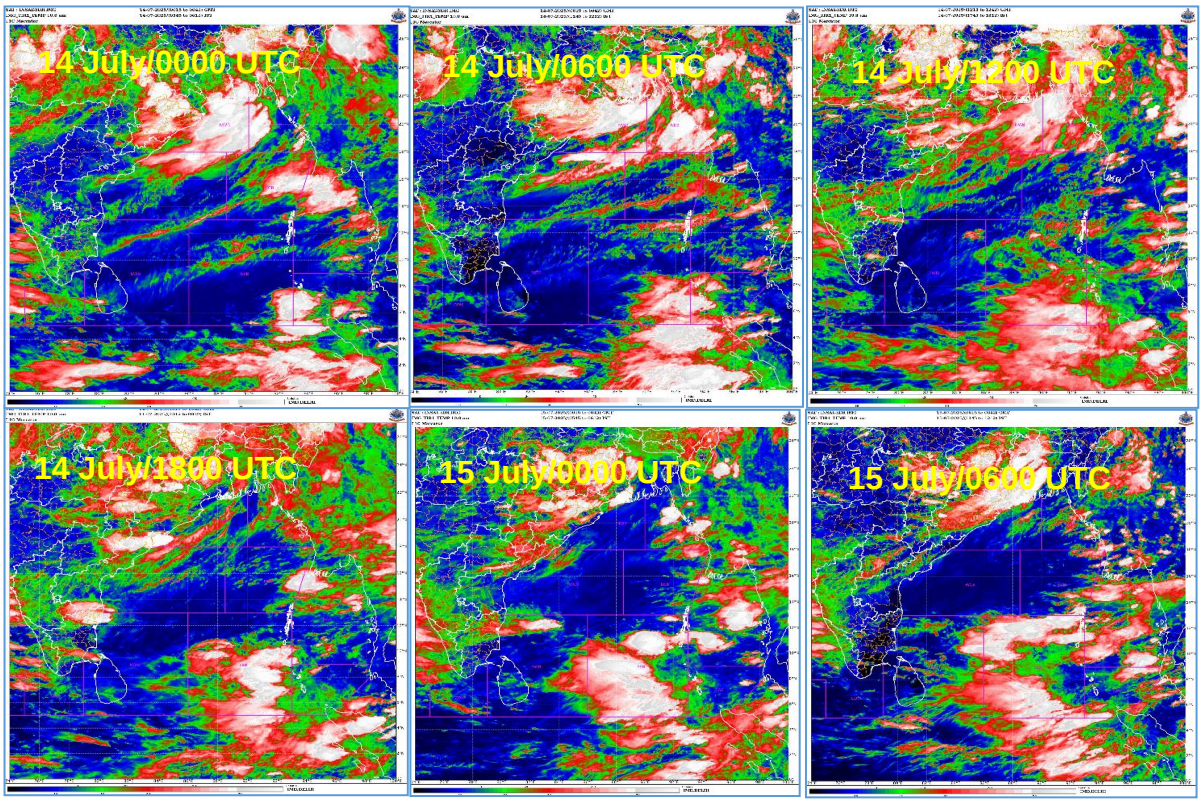


Fig.2.4.2(c): INSAT-3D NHC imageries during life cycle of Depression over southeast Gangetic West Bengal and adjoining Bangladesh during 14th–15th July, 2025.

2.4.3.2 Radar Features:

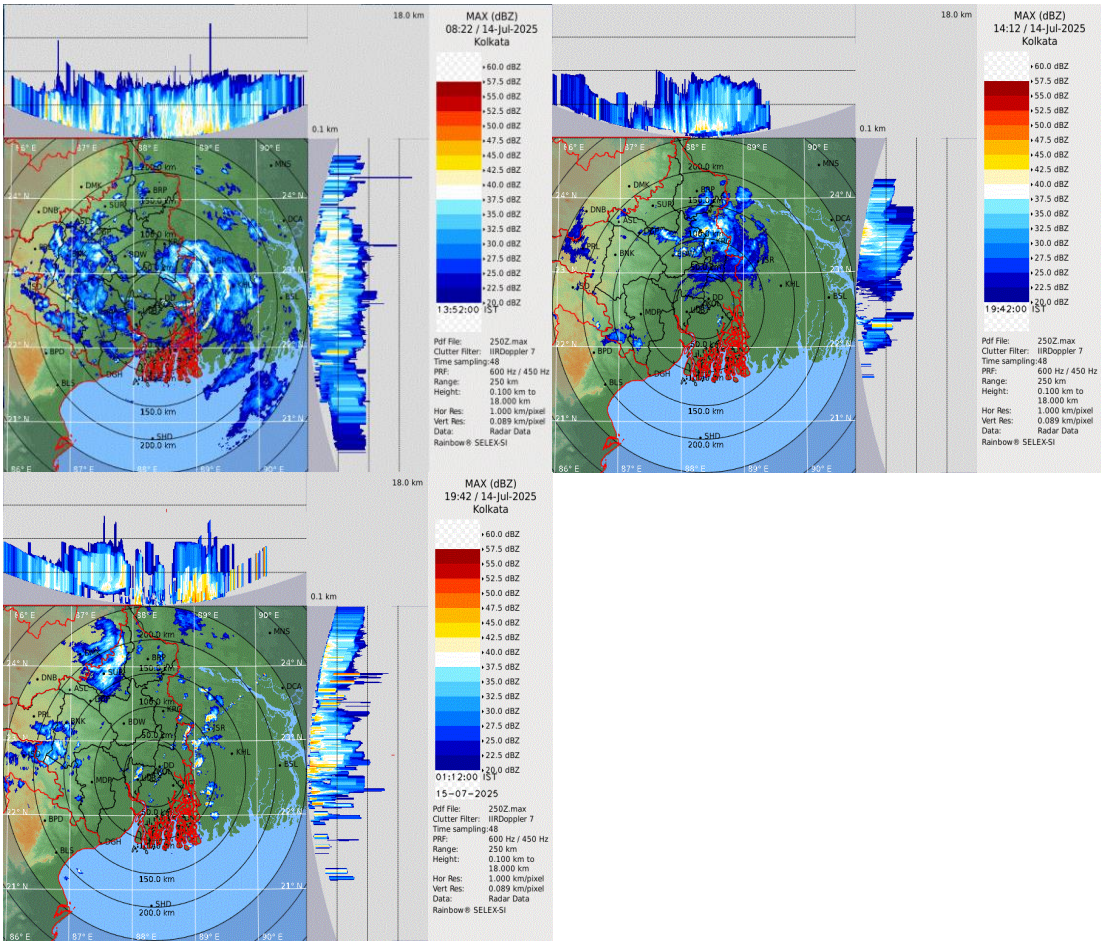


Fig2.4.3: Maximum Reflectivity (dBZ) Observation by Doppler Weather Radar (DWR) at Kolkata

Four Doppler-radar "MAX dBZ" frames from the Kolkata radar on 14 July 2025 (into early 15 Aug), showing maximum reflectivity and vertical echoes have been represented in **Fig.2.4 3**.

The reflectivity pattern showed spiral band characteristic. It represents a monsoon rain area with embedded thunderstorms. Echoes are arranged in curved/spiral bands, indicating a cyclonic circulation associated with a low-pressure area over/near the North Bay of Bengal feeding rain into south Bengal and Bangladesh.

The high values of reflectivity i.e. the intensity signifies mostly light–moderate rain (blue/green), with pockets of heavy downpours (yellow/orange, occasional red >40–50 dBZ). Echo tops generally 12–16 km and a melting layer near ~4–5 km, showing widespread stratiform rain with convective cells. From four frames at different times portray the evolution with time from: Morning—broad rain shield affecting the coast and moving inland; Midday—breaks with scattered cells mainly north of Kolkata; in the Evening—new convective band crosses the city with heavier cores; and Late night—precipitation persists but becomes patchier. Therefore, overall, a rainy, stormy day with periodic heavy showers and thunderstorms around Kolkata, typical of a monsoon low/depression.

2.4.4 Model Guidance:

IMD maintained a round the clock watch and the system were monitored since 14th July.

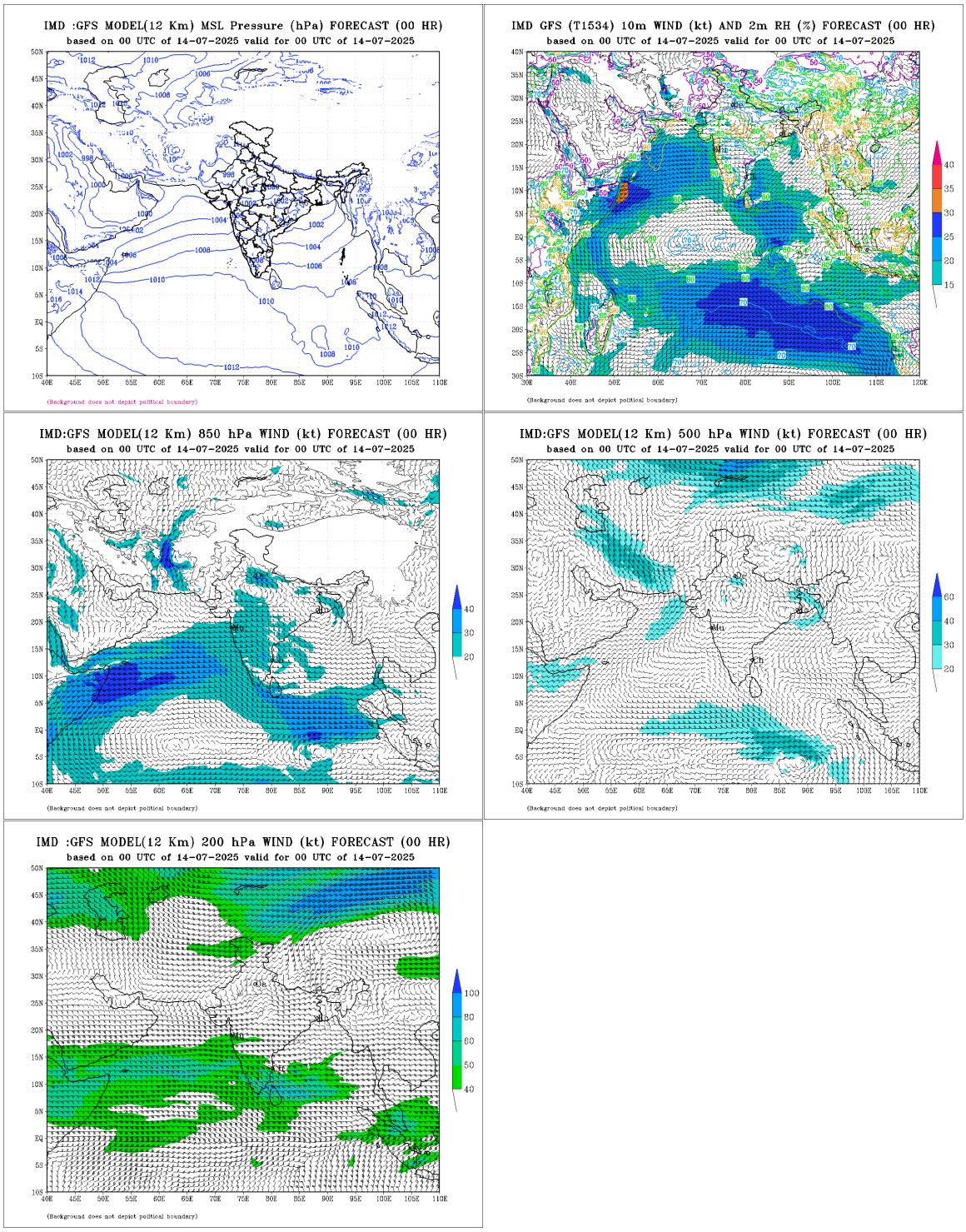


Fig.2.4.4(a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 14th July 2025

IMD-GFS analyses at 0000 UTC of 14th July for Mean Sea Level Pressure and wind at various levels starting from 10 m above sea level to 200 hPa pressure level are plotted in various panels of **Fig.2.4.3(a)**.

Mean sea-level pressure (MSLP) showed that the Monsoon trough lay east–west across north/central India. A closed low and associated cyclonic circulation lay over the north Bay of Bengal–Ganges delta region, with the strong pressure gradient on the Bay side. The 2-m Relative Humidity (RH) was very high (80–95%) over the north Bay, East India and the Himalayan foothills, indicating a very moist boundary layer and active monsoon conditions.
The 850-hPa wind pattern portrayed a pronounced low-level cyclonic vortex over the north Bay/east India with 20–30+ kt wind speed on its southern/eastern sectors. The southwesterly low-level jet over the Arabian Sea and Bay of Bengal fed moisture toward the Gangetic plains and NE India. The 500-hPa winds showed a broad troughing/weak cyclonic flow over east/northeast India i.e. mid-level winds are modest (generally 10–25 kt), keeping shear supportive of organized convection near the low. The upper-level winds at 200-hPa signify strong easterlies of the Tropical Easterly Jet over peninsular India (40–60 kt in cores) with weaker westerlies to the north and the divergence aloft over East/Northeast India, favouring ascent above the low. Therefore, the analyses depicted an active monsoon setup with a North Bay low embedded in the monsoon trough, strong moist inflow at the surface/850 hPa and supportive upper-level outflow—consistent with widespread rain and embedded thunderstorms over eastern India and adjoining areas.

The model analyses at 0000 UTC of 15th July for surface and other levels starting from 10 m above sea level to 200 hPa pressure level are again plotted in various panels of **Fig.2.4.3(b)**.

In the figure the mean sea-level pressure depicted a broad monsoon trough runs west–east across north India. The model analyses of MSLP and 10 m wind represented a very weak low over the region where observed low pressure area was observed on the day. Rather another low-pressure area and associated cyclonic circulation lay over the north Rajasthan region. However, the stronger pressure gradient over the Arabian Sea supported a strong monsoon flow toward the west coast. The 2-m RH showed a moist boundary layer (RH mostly 80–95%) over the seas and Indian region. The on-shore southwesterlies along the west coast, cyclonic curvature near the North Arabian Sea and over the Bay of Bengal feed moisture inland over the monsoon trough zone across central/east India.

The 850-hPa wind illustrated the vigorous southwesterly low-level jet (about 25–35+ kt) over the central/eastern Arabian Sea aimed at Konkan–Gujarat and into central India. The WSW/SWlies with 15–25 kt wind speed took cyclonic curvature over the Bay of Bengal into Odisha–West Bengal and Northeast India, finally producing convergence across central/east India. In the 500-hPa wind pattern, weak to moderate westerlies with a shallow trough over central/east India, with speeds generally of 10–25 kt, are favorable for embedded convection. The 200-hPa wind shows the Tropical Easterly Jet across peninsular India (around 40–60 kt) with upper-level divergence over central/east India and a weaker westerly north of about 25°N. Hence, it was an active monsoon situation with strong moist inflow at low levels (especially from the Arabian Sea), a monsoon trough over north India, and

supportive upper-level easterlies—favoring widespread rain, particularly along the west coast and across central/east India.

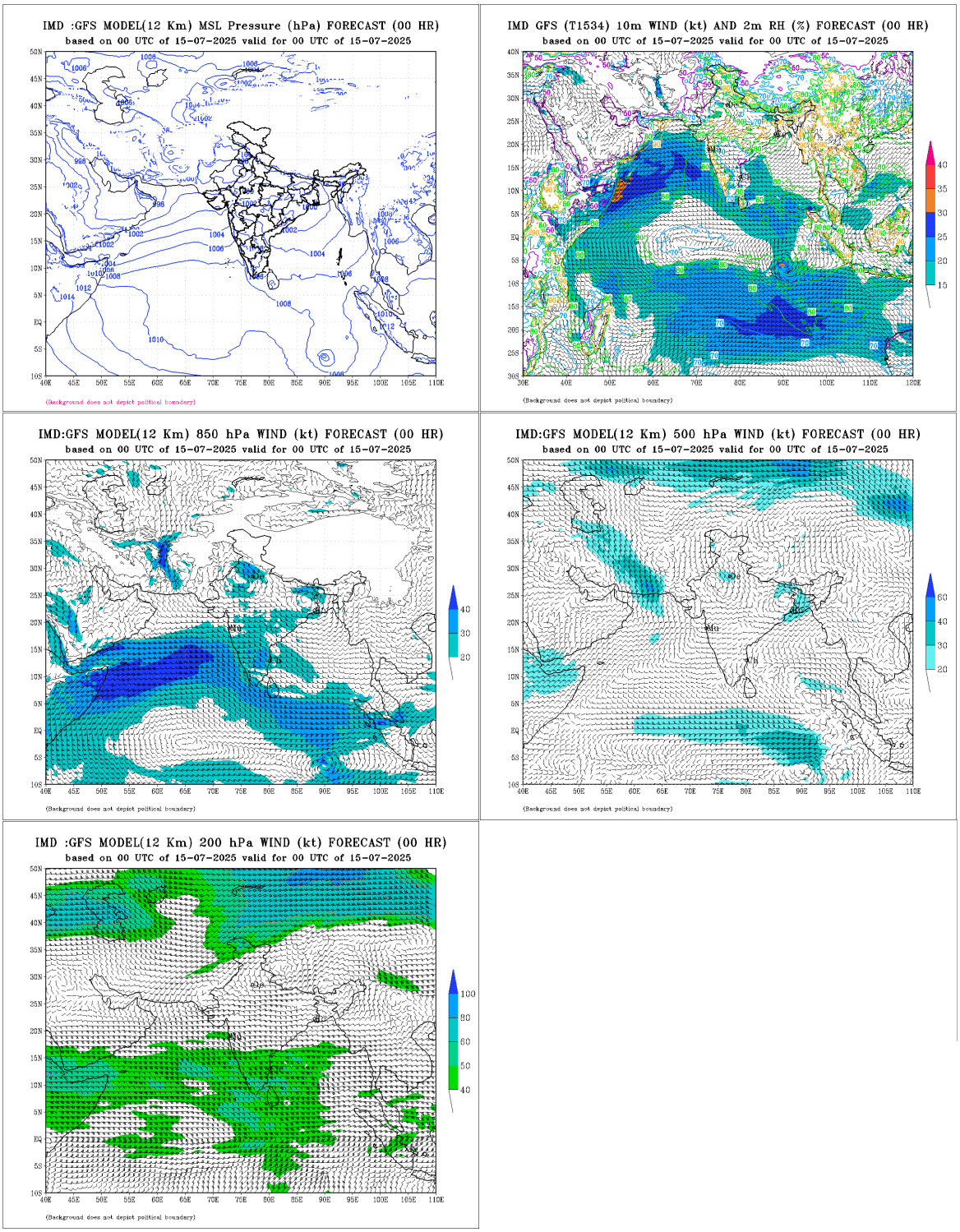


Fig.2.4.4(b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 15th July 2025

2.4.5 Forecast performance (Genesis, Intensification, Movement and Weakening):

- First information about the likely formation of an upper-air cyclonic circulation over the north BoB and adjoining coastal West Bengal-Odisha and Bangladesh during the week (11-17 July) was issued in the extended range outlook issued on 3rd July.

- Actually, an upper air cyclonic circulation formed over northwest BoB and adjoining West Bengal-North Odisha coasts in the evening (1730 hrs IST/1200 UTC) of 12th July, 2025. Under its influence, a low-pressure area formed over northwest BoB and adjoining coastal areas of West Bengal and Odisha on 13th July, 2025. It concentrated into a depression over southeast Gangetic West Bengal and adjoining Bangladesh at noon (1130 hrs IST/0600 UTC) of 14th July 2025. It moved west-northwestwards and weakened into a well-marked low-pressure area over north Jharkhand and adjoining south Bihar in the forenoon (0830 hrs IST/0300 UTC) of 15th July 2025.

- The first special message issued at 1230 hrs IST (0700 UTC) of 14th July indicated further intensification of the system into a depression on 14th July.

- Thus, formation of cyclonic circulation over northwest BoB and adjoining West Bengal-North Odisha was predicted well in week 2 forecast (about 9 days ahead) with some spatial variations.

REGIONAL SPECIALISED METEOROLOGICAL CENTRE -TROPICAL CYCLONES, NEW DELHI
TROPICAL WEATHER OUTLOOK

DEMS-RSMC TROPICAL CYCLONES NEW DELHI DATED 13.07.2025

TROPICAL WEATHER OUTLOOK FOR THE NORTH INDIAN OCEAN (THE BAY OF BENGAL AND THE ARABIAN SEA) VALID FOR THE NEXT 168 HOURS ISSUED AT 0600 UTC OF 13.07.2025 BASED ON 0300 UTC OF 13.07.2025.

BAY OF BENGAL:

An upper air cyclonic circulation formed over northwest Bay of Bengal adjoining West Bengal and north Odisha coasts at 1200 UTC of 12th July 2025 and now lay over north Bay of Bengal at 0300 UTC of today, the 13th July 2025. The associated cyclonic circulation extended upto 5.8 km above mean sea level tilting southwestwards with height. Under its influence, a low-pressure area is likely to form over northwest Bay of Bengal and adjoining coastal areas of West Bengal and Odisha during next 24 hours.

Scattered low and medium clouds with embedded intense to very intense convection lay over north & adjoining central Bay of Bengal and north Andaman Sea. Scattered low and medium clouds with embedded moderate to intense convection lay over the rest of the Bay of Bengal and south Andaman Sea.

Fig.2.4.5: Tropical Weather Outlook date 13.07.2025 indicating likely formation of low-pressure area around 14th July, 2025.

2.4.6 Warnings and advisories issued

Bulletins issued by Cyclone Warning Division, New Delhi

- **Track, intensity and landfall forecast:** IMD continuously monitored, predicted and issued bulletins containing track and intensity forecast for five times a day.

- **Adverse weather warning bulletins:** The adverse weather like heavy rainfall, flash flood, squally wind for the states of Odisha, West Bengal, Bihar, Sikkim Jharkhand Chhattisgarh Madhya Pradesh Rajasthan were issued every six hourly to central, state and district level disaster management agencies including Ministry of Home Affairs (MHA), National Disaster Response Force (NDRF), National Disaster Management Authority (NDMA) and state disaster management agencies. The bulletins also contained the suggested actions for disaster managers and the general public, in particular for fishermen, ports, offshore & onshore industries and installations and people. These bulletins were also issued to the Defence including the Indian Navy & Indian Air Force, NDRF, Indian Coast Guard, Ports, Mines, Fishery, Railways, Surface transport and aviation authorities etc

- **Flash Flood Guidance:**
  IMD, New Delhi acts as WMO's Regional Centre for Flash Flood Guidance at watershed level over South Asian region (Nepal, Bhutan, Bangladesh, Sri Lanka and India). It covers about 1 lakh watersheds in the region. Flash flood guidance was issued twice daily.

- **Warning graphics:** The graphical display of the observed and forecast track were disseminated by email and uploaded in the RSMC, New Delhi website (http://rsmcnewdelhi.imd.gov.in/) regularly. The adverse weather warnings related to fishermen were also presented in graphics along with colour codes in the website.

- **Warnings and advisories through social media:** Daily updates (every six hourly whenever) were uploaded on Facebook and Twitter during the life period of the system since the development of low-pressure area.

- **Diagnostic and prognostic features of cyclone:** The prognostic and diagnostic features of the cyclone based on all meteorological observations and numerical model guidance were described in each RSMC bulletin since 14th July.

2.4.7 Realised Weather:

Realized 24-hour heavy rainfall (≥ 7 cm) ending at 0300 UTC of date Station (District)

15.07.2025

Jharkhand: Rajmahal (Sahibganj) 19; Maharo (Dumka) 14; Zrs Dumka (Dumka) 12; Daltonganj (Palamu), Maheshpur (Pakur), Messenjor (Dumka), Manoharpur (West Singbhum), Goilkera (West Singbhum) 9 Each; Jamshedpur AP (East Singbhum), Chandil (Seraikela-kharsawan), Rajdhanwar (Giridih), Chandrapura (Bokaro), Anandpur (West Singbhum), Sisai (Gumla), Chainpur (Palamu), Manoharpur Phc (West Singbhum) 8 Each;

Chaibasa (West Singbhum), Amrapara (Pakur), Jamshedpur (East Singbhum), Bokaro Thermal (Bokaro), Gudri (West Singbhum), Chakulia (East Singbhum), Boram (East Singbhum) 7 Each;

South Interior Karnataka: Kannada), Siddapura (Udupi), Gokarna (Uttara Kannada) 7 Each;

Gangetic West Bengal: Debagram (Nadia) 14; Tusuma (Purulia) 9; Midnapore (West Midnapore), Kharidwar (Purulia), Hetampur (Birbhum), Berhampore (Murshidabad) 8 Each; Kansabati Dam (Bankura), Rampurhat (DRMS) (Birbhum), Phulberia (Purulia), Midnapore (CWC) (West Midnapore), Jangipur (Murshidabad) 7 Each;

Sub Himalayan West Bengal & Sikkim: Amfu Kalimpong (Kalimpong) 12; Kalimpong (Kalimpong), Ghatia T.e. (Jalpaiguri) 11 Each; Hilla T.e. (Jalpaiguri), Kurti T.e. (Jalpaiguri) 10 Each; Buxaduar (Alipurduar), Malda (Malda), Indong T.e. (Jalpaiguri), Lava (Kalimpong) 9 Each; Chengmari/Diana (Jalpaiguri), Bhagatpur Tea Estate (Jalpaiguri), Chalouni Tea Estate (Jalpaiguri) 8 Each; Darjeeling (Darjeeling), Rongo (Kalimpong), Chel (Jalpaiguri), Tra Nagrakata (Jalpaiguri), Zurrantee T.e (Jalpaiguri), Nagarkata (Jalpaiguri) 7 Each;

Bihar: Sangrampur (Monghyr), Amdabad (Katihar) 7 Each.

16.07.2025

Jharkhand: Chainpur (Palamu) 20; Daltonganj (Palamu) 16; Rajdhanwar (Giridih) 15; Dhurki (Garhwa) 11; Sikatia (Deoghar), Lesliganj (Palamu) 10 Each; Panki (Palamu), Barkisuriya (Giridih), Tuladih (Giridih) 9 Each; Giridih (Giridih), Sujani Kvk AWS (Deoghar), Hazaribagh Kvk AWS (Hazaribag), Bariyatu (Latehar), Nawa Bazar (Palamu) 8 Each; Jamtara (Jamtara), Topchanchi (Dhanbad), Papunki (Dhanbad), Koner (Hazaribag), Tilaiya (Koderma), Palganj (Giridih), Purvi Tundi (Dhanbad), Borio (Sahibganj), Naudiha Bazar (Palamu), Karmatand (Jamtara), Padma Dvc (Hazaribag), Tundi (Dhanbad) 7 Each;

Bihar: Dobhi (Gaya) 19; Sherghati (Gaya), Fatehpur (Gaya) 18 Each; Kodawanpur/C.b Ii (Begusarai), Barachatti (Gaya), Mohanpur (Gaya) 17 Each; Cheria B.pur 1 (Begusarai), Bankey Bazar (Gaya) 16 Each; Dalsinghsarai (Samastipur), Khaira (Jamui) 14 Each; Garhi (Jamui), Sonbarsa (Saharsa), Nawkothi (Begusarai), Imamganj (Gaya), Tankuppa (Gaya) 13 Each; Madanpur (Aurangabad), Bachwara (Begusarai) 12 Each; Adhwara (Bhabua), Chakai (Jamui), Gidhaur (Jamui), Sirdala (Nawada) 11 Each; Barauni (Begusarai), Wazirganj (Gaya), Kutumba (Aurangabad), Bhagwanpur (Begusarai), Belaganj (Gaya) 10 Each; Sono (Jamui), Samastipur (Samastipur), Manihari (Katihar), Jamui (Jamui), Rajauli (Nawada), Salakhua (Saharsa), Laxmipur (Jamui), Beldaur (Khagaria), Begusarai (Begusarai) 9 Each; Sirmari B.pur (Saharsa), Jhajha (Jamui), Amarpur (Banka), Dumaria (Gaya), Chhaurahi (Begusarai), Garhpura (Begusarai), Chautham (Khagaria), Meskaur (Nawada), Akbarpur (Nawada), Bibhutipur (Samastipur) 8 Each; Banka (Banka), Kursela (Katihar), Suryagadha (Lakhisarai), Hasanpur (Samastipur), Gaya AP (Gaya), Dehri (Rohtas), Dharhara (Monghyr), Bakhari (Begusarai), Amas (Gaya), Guraru (Gaya), Nagar (Gaya), Manpur (Gaya), Mansi (Khagaria), Vidyapati Nagar (Samastipur), Rosera (Samastipur) 7 Each;

Chhattisgarh: Ramanujganj (Balrampur) 12; Doura Kochali (Balrampur), Chalgali (Balrampur), Suhela (Baloda Bazar) 10 Each; Ramchandrapur (Balrampur) 9; Balrampur (Balrampur), Kusmi (Balrampur), Takhatpur (Bilaspur) 8 Each; Pallari/Palari (Baloda Bazar), Shankargarh (Balrampur) 7 Each;

Bihar: Rampur (Bhabua), Bhagwanpur (Bhabua) 16 Each; Raghopur (Vaishali) 14; Nauhatta (Rohtas) 13; Sasaram (Rohtas), Mahanar (Vaishali), Sahdei Buzurg (Vaishali) 12 Each; Sheosagar (Rohtas) 11;

Jharkhand: Hunterganj (Chatra) 13; Borio (Sahibganj) 11; Dhurki (Garhwa), Sujani Kvk AWS (Deoghar), Japla (Palamu) 7 Each;

Chhattisgarh: Janakpur Bharatpur (Manendragarh Bharatpur) 12; Pondi Bachra (Koriya) 11; Kotadol (Manendragarh Bharatpur) 10; Surajpur (Surajpur) 9; Kelhari (Manendragarh Bharatpur) 8; Kusmi (Balrampur), Doura Kochali (Balrampur), Latori (Surajpur), Biharpur (Surajpur) 7 Each;

17.07.2025

Odisha: Kotraguda (Rayagada) 12; Padia (Malkangiri) 10; Phulbani (Kandhamal), Rajgangpur (Sundargarh) 7 Each;
Bihar: Sheikhpura (Sheikhpura), Fatuha (Patna) 9 Each; Barbigha (Sheikhpura) 8;
Chhattisgarh: Sukma (Sukma) 8;

18.07.2025

Bihar: Birpur (Supaul) 7;

The system caused vigorous rainfall activity over West Bengal, Bihar, Jharkhand, Chhattisgarh. The 24 hrs accumulated realised rainfall during 14th to 18th July is presented in **Fig 2.4.6(a)** and **2.4.6(b).**

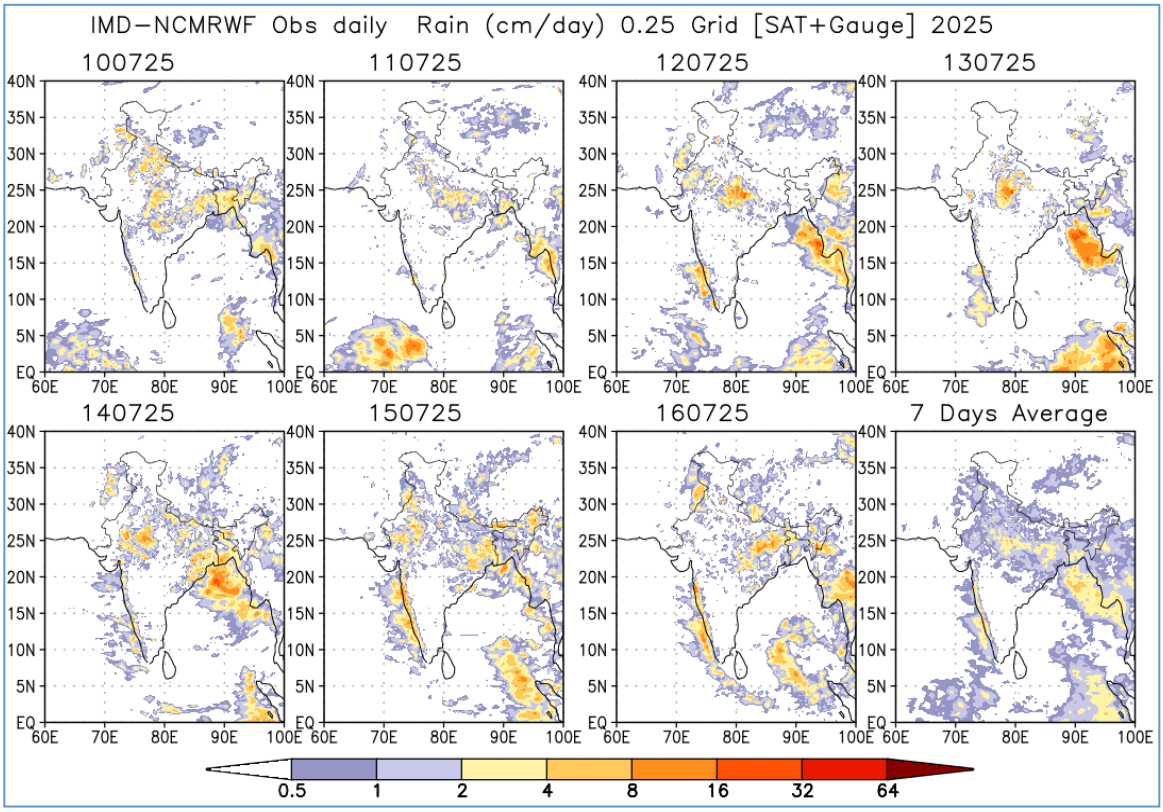


Fig.2.4.6(a): NCMRWF-IMD satellite gauge merged data plots of 24 hours accumulated realized rainfall ending at 0830 IST of 10th July to 16th July, 2025 and 7 days averaged value.

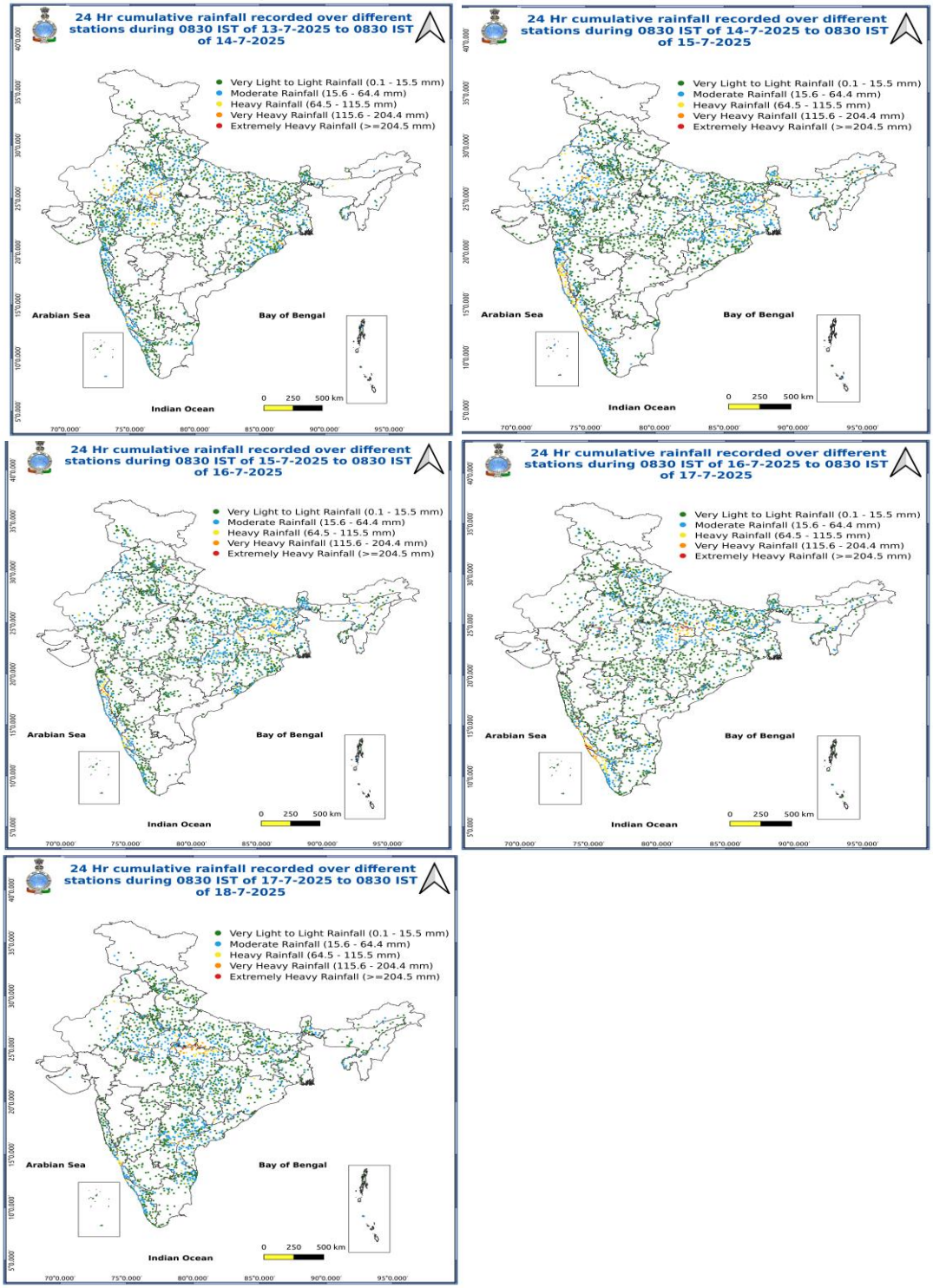


Fig.2.4.6(b): Station wise rainfall from 14th July to 18th July, 2025

2.5 Depression over central parts of north Rajasthan during 15th July-16th July, 2025

2.5.1 Life History:

- The low pressure system initially was over northeast Rajasthan and adjoining northwest Madhya Pradesh as a well-marked low pressure area at 8:30 hrs IST on July 14, 2025.
- The low pressure area slowly moved west-northwestward across Rajasthan and concentrated into a depression over the central part of northern Rajasthan, near latitude 27.4°N and longitude 75.6°E at 0530 hrs IST of 15th July.
- Moving west-northwestward, the depression lay centered at 0830 hrs IST of 15th July, near latitude 27.5°N and longitude 75.4°E over the same region, approximately 40 km southeast of Sikar and 110 km south-southeast of Churu.
- The depression continued its slow west-northwestward movement at a speed of 7 kmph, over the same region at 11:30 hrs IST on July 15, it was centered near latitude 27.7°N and longitude 75.0°E, about 20 km northwest of Sikar and 60 km south of Churu.
- Later that day, at 1730 hrs IST, the depression moved northwestward and was centered over northwest Rajasthan near latitude 29.0°N and longitude 73.7°E. about 60 km east-southeast of Anupgarh, 100 km south of Ganganagar, and 120 km north-northeast of Bikaner.
- The depression slowly moved north-northwestward at a speed of 7 kmph, remaining over the same region near latitude 29.2°N and 73.5°E at 2330 hrs IST. on July 15.
- It continued its slow north-northwestward movement before weakening into a well-marked low pressure area at 5:30 hrs IST on July 16, 2025.

The observed track of the system and its best track parameters were presented in **Fig**. 2.5.1 and **Table**2.5.1, respectively.

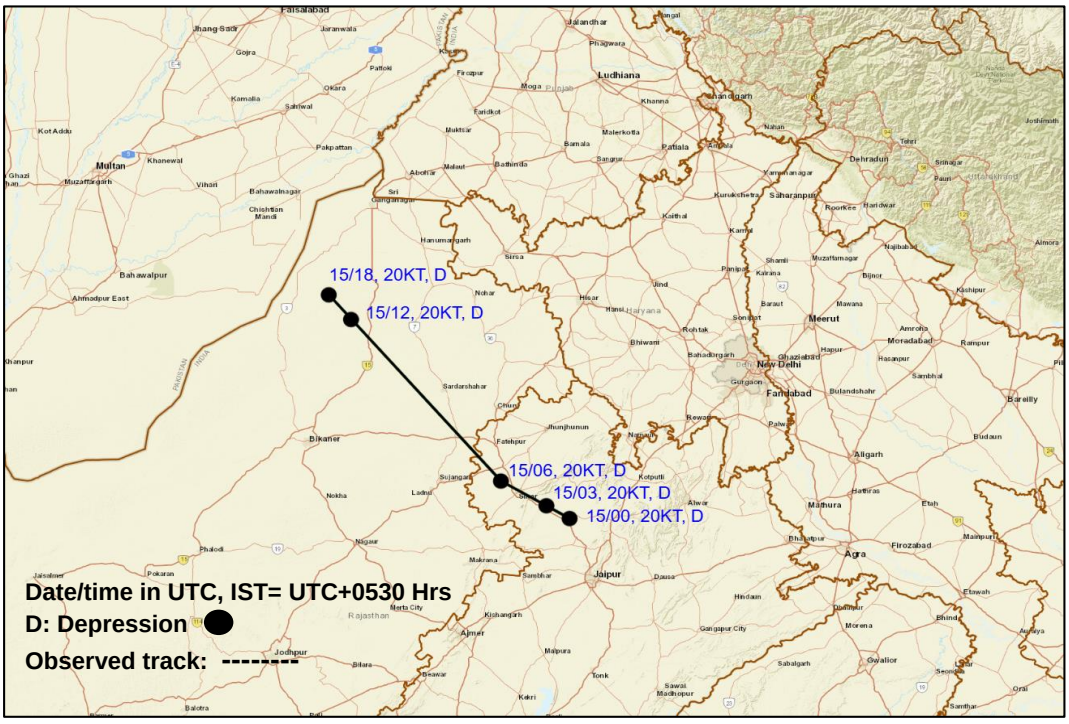


Fig. 2.5.1: Observed track of Depression over North Rajasthan during 15th July-16th July, 2025.

Table2.5.1: Best track positions and other parameters of the Depression over central parts of north Rajasthan during 15th July-16th July, 2025

Date	Time (UTC)	Lat.	Long.	C.I. No.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure Drop at the Centre (hPa)	Grade
15.07.2025	0300	27.4	75.4	-	998	3	20	D
	0600	27.7	75.0	-	998	3	20	D
	1200	29.0	73.7	-	998	3	20	D
	1800	29.2	73.5	-	998	3	20	D
16.07.2025	0000	Weakened into a well-marked low-pressure area over northwest Rajasthan.						

Kt: Knots (nautical mile per hour), 1 KT=1.85 kmph, D: Depression

2.2.5 Salient features of the system

- The system had a very short life period of 24 hours.
- Climatologically, during the period 1965-2024, 14 depressions formed over land in the month of July.

2.5.3 Monitoring of Depression

India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean (NIO) and the system was monitored well in advance since 14th July. The system was monitored with the help of available 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.

2.5.4 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 coloured imageries, visible/ IR, brightness temperature and water vapour imageries are presented in **Fig. 2.5.2. (a) to (c)**. The detailed features from the INSAT-3DR satellite pictures are discussed in this section.

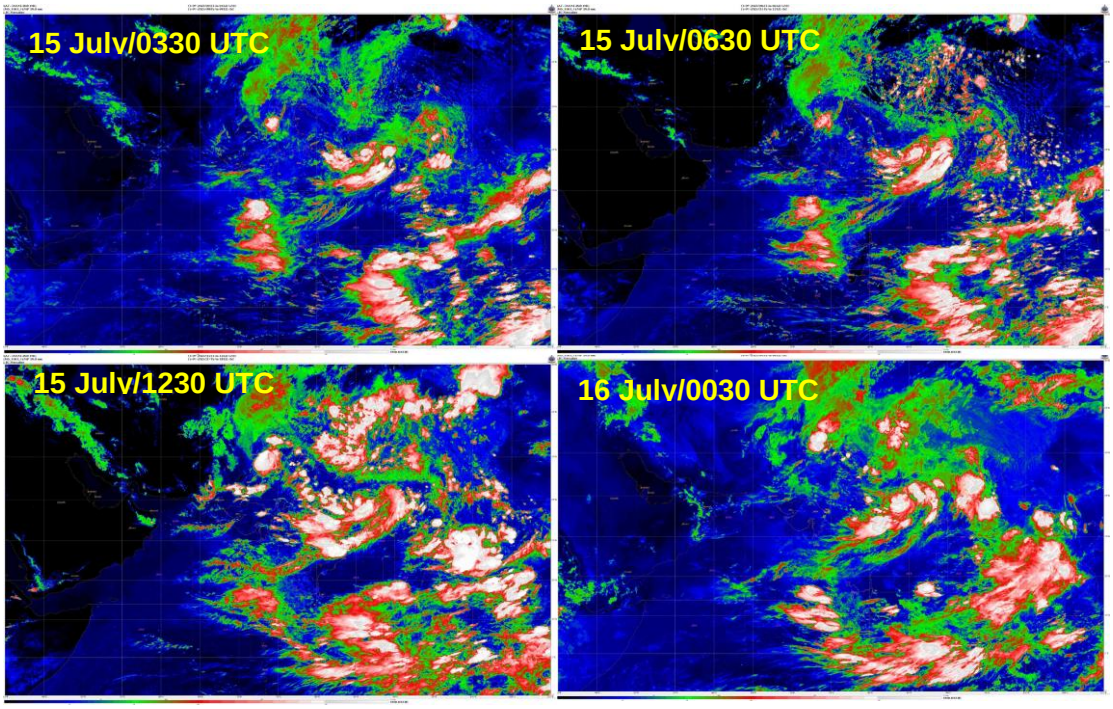


Fig.2.2.5(a): INSAT-3D enhanced colored imageries during life cycle of Depression over North Rajasthan during 15th July-16th July 2025

- 0300 UTC, 15 July 2025 (INSAT-3DR IR): Scattered to broken low/medium clouds with embedded intense to very intense convection over north Rajasthan (minimum CTT −70 to −90°C). Moderate to intense convection over east Punjab and west Haryana (minimum CTT −50 to −60°C).
- 1200 UTC, 15 July 2025 (INSAT-3DR IR): Scattered to broken low/medium clouds with embedded intense to very intense convection over north Rajasthan, extending into adjoining Haryana and southwest Punjab (minimum CTT −60 to −80°C).

Weather feature: Deep, organized convective clusters persisting over NW India, indicative of strong updrafts/over shooting tops and a risk of heavy rainfall, lightning, and gusty winds in the affected areas.

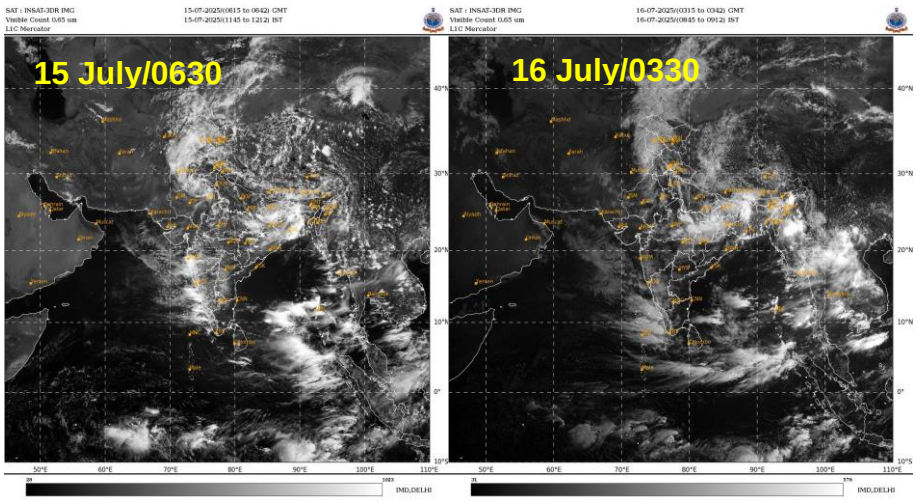


Fig. 2.5.2(b): INSAT-3D Visible imageries during life cycle of Depression over North Rajasthan during 15th July-16th July 2025.

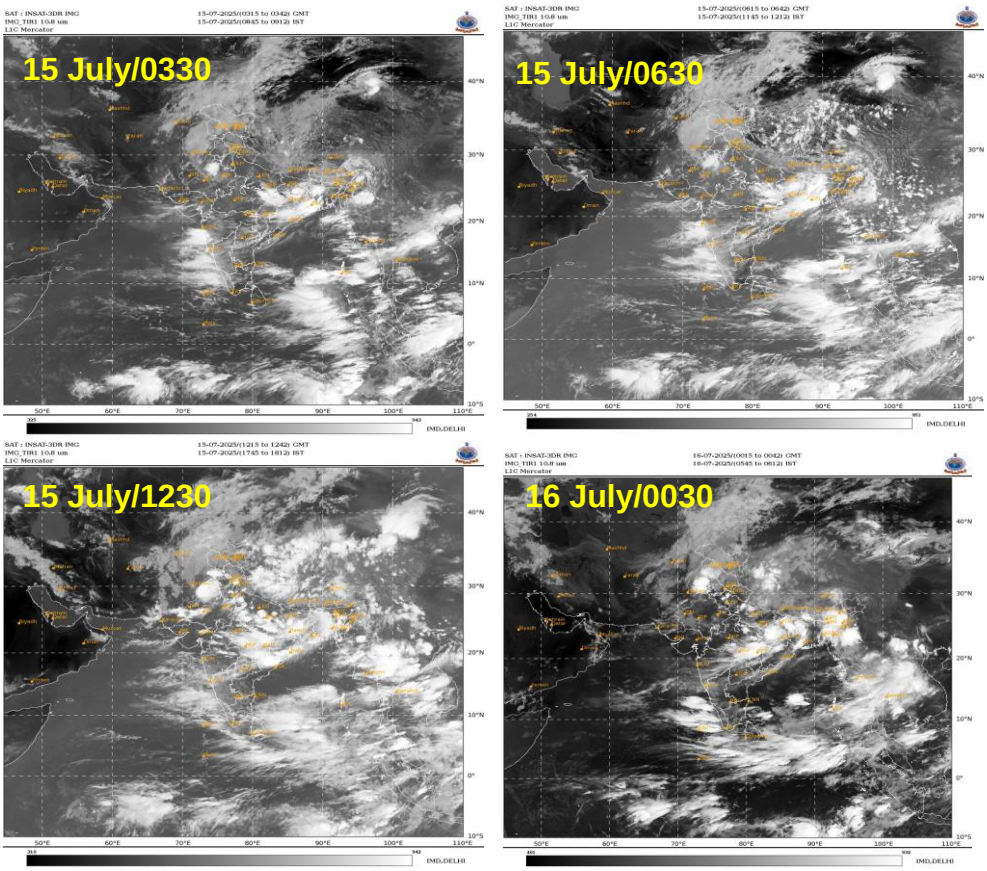


Fig. 2.5.2(c): INSAT-3D IR imageries during life cycle of Depression over North Rajasthan during 15th July-16th July 2025

Key features seen consistently across the frames in Fig 2.5.2(a) to 2(c):

- A large, organized convective complex over north Rajasthan with very cold tops (≈ −70 to −90°C), expanding into adjoining Haryana and SW Punjab by 1200 UTC. Strong overshooting tops and broad cirrus shield indicate deep, persistent convection and outflow aloft.
- Cloud bands and embedded convection align from Pakistan–NW India eastward across the Indo-Gangetic plains to the north Bay, consistent with the monsoon trough lying close to/just north of its normal position.
- Repeated deep convection near the Odisha–WB–Bangladesh coast and north/central Bay suggests an embedded cyclonic circulation/weak low at the trough's eastern end.
- Parallel convective bands off the Konkan–Goa–Karnataka coast with stratiform shields over the east-central Arabian Sea, typical of a sustained westerly surge and an offshore trough from south Gujarat to Karnataka.
- Scattered diurnal convection over central Maharashtra, Telangana, interior Karnataka, Kerala and Tamil Nadu; no organized vortex noted.
- Widespread layered cloud with embedded cells along the Himalayan foothills and NE states, fed by moist easterlies from the Bay.

Evolution from 0300 to 1200 UTC:

- NW India convection persisted and spread E/SE from north Rajasthan into Haryana/SW Punjab; CTTs warm slightly (−60 to −80°C later), implying gradual weakening after peak.

- Bay and Arabian Sea convective clusters remain quasi-stationary, maintaining the monsoon moisture supply; no cyclonic eye/banding to suggest a tropical cyclone.

No signs of further intensification in the region during the analysed period.

2.5.5 Dynamical Features

IMD GFS (T1534) daily analyses at 0000 UTC of mean sea level pressure (MSLP), winds at various pressure levels on 15th July & 16th July are presented in **Fig. 2.5.3(a) and (b)** respectively.

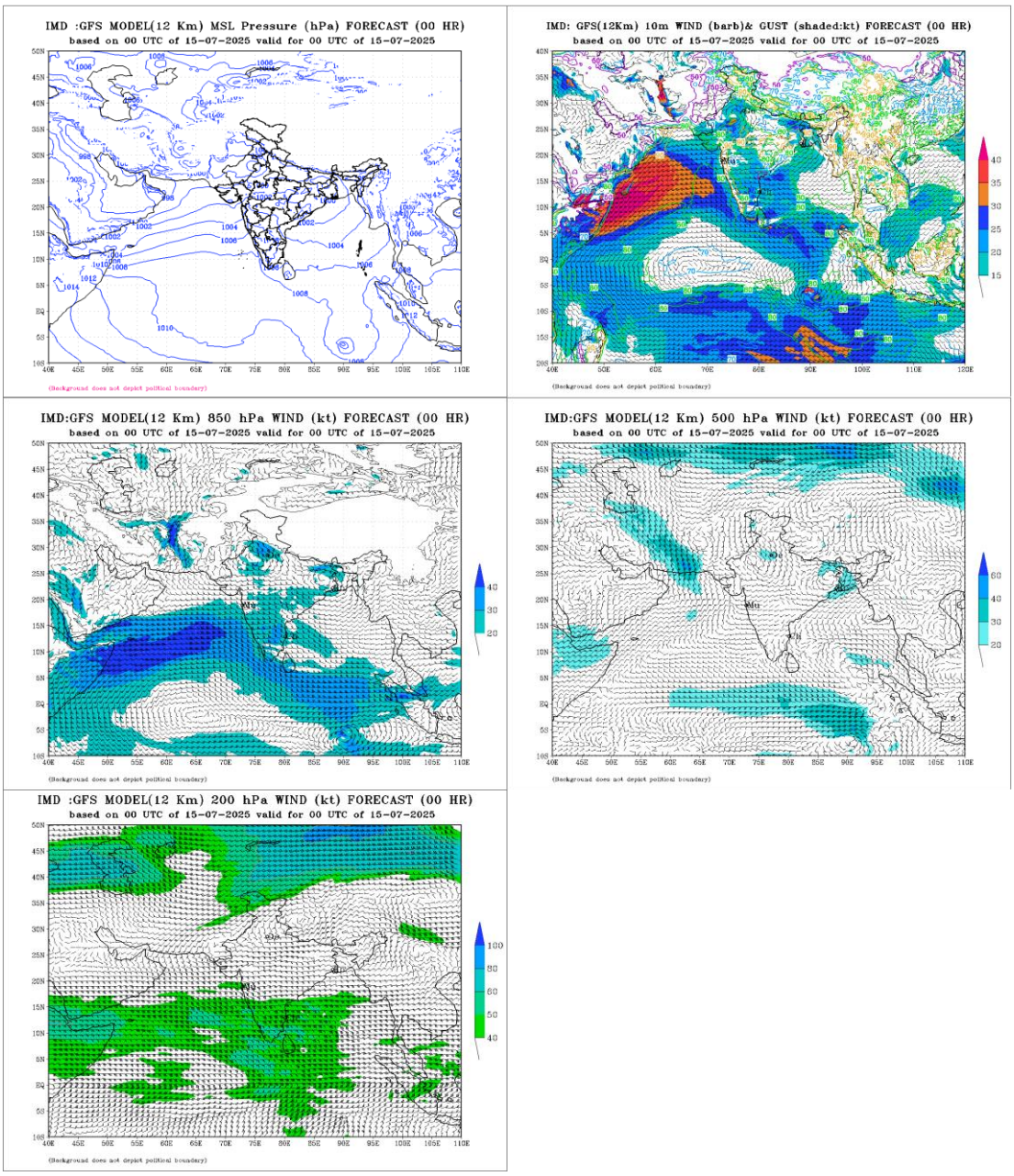


Fig. 5.2.3(a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 15th July 2025

Summary of weather characteristic features from the 00 UTC IMD-GFS (12 km) analyses for 15 and 16 July 2025 are described below. A broad monsoon trough was present from the Pakistan–Rajasthan heat low across the Indo-Gangetic plains to the north/north-west Bay of Bengal. A low pressure area (LPA) was seen over north Rajasthan with only one closed isobar on 15th July. Although the MSLP analysis of the model could capture the system, it could not represent the intensity of a depression. During next day, the LPA shifted northwestwards over northwest Rajasthan without any further intensification.

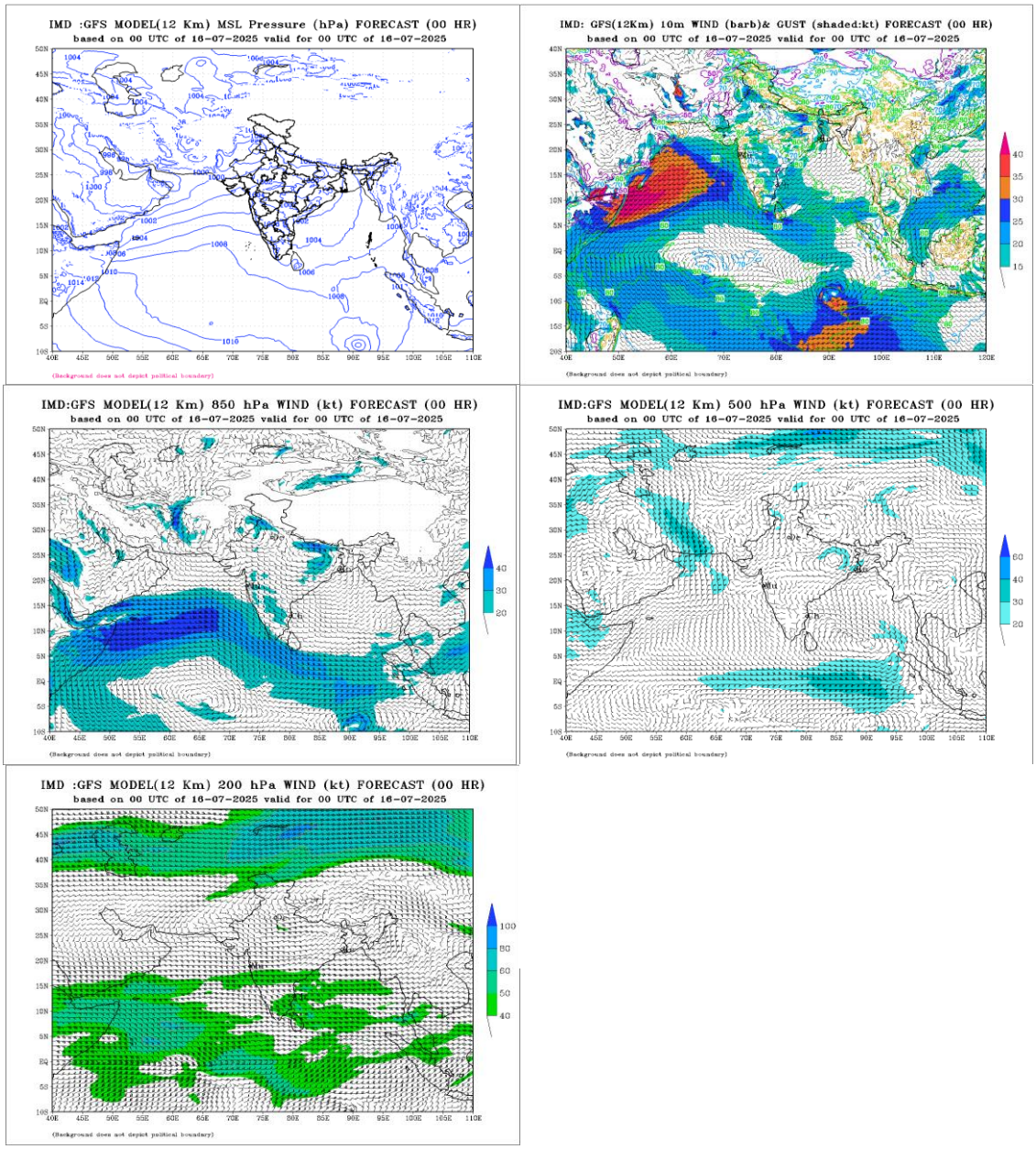


Fig. 5.2.3(b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 16th July 2025

The embedded cyclonic circulation inside the western end of monsoon trough were indicated over north Rajasthan on 15th July. It persisted but weakened over northwest Rajasthan on 16th July. Another embedded cyclonic circulation in the eastern end of the trough was seen over

the coastal areas of north-west Bay of Bengal on 15th July, persisted and appeared to shift slightly inland toward Odisha–Chhattisgarh, keeping the trough active on 16th July.

Strong SW/Wly monsoon flow over the Arabian Sea with a core of 35–45 kt off Somalia and extending toward the Konkan–Karnataka coast (squally along the west coast; rough sea). Moderate to fresh SWly winds (20–30 kt) over the Bay of Bengal feeding into East India/Bangladesh. The Day-to-day change was small, with a slight strengthening and northward spread of strong winds over the northeast Arabian Sea on 16 July.

Two distinct cyclonic circulations at 850 hpa associated with the low pressure systems were clearly visible at this pressure level. The first one associated with the depression over north Rajasthan is clearly having stronger easterly winds in the northern sectors compared to the one associated with the well marked low pressure area over Jharkhand and neighbourhood. As the depression over north Rajasthan shifted northwestwards over northwest Rajasthan and weakened, the associated cyclonic circulation also shifted accordingly with the weakening in wind speed on 16th July.

A well-defined low-level jet (LLJ) from the central Arabian Sea into the west coast of India; another SWly stream from the Bay of Bengal into Odisha–West Bengal. Speeds were around 25–40 kt. A shear zone/cyclonic curvature over central–east India is consistent with the Bay of Bengal low pressure system moving inland by 16 July.

At the 500 hPa pressure level also two distinct cyclonic circulations associated with the low pressure systems are clearly visible on 15th July. However, the cyclonic circulation associated with the depression over north Rajasthan is not as organised and strong compared to the cyclonic circulation over east India associated with the well marked low pressure area. Predominantly westerlies over North India with a weak trough/cyclonic circulation over central/east-central India, supporting deep convection along the monsoon trough. Little change has been noticed between the two days, with a slight west-northwest shift in the cyclonic feature on 16 July.

Well-established Tropical Easterly Jet across the Peninsula (≈60–80 kt) with an upper-level anticyclonic circulation over the Tibetan Plateau. Favourable divergence north of the jet over central/east India. The structure remains steady across the two analyses.

2.5.6 Realized Weather
Realised 24-hour heavy rainfall (≥ 7 cm) ending on

15th July 2025/0830 IST
Jharkhand: Rajmahal (Sahibganj) 19; Maharo (Dumka) 14; Zrs Dumka (Dumka) 12; Daltonganj (Palamu), Maheshpur (Pakur), Messenjor (Dumka), Manoharpur (West Singbhum), Goilkera (West Singbhum) 9 Each; Jamshedpur AP (East Singbhum), Chandil (Seraikela-kharsawan), Rajdhanwar (Giridih), Chandrapura (Bokaro), Anandpur (West Singbhum), Sisai (Gumla), Chainpur (Palamu), Manoharpur Phc (West Singbhum) 8 Each; Chaibasa (West Singbhum), Amrapara (Pakur), Jamshedpur (East Singbhum), Bokaro Thermal (Bokaro), Gudri (West Singbhum), Chakulia (East Singbhum), Boram (East Singbhum) 7 Each;
Konkan & Goa: Savarde- (Ratnagiri) 19; Sudhagad Pali (Raigad), Chiplun (Ratnagiri), Rajapur (Ratnagiri) 14 Each; Mandangad (Ratnagiri), Mhasla (Raigad) 13 Each; Guhagarh

(Ratnagiri), Roha (Raigad), Dodamarg (Sindhudurg) 12 Each; Mangaon (Raigad), Shriwardhan (Raigad), Ratnagiri (Ratnagiri), Sawantwadi (Sindhudurg), Sangameshwar Devrukh (Ratnagiri), Lanja (Ratnagiri) 11 Each; Kudal (Sindhudurg), Dapoli (Ratnagiri), Poladpur (Raigad) 10 Each; Harnai IMD (Ratnagiri), Pen (Raigad), Tala (Raigad) 9 Each; Matheran (Raigad), Murud (Raigad), Ponda (North Goa), Canacona (South Goa), Awalegaon - (Sindhudurg), Wakwali (Ratnagiri), Quepem (South Goa) 8 Each; Sanguem (South Goa), Khed (Ratnagiri), Kankavli (Sindhudurg) 7 Each;

East Rajasthan: Bijoliya (Bhilwara) 18; Bhainsroadgarh (Chittorgarh) 17; Niwai (Tonk) 13; Mandana (Kota) 12; Sambhar (Jaipur) 10; Rajsamand (Rajsamand), Naraina (Jaipur) 9 Each; Chothkabarwara (Sawai Madhopur) 8; Deogarh (Rajsamand), Malpura (Tonk), Veja (Dungarpur), Tonk Tehsil (Tonk), Lachmangarh (Sikar), Mavli (Udaipur), Piplu (Tonk), Chomu (Jaipur) 7 Each;

Madhya Maharashtra: Mahabaleshwar (Satara) 15; Gaganbawada (Kolhapur) 13; Radhanagari (Kolhapur) 12; Shahuwadi (Kolhapur), Lonavala (Pune) 10 Each; Igatpuri (Nashik) 8;

West Rajasthan: Makrana (Nagaur) 14; Degana (Nagaur) 12; Parbatsar (Nagaur), Nawa (Nagaur) 11 Each; Pali (Pali) 9; Ratangarh (Churu), Anupgarh Tehsil (Sri Ganganagar) 8 Each; Padampur (Sri Ganganagar), Sedwa(Barmer) 7 Each;

East Uttar Pradesh: Chhibramau (Kannauj) 9;

South Interior Karnataka: Agumbe (Shivamogga) 9;

West Uttar Pradesh: Karhal (Mainpuri) 8;

Chhattisgarh: Latori (Surajpur) 8; Chando (Balrampur) 7;

Gujarat Region: Vansda (Navsari) 8; Saraswati (Patan), Dediapada (Narmada) 7 Each;

East Madhya Pradesh: Sidhi (gopadbanas) (Sidhi) 7;

Bihar: Sangrampur (Monghyr), Amdabad (Katihar) 7 Each

16th July 2025/0830 IST

Jharkhand: Chainpur (Palamu) 20; Daltonganj (Palamu) 16; Rajdhanwar (Giridih) 15; Dhurki (Garhwa) 11; Sikatia (Deoghar), Lesliganj (Palamu) 10 Each; Panki (Palamu), Barkisuriya (Giridih), Tuladih (Giridih) 9 Each; Giridih (Giridih), Sujani (Deoghar), Hazaribagh (Hazaribag), Bariyatu (Latehar), Nawa Bazar (Palamu) 8 Each; Jamtara (Jamtara), Topchanchi (Dhanbad), Papunki (Dhanbad), Koner (Hazaribag), Tilaiya (Koderma), Palganj (Giridih), Purvi Tundi (Dhanbad), Borio (Sahibganj), Naudiha Bazar (Palamu), Karmatand (Jamtara), Padma Dvc (Hazaribag), Tundi (Dhanbad) 7 Each;

Chhattisgarh: Ramanujganj (Balrampur) 12; Doura Kochali (Balrampur), Chalgali (Balrampur), Suhela (Baloda Bazar) 10 Each; Ramchandrapur (Balrampur) 9; Balrampur (Balrampur), Kusmi (Balrampur), Takhatpur (Bilaspur) 8 Each; Pallari/Palari (Baloda Bazar), Shankarh (Balrampur) 7 Each;

Bihar: Dobhi (Gaya) 19, Sherghati (Gaya) 18, Fatehpur (Gaya) 18, Mohanpur(Gaya) 17, Kodawanpur/c.b Ii (Begusarai) 17, Barachatti (Gaya) 17, Cheria B.pur 1 (Begusarai) 17, Bankey Bazar (Gaya) 16, Dalsinghsarai (Samastipur) 14, Khaira (Jamui) 14, Tankuppa (Gaya) 13, Garhi (Jamui) 13, Imamganj (Gaya) 13, Sonbarsa (Saharsa) 13, Nawkothi (Begusarai) 13, Bachwara (Begusarai) 12, Madanpur (Aurangabad) 12, Adhwara (Bhabua) 11, Chakai (Jamui) 11, Gidhaur (Jamui) 11, Sirdala (Nawada) 11, Barauni (Begusarai) 11, Wazirganj (Gaya) 10, Belaganj (Gaya) 10, Kutumba (Aurangabad) 10, Bhagwanpur (Begusarai) 10, Samastipur (Samastipur) 9, Laxmipur (Jamui) 9, Jamui (Jamui) 9, Sono (Jamui) 9, Salakhua (Saharsa) 9, Beldaur (Khagaria) 9, Manihari (Katihar) 9, Begusarai (Begusarai) 9, Rajauli (Nawada) 9, Amarpur (Banka) 8, Sirmari B.pur (Saharsa) 8, Akbarpur (Nawada) 8, Jhajha

(Jamui) 8, Chautham (Khagaria) 8, Meskaur (Nawada) 8, Dumaria (Gaya) 8, Chhaurahi (Begusarai) 8, Garhpura (Begusarai) 8, Bibhutipur (Samastipur) 8, Suryagadha (Lakhisarai) 8, Vidyapati Nagar (Samastipur) 7, Hasanpur (Samastipur) 7, Banka (Banka) 7, Amas (Gaya) 7, Gaya Aero (Gaya) 7, Guraru (Gaya) 7, Dehri (Rohtas) 7, Manpur (Gaya) 7, Dharhara (Monghyr) 7, Nagar (Gaya) 7, Rosera (Samastipur) 7, Mansi (Khagaria) 7, Bakhari (Begusarai) 7, Kursela (Katihar) 7, Sahebpur Kanal (Begusarai) 7, Alauli (Khagaria) 7,
Odisha: Baripada (Mayurbhanj) 8, Hatadihi (Keonjharh) 8,

17th July, 2025/0830 IST:
East Uttar Pradesh: Chunar (Mirzapur) 24, Meja (Prayagraj) 21, Jaunpur Tehsil (Jaunpur) 14, Mirzapur Cwc (Mirzapur) 11, Ghorawal (Sonbhadra) 10, Churk (Sonbhadra) 10, Rihand Dam Fmo (Sonbhadra) 10, Varanasi/bab Aero (Varanasi) 9, Varanasi-b.h.u. (Varanasi) 9, Koraon (Prayagraj) 8, Prayagraj Sadar (Prayagraj) 7, Karchhana (Prayagraj) 7,
Bihar: Bhagwanpur (Bhabua) 16, Rampur (Bhabua) 16, Raghopur (Vaishali) 14, Nauhatta (Rohtas) 13, Sahdei Buzurg (Vaishali) 12, Sasaram (Rohtas) 12, Mahanar (Vaishali) 12, Sheosagar (Rohtas) 11, Rohtas (Rohtas) 10, Dehri (Rohtas) 10, Akorhi Gola (Rohtas) 9, Mahua (Vaishali) 9, Bidupur (Vaishali) 9, Kargahar (Rohtas) 8, Chenari (Rohtas) 8, Indrapuri (Rohtas) 8, Barbigha (Sheikhpura) 8, Lalganj (Vaishali) 8, Jandhaha (Vaishali) 7, Kudra (Bhabua) 7, Barun (Aurangabad) 7, Bind (Nalanda) 7, Goraul/doli (Vaishali) 7, Banka (Banka) 7, Hilsa (Nalanda) 7, Durgawati (Bhabua) 7, Patepur (Vaishali) 7, Jhanjharpur (Madhubani) 7, Tilouthu (Rohtas) 7, Hajipur (Vaishali) 7, Balchhi (Patna) 7, Bhagalpur (Bhagalpur) 7, Mohania (Bhabua) 7,
East Madhya Pradesh: Naigarhi (Rewa) 25, Mauganj (Rewa) 22, Hanumana (Rewa) 21, Bahri (Sidhi) 20, Chitrangi (Singrauli) 15, Dindori-aws (Dindori) 13, Semariya (Rewa) 13, Sihawal (Sidhi) 13, Raipurkarchuliyan (Rewa) 13, Majhauli (Sidhi) 12, Huzur (Rewa) 12, Kusmi (Sidhi) 12, Beohari (Shahdol) 12, Rampur (Sidhi) 11, Shahpura (Dindori) 11, Mangawan (Rewa) 11, Devser (Singrauli) 11, Sarai (Singrauli) 10, Birsingpur (Satna) 9, Mada (Singrauli) 8, Singrauli-aws (Singrauli) 8, Churhat (Sidhi) 8, Teonthar (Rewa) 8, Jaisingh Nagar (Shahdol) 8, Sidhi (gopadbanas) (Sidhi) 8, Gohparu (Shahdol) 7, Jaitpur (Shahdol) 7, Waraseoni (Balaghat) 7 WEST MADHYA PRADESH: Bhanpura (Mandsaur) 21, Narwar (Shivpuri) 8, Timarni (Harda) 8, Rahatgaon (Harda) 7, Karera (Shivpuri) 7, Harda (Harda) 7
Chhattisgarh: Janakpur Bharatpur (Manendragarh Bharatpur) 12; Pondi Bachra (Koriya) 11; Kotadol (Manendragarh Bharatpur) 10; Surajpur (Surajpur) 9; Kelhari (Manendragarh Bharatpur) 8; Kusmi (Balrampur), Doura Kochali (Balrampur), Latori (Surajpur),
East Rajasthan: Ramganj mandi (Kota) 19, Sarmathura (Dolour) 9, Asnawar (Jhalawar) 8, Lalsot (Dausa) 6, Indergarh (Bundi) 4, Govindgarh (Alwar) 4,
Jharkhand: Hunterganj (Chatra) 13, Borio (Sahibganj) 11, Dhurki (Garhwa) 7, Japla (Palamu) 7, Sujani (Deoghar) 7, Ghatsila (East Singbhum) 7, Jamshedpur Aero (East Singbhum) 7.

18th July, 2025/0830 IST:
East Madhya Pradesh: Chahtarpur-aws (Chhatarpur) 31, Gaurihar (Chhatarpur) 27, Palera (Tikamgarh) 23, Lavkushnagar (Chhatarpur) 19, Rajnagar (Chhatarpur) 18, Ajaigarh (Panna) 17, Khajuraho Aero (Chhatarpur) 15, Satna (raghurajnagar) (Satna) 14, Sohawal (Satna) 14, Birsingpur (Satna) 14, Nowgong (Chhatarpur) 13, Amarpatan (Satna) 13, Jatara (Tikamgarh) 13, Mohangarh (Tikamgarh) 13, Badamalhera (Chhatarpur) 13, Sirmaur (Rewa) 12, Nagode (Satna) 11, Majhgaon (Satna) 11, Panna-aws (Panna) 11, Khargapur (Tikamgarh) 11,

Devendranagar (Panna) 10, Naigarhi (Rewa) 10, Amanganj (Panna) 9, Bijawar (Chhatarpur) 9, Gonour (Panna) 9, Raipurkarchuliyan (Rewa) 9, Rampur Baghelan (Satna) 9, Tikamgarh-aws (Tikamgarh) 9, Mangawan (Rewa) 9, Semariya (Rewa) 7, Baldevgarh (Tikamgarh) 7, Hanumana (Rewa) 7, Pawai (Panna) 7, Bilhari (Katni) 7, Teonthar (Rewa) 7, Badagaon Dhasan (Tikamgarh) 7, Orchha (Niwari) 7,

West Madhya Pradesh: Bhanpura (Mandsaur) 18, Datia-aws (Datia) 13, Indergarh (Datia) 12, Bhander (Datia) 10, Seodha(seondha) (Datia) 9, Mau (Bhind) 9, Guna-aws (Guna) 7, Khilchipur (Rajgarh) 7

East Rajasthan: Sangod (Kota) 17, Atru(Baran) 8, Nasirabad (Ajmer) 8, Ajmer (Ajmer) 8, Mandana(Kota) 8, Mangrol (Baran) 8, Ajmer Tehsil(Ajmer) 7,

West Rajasthan: Pilibanga(Hanumangarh) 11, Bhadra (Hanumangarh) 7, Degana (Nagaur) 7,

East Uttar Pradesh: Chilaghat (Banda)-21, Attarra (Banda)-20, Banda (Banda) 15**,**

West Utttar Pradesh: Kulpahar (Mahoba) 17, Hamirpur Obsy (Hamirpur) 10, Talbehat (Lalitpur) 8

Rainfall associated with the depression based on IMD-NCMRWF satellite gauge merged data are depicted in **Fig 2.5.4** and Point rainfall recorded over different stations during 14 to 18 July **Fig 2.5.5.**

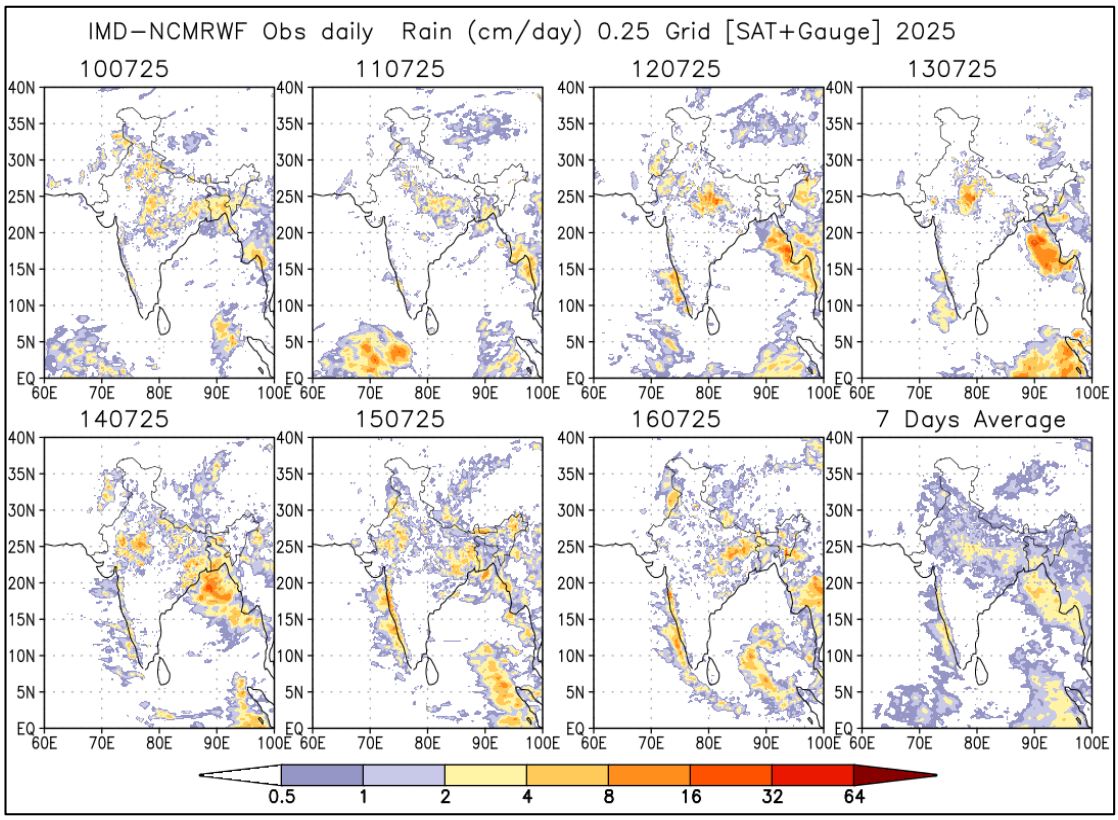


Fig. 2.5.4: NCMRWF-IMD satellite gauge merged data plots of realized 24 hours accumulated rainfall from 14th to 16th July, 2025.

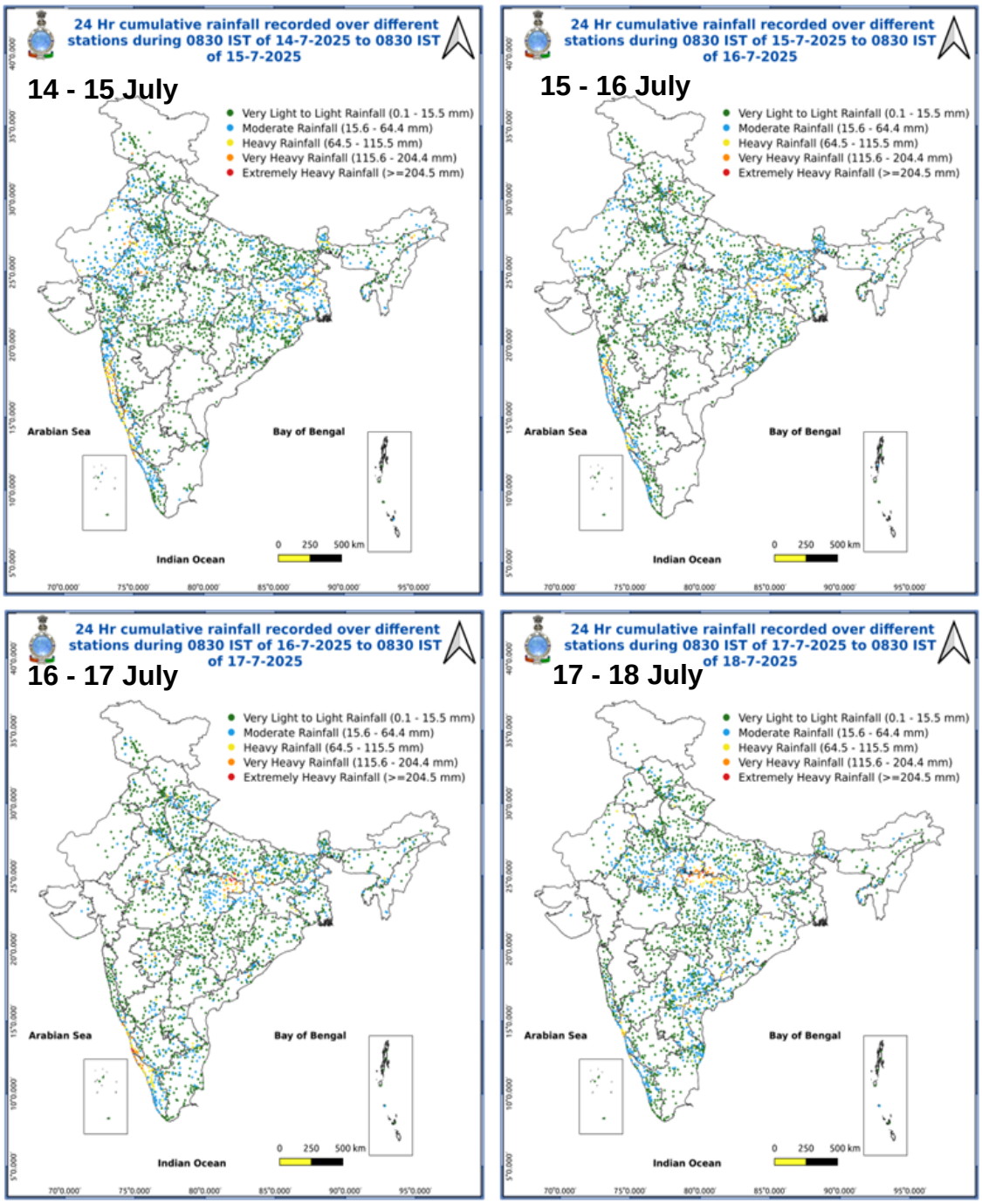


Fig 2.5.5: 24 hrs Point rainfall recorded over different stations during 14 to 18 July.

2.6 Depression over Southeast Uttar Pradesh (17th-20th July 2025)

2.6.1 Life History:

- A well-marked low-pressure area formed over north Jharkhand and adjoining south Bihar in the morning (0830 hours IST/0300 UTC) of 15th July.
- It moved nearly west-northwestwards and intensified into a depression over Southeast Uttar Pradesh by the morning of 17th July (0530 hours IST/0000 UTC).
- It continued to move west-northwestwards and reached over northwest Madhya Pradesh in the morning of 18th July (0530 hours IST/0000 UTC).
- It moved westwards across northwest Madhya Pradesh till 1130 IST/0600 UTC of 18th July.
- Thereafter, it moved again nearly west-northwestwards and reached upto northwest and adjoining northeast Rajasthan as a depression in the morning (0830 IST/0300 UTC) of 19th July.
- Then, it moved westwards across west Rajasthan nearly for a day and weakened into a well-marked low (WML) pressure area over west Rajasthan and adjoining Pakistan in the morning (0530 hours IST/0000 UTC) of the 20th July.

The observed track of the depression is presented in **Fig. 2.6.1**. The best track parameters of the system are presented in **Table 2.6.1.**

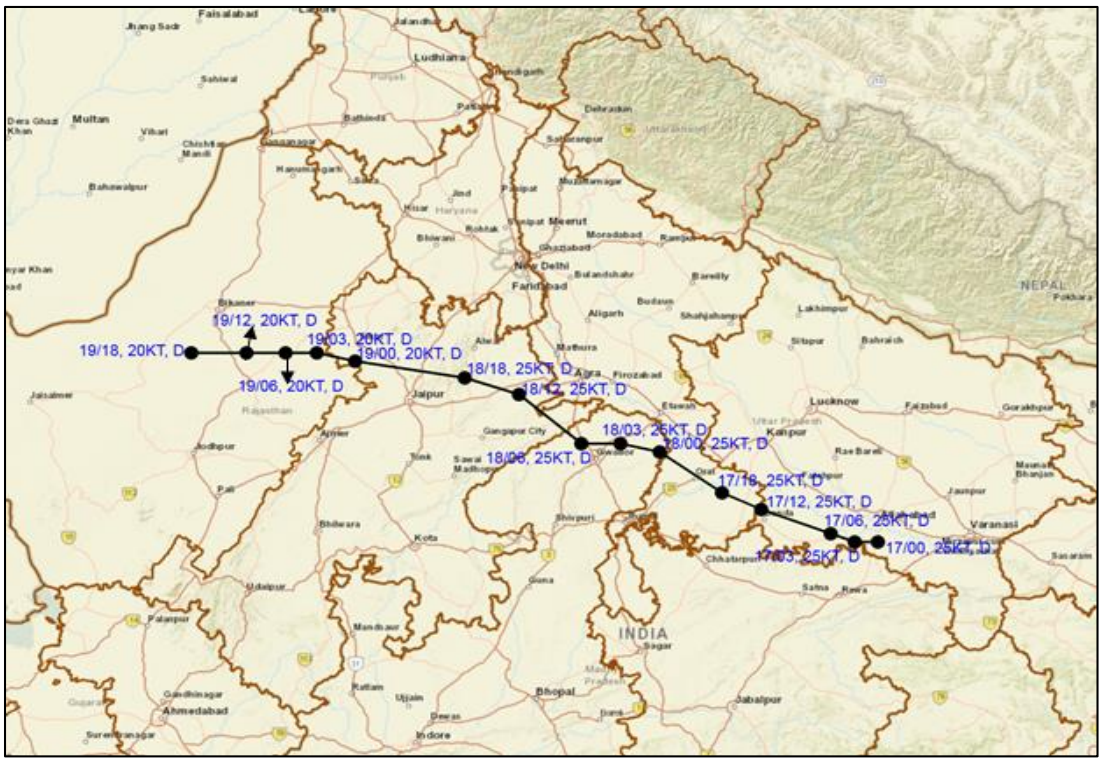


Fig. 2.6.1: Observed track of Depression over Southeast Uttar Pradesh during 17th July – 20th July, 2025

Table 2.6.1: Best track positions and other parameters of the Depression over Southeast Uttar Pradesh during 17th July – 20th July, 2025

Date	Time (UTC)	Lat.(^{0}N)	Long.(^{0}E)	C.I. No.	ECP (hPa)	ΔP (hPa)	MSW (kt)	Category
17.07.2025	0000	25.2	81.8	-	993	4	25	D
	0300	25.2	81.5	-	993	4	25	D
	0600	25.3	81.2	-	993	4	25	D
	1200	25.6	80.3	-	993	4	25	D
	1800	25.8	79.8	-	993	4	25	D
18.07.2025	0000	26.3	79.0	-	993	4	25	D
	0300	26.4	78.5	-	993	4	25	D
	0600	26.4	78.0	-	993	4	25	D
	1200	27.0	77.2	-	993	4	25	D
	1800	27.2	76.5	-	993	4	25	D
19.07.2025	0000	27.4	75.1	-	993	4	25	D
	0300	27.5	74.6	-	993	3	20	D
	0600	27.5	74.2	-	993	3	20	D
	1200	27.5	73.7	-	993	3	20	D
	1800	27.5	73.0	-	993	3	20	D
20.07.2025	0000	Weakened into a well-marked low-pressure area over west Rajasthan and adjoining Pakistan						

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

2.6.2 Salient Features:

(1) It developed from the remnant well marked low pressure area of the depression that developed over Southeast Gangetic West Bengal and adjoining Bangladesh on 14th July (0600 UTC/1130 hrs IST). It moved across Gangetic West Bengal on 14th July and weakened into a well marked low pressure area over North Jharkhand & adjoining South Bihar in the morning of 15th July (0300 UTC/0830 hrs IST).
(2) It had a life period of 72 hours against a normal of 50 hours over the North Indian Ocean for the depression category based on the data of 1990-2013.
(3) Its total track length was 1022 km.

2.6.3.1 Monitoring of Depression

India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean (NIO) and the system was monitored well in advance since 03rd July, since it had evolved from a previous system. The system was monitored with the help of

available 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 the Ministry of Earth Sciences (MoES) institutions, global models and dynamical-statistical models were utilised to predict the genesis, track, landfall and intensity of the system. A digitised forecasting system of IMD was utilized for analysis and comparison of various models' guidance, decision-making process and warning products generation.

2.6.3.2 Features observed through satellite

Satellite monitoring of the system was mainly done by using half-hourly INSAT 3DR imageries. However, satellite imageries of other international geostationary satellites, high-resolution polar orbiting satellites, were also utilised for continuous monitoring. The compact diagnosis of the synoptic and mesoscale weather features seen on the four consecutive days (17–20 July 2025) from the INSAT-3DR products. Typical INSAT-3DR enhanced coloured imageries, visible and Infra-Red (IR) are presented in Fig. 2.6.2 (a) to 2 (c). During the entire life cycle, the clouds were organised in the shear pattern. The detailed features from the satellite pictures are discussed in this section.

The panel in Fig. 2.6.2(a) is for INSAT-3DR enhanced colour imageries for all four days at 0615 UTC. The second collage of Fig.2.6.2(b) is of TIR1 (10.8 µm – IR) and the third is of the VIS (0.65 µm) channel. All frames were around 11:40–12:20 IST (0615 UTC) each day.

As per the INSAT-3DR imagery at 0615 UTC of 17th July, the system lay as a depression over Southeast Uttar Pradesh & adjoining Madhya Pradesh. Scattered to broken low & medium clouds with embedded intense to very intense convection lay over east Uttar Pradesh, Madhya Pradesh, north Chhattisgarh, with minimum Cloud Top Temperature (CTT) between -70˚ C to -90˚ C.

As per the INSAT-3DR imagery at 0615 UTC of 18th July, the system lay as a depression over Northwest Madhya Pradesh & adjoining Southwest Uttar Pradesh. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over southwest Uttar Pradesh, north Madhya Pradesh, and Rajasthan, with minimum CTT between -70˚ C to -90˚ C.

As per the INSAT-3DR imagery at 0615 UTC of 19th July, the system lay as a depression over the Northeast & adjoining areas of Northwest Rajasthan. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over Rajasthan & North Gujarat minimum CTT within a range of -60˚ C to -70˚ C.

As per the INSAT-3DR imagery at 0615 UTC of 20th July, the system lay as a Well Marked Low Pressure Area over the Northwest & adjoining areas of Northeast Rajasthan. Scattered to broken low and medium clouds with embedded moderate to intense convection lay over south Pakistan, with minimum CTT between -50˚ C to -60˚ C and isolated weak to moderate convection lay over Rajasthan.

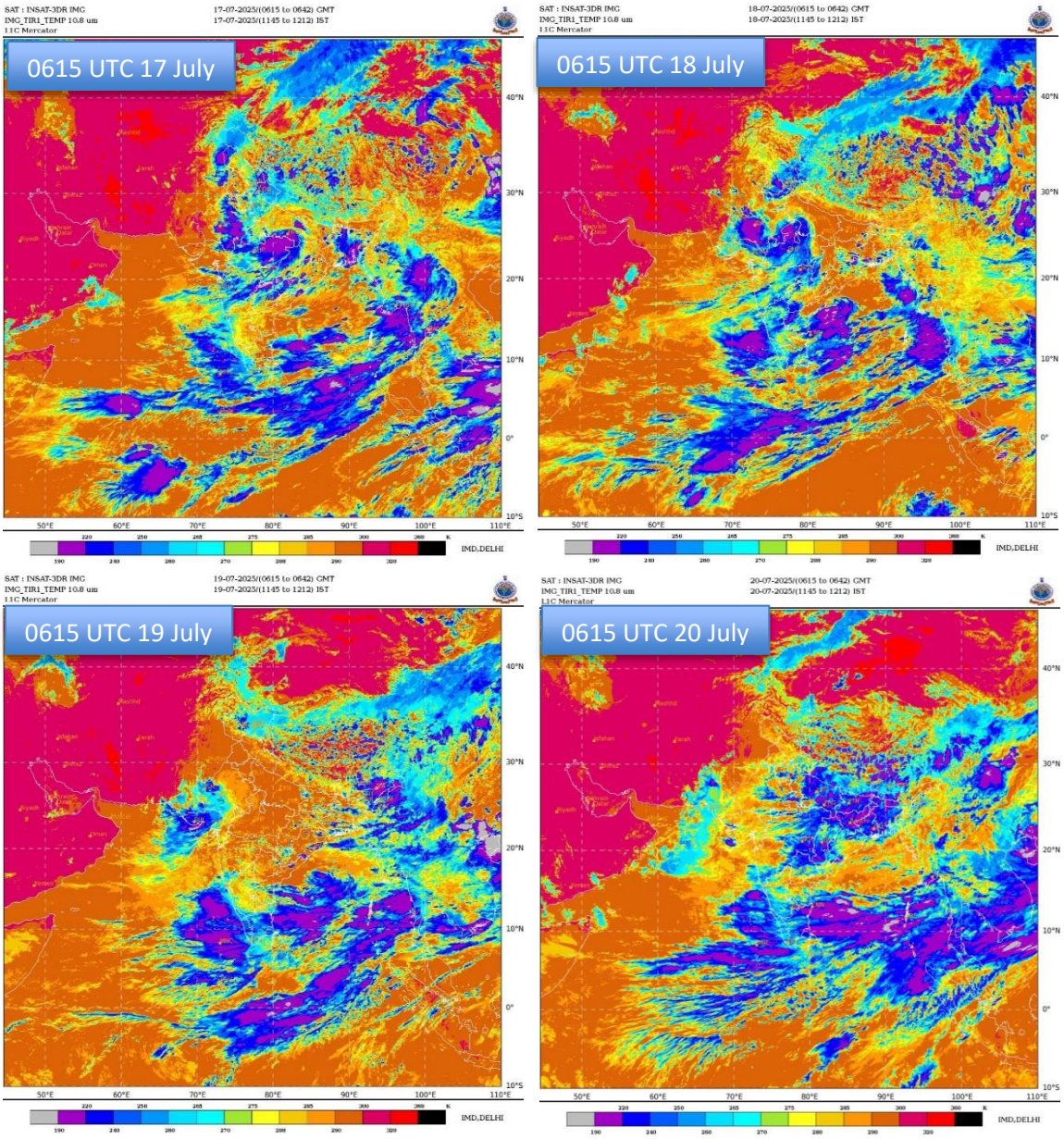


Fig. 2.6.2 (a): INSAT-3DR enhanced coloured imageries during life cycle of Depression over Northwest Bay of Bengal during 17th July-20th July 2025.

The visible imagery on 17th July, indicated strong vertical towers embedded in the central and adjoining north India cluster, confirming intense convection. These were in association with the system in east Uttar Pradesh. There were streaks/rolls of low cloud aligned SW–NE over the Arabian Sea, indicating strong monsoon westerlies. The visible image of the next day, on 18th July depicted the very bright, granular tops over the shifted core (numerous deep cells). The depression related Cirrus & stratus clouds over north India behind the convective lines show outflow and post-convective stratiform rain. As the system moved further northwestwards, the visible imagery on 19th July demonstrated less concentrated deep towers over the interior but more stratiform sheets over northwest India, mainly over Rajasthan. A new, bright convective zone started to appear over/near the Bay of Bengal and along the Andhra Pradesh-Odisha–Gangetic West Bengal coasts. On 20th July, organised convective

clouds with bright cores over the system with curved rainbands decreased with the westward movement of the cloud mass. However, the flow from the Arabian Sea generated scattered convective clouds over Gujarat state. A copious low cloud in the Arabian Sea onshore flow and active convection off Kerala–Karnataka were represented well by a strong monsoon flow over the region.

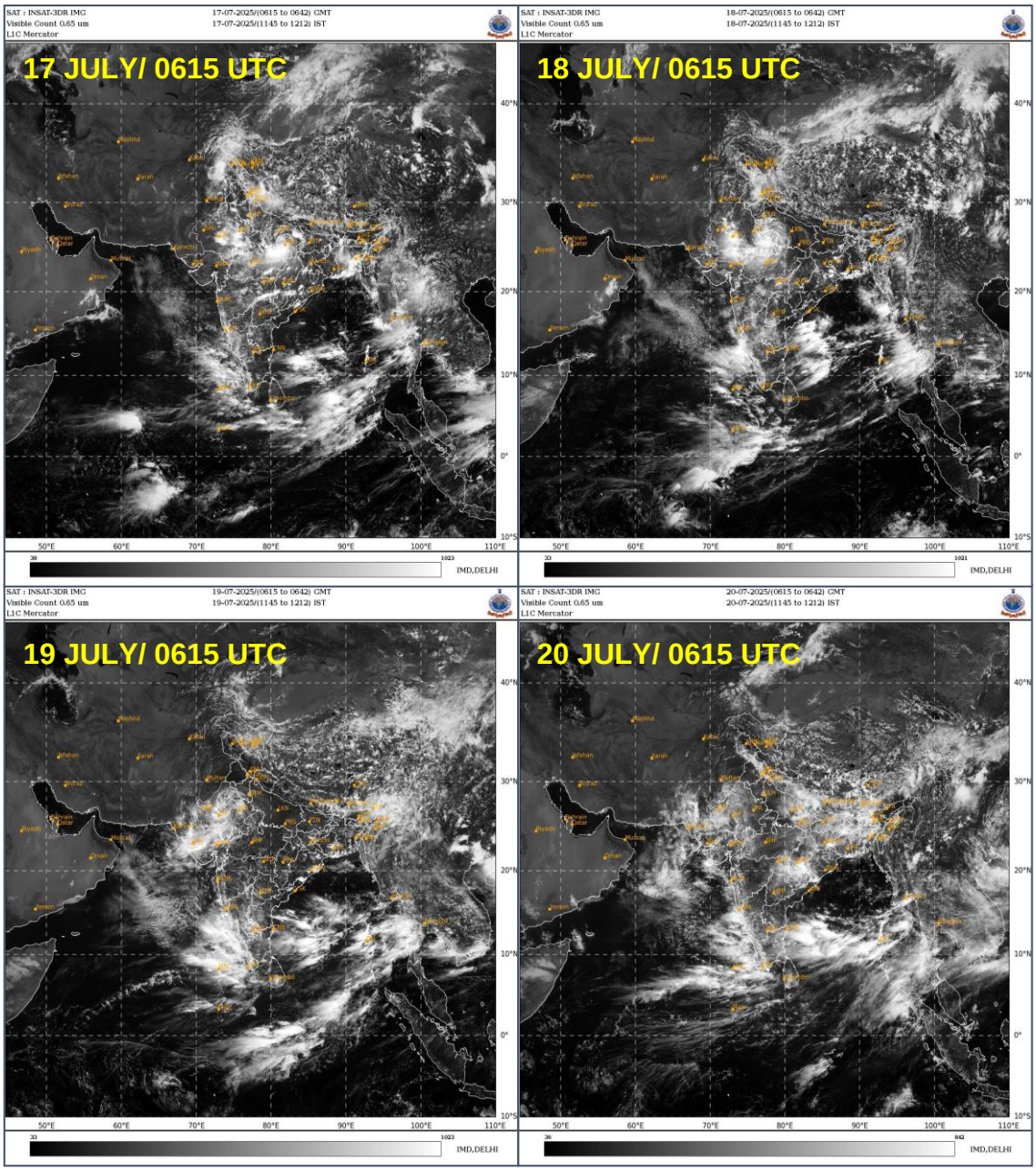


Fig. 2.6.2 (b): INSAT-3DR Visible imageries during life cycle of Depression over Northwest Bay of Bengal during 17th July - 20th July 2025.

As per the IR imagery of 17th July, a large, nearly circular cold-cloud mass centred over west-central India (Maharashtra–Madhya Pradesh). Curved bands wrap in from the Arabian Sea to the monsoon depression (i.e. associated cyclonic circulation) over the interior central-northwest India. Cold anvils extended NE toward the east MP/Chhattisgarh. The off-shore

west-coast cloud bands were present but fragmented. The depression moved west-northwestwards and accordingly, the main convective core shifted along with a broad stratiform shield in the IR imagery of 18th July. The thick cloud also spread along the foothills of the Himalayas. West-coast off-shore trough continued with a broken line of convection. In the imagery of 19th July, the extensive mid–high cloud associated with the system spread across west and adjoining central India. At the same time, the convection over the Bay of Bengal off Andhra Pradesh-Odisha coasts became more organised. The Arabian Sea showed a long, continuous SW–NE cloud band typical of a strong monsoon surge. During 20th July, the cloud mass associated with the system over west India reduced drastically as the system moved further west-northwestwards and weakened. The deepest, coldest cloud now lies from the north Bay through Bangladesh/NE India with banding—consistent with a monsoon low/depression moving to the NE along the monsoon trough. A second active belt persisted south of the Peninsula and along the west coast.

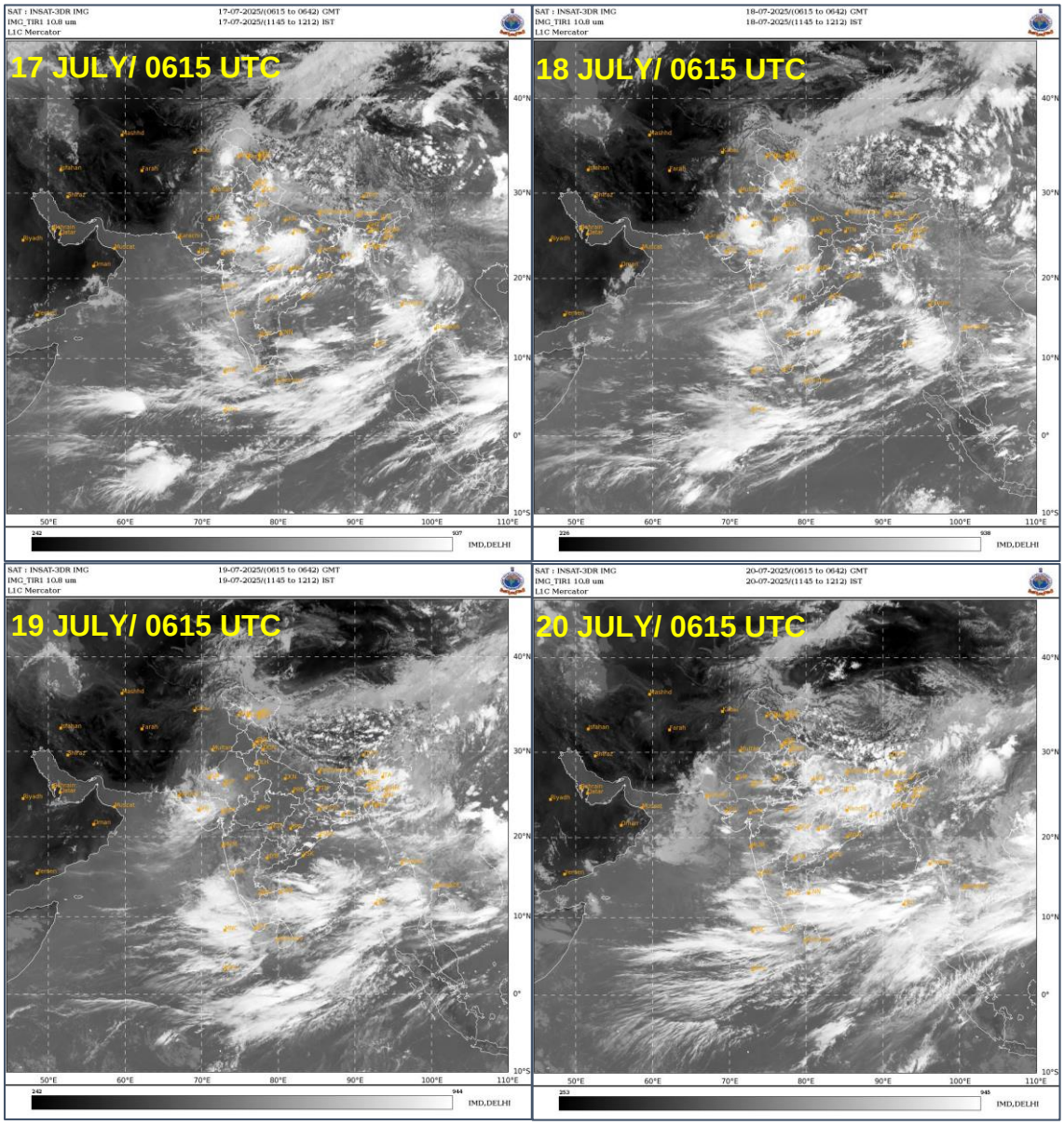


Fig. 2.6.2 (c): INSAT-3D IR imageries during life cycle of Depression over the Northwest Bay of Bengal during 17th July - 20th July 2025.

2.6.4 Dynamical Features

IMD GFS (T1534) daily analyses at 0000 UTC of mean sea level pressure (MSLP), winds at the surface and various pressure levels from 17th July to 20th July are presented in **Fig. 2.6.3(a) to (d)** respectively.

The MSLP analysis field on 17th July indicated that the system was over east Uttar Pradesh near 25.0°N/81.0°E. Actually, based on the best track, the system was located near 25.2°N/81.8°E at 0000 UTC. Thus, GFS fairly captured the location of the system. The monsoon trough from Pakistan across north India into the north Bay was also seen. There was a prevailing offshore trough along the west coast. Associated cyclonic circulation in the 10 m wind field was clearly represented in the specific chart. Although there were very strong winds at the eastern side of the system but an overestimation of the wind speed was established.

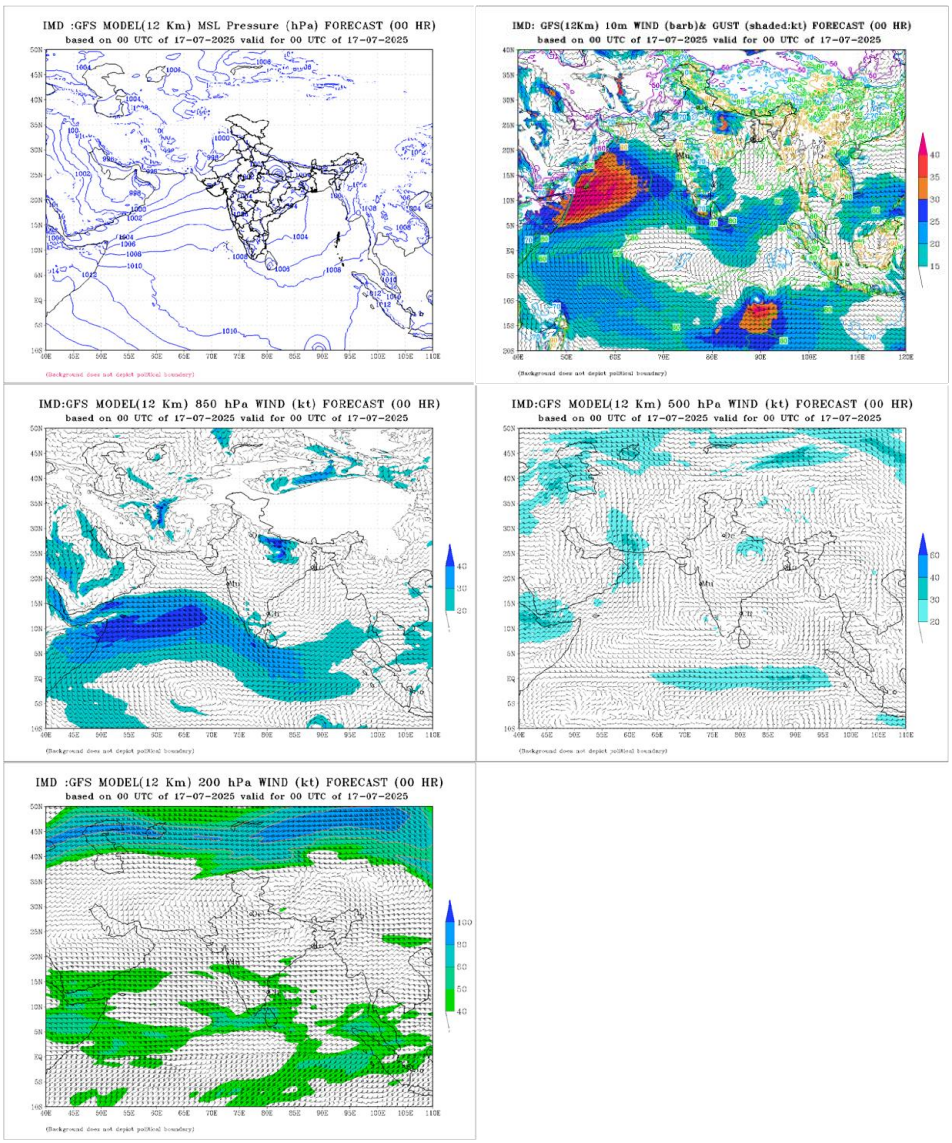


Fig. 2.6.3(a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 17th July 2025**.**

The winds at 850 and 500 hPa pressure levels clearly indicated associated upper-air cyclonic circulation extending up to 500 hPa, with stronger easterly winds surrounding the northern sectors of the systems. However, the system was mainly supported by the moisture feeding from the Bay of Bengal. Moreover, Low Level Jet (LLJ) in the southwesterlies with 30–40 kt speed over the central Arabian Sea, aiming at Konkan–Karnataka was indicating an active monsoon situation. The whole of central India was under a cyclonic wind flow pattern. The 200 hPa wind portrayed Tropical Easterly Jet (TEJ) over south India with upper-level divergence over the west coast and central India. Expected weather would be around the system with enhanced convection in the north sectors of the system. Active monsoon conditions with rainfall along the west coast (Konkan/Goa–coastal Karnataka) and scattered rain over central India.

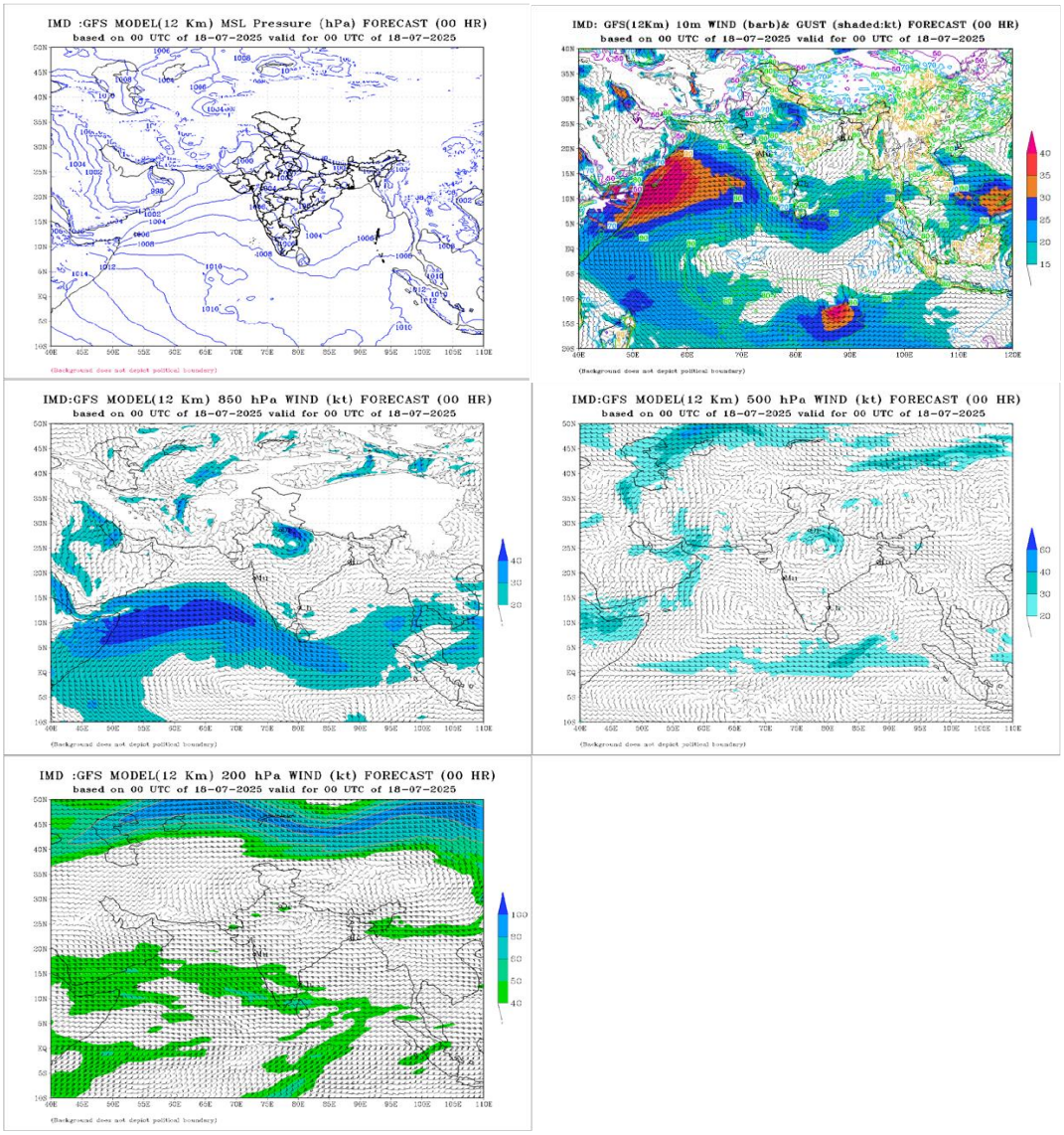


Fig. 2.6.3 (b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 18th July 2025.

In the Fig. 2.6.3(b), the model analyses of MSLP and 10m wind at the surface and wind flow patterns at various pressure levels are plotted for 0000 UTC of 18th July 2025. In the MSLP analysis, the system was located over west Uttar Pradesh embedded within the monsoon

trough, which was a little south-leaning across Rajasthan–MP compared to the normal position. The number of closed isobars also indicated the intensity of a depression. The plot of the surface (10m) winds indicated the cyclonic circulation over the same region, with stronger wind speed northern sectors of the system. The strongest wind speed was seen over the southwest and central Arabian Sea.

The wind flow patterns at 850 and 500 hPa pressure levels clearly depicted the associated upper-air cyclonic circulation without any tilt with height. Similar to the surface wind, the stronger winds were noticed at the northern sectors of the depression. However, the strength of the wind speed was seen to decrease with height. The LLJ persisted with strong onshore flow in the southern parts of the west coast. The closed mid-tropospheric cyclonic flow over central India was favourable for organised convection over the region. The 200 hPa winds were predominantly easterly, and the TEJ was found with a core south of 15°N. The upper-level winds indicated a westward steering for the future movement of the depression.

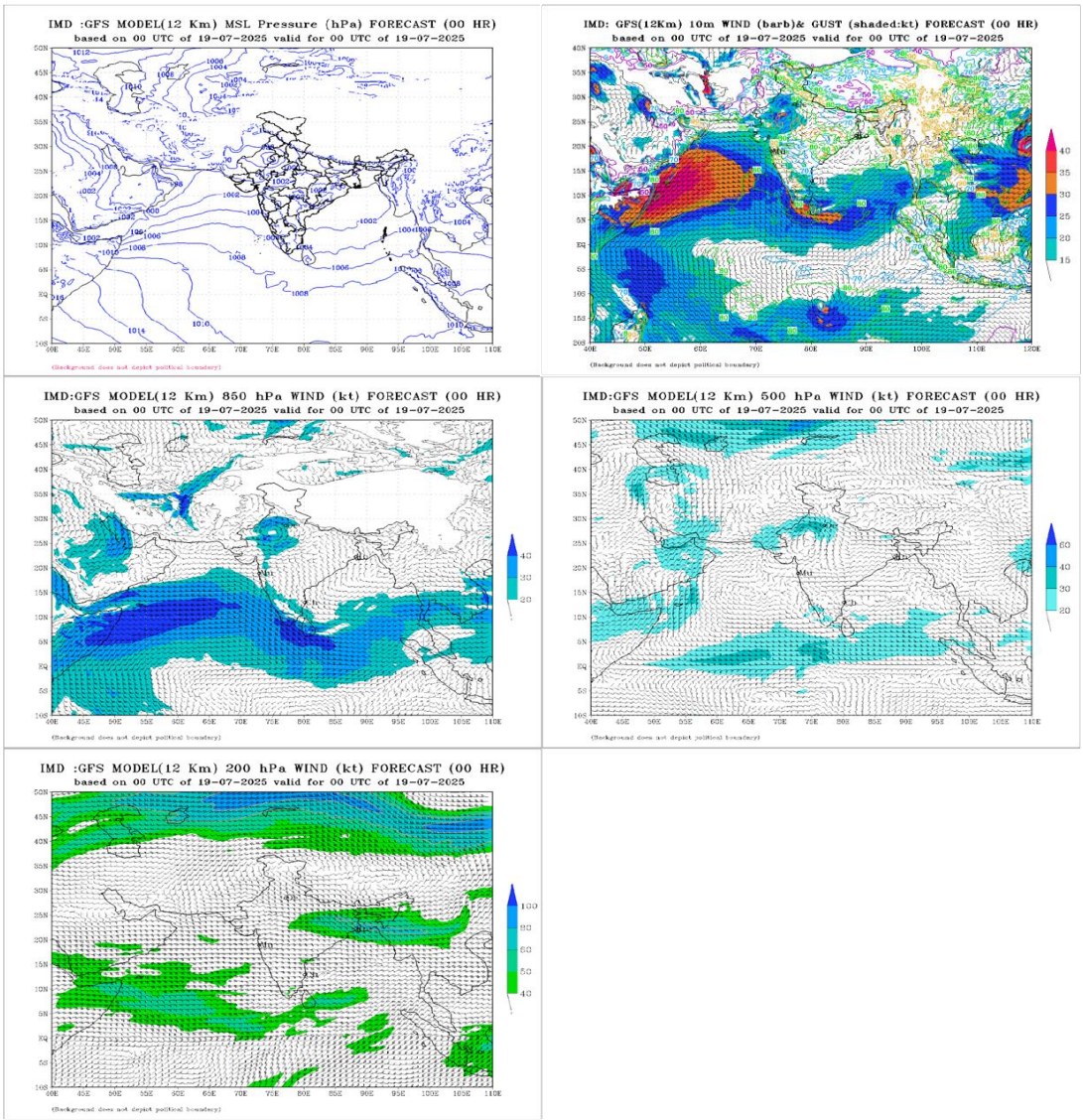


Fig. 2.6.3 (c): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 19th July 2025.

The panels of Fig. 2.6.3(c) represent the IMD GFS analyses of MSLP and winds at the surface (10m above mean sea level) and other pressure levels valid at 0000 UTC of 19th July, 2025.

The isobaric analysis in the top-left panel of the figure indicated the low-pressure system as a depression located over northeast Rajasthan and the adjoining areas of west Rajasthan. The monsoon trough was also seen south of its normal position. Although, the 10 m wind circulation pattern also depicted the core structure of the system with strong wind surrounding the centre, the maximum strength of the surface wind was shown in the southern sectors of the depression.

The vertical extent of the depression was established by the upper-air cyclonic circulations extending up to 500 hPa pressure level. The wind distribution pattern at 850 hPa and 500 hPa pressure levels indicated that the core of the depression was weakening with height. Moreover, the core was more symmetric at 850 hPa which became asymmetric with stronger winds prevailing at the northern sectors of the depression at 500 hPa pressure level. The 200 hPa wind distribution portrayed that the system was steered by the easterly winds with the ridgeline very much far north (along 30°N latitude) of the system centre. The outflow from the Tibetan high, the strong easterlies could be noticed along 22°N latitude over east India. Accordingly, the TEJ could not be found at its normal position.

The model analyses of MSLP and winds at various levels e.g. 10 m above ground, 850 hPa, 500 hPa and 200 hPa pressure levels at 0000 UTC of 20th July, 2025, were described in various panels of Fig. 2.6.3(d) similar to Fig. 2.6.3(a)–(c). In general, it was found that the low pressure system weakened considerably over northwest Rajasthan & neighbourhood and only a feeble low pressure area could be seen over the region as the remnant of the depression.

The MSLP analysis in the Fig. 2.6.3(d), could not establish an extended low pressure area over northwest Rajasthan and neighbourhood. Accordingly, the 10 m wind pattern also did not show any obvious core cyclonic circulation over the region. Very weak cyclonic wind flow was only noticed.

The winds at 850 hPa, however indicated upper-air cyclonic circulation associated with the feeble low pressure area at the surface. The winds at 500 hPa pressure level did not indicate any upper air cyclonic circulation over the region of low pressure area. However, at this pressure level, a feeble cyclonic circulation was noticed over Saurashtra & Kutch region indicating southward tilt of the system centre with height. The wind distribution at 200 hPa level indicated an established anticyclone over Leh - Ladakh and neighbourhood with associated ridgeline along latitude 29□N. The strong easterlies were found south of the system across central India with strongest wind flowing along 19□N latitude. It increased the vertical wind shear over monsoon trough region and which in turn supporting the establishment of TEJ at its normal position.

The sequence shows an active monsoon phase dominated by a land depression from east Uttar Pradesh moving nearly west-northwestwards reached up to northwest Rajasthan and associated upper air cyclonic circulations extending vertically up to mid-tropospheric (500 hPa pressure level) levels. There was monsoon trough across north/central India, strong Arabian Sea LLJ and upper level strong easterlies which created supporting environment for convective activities over northwest and western part of central and west India.

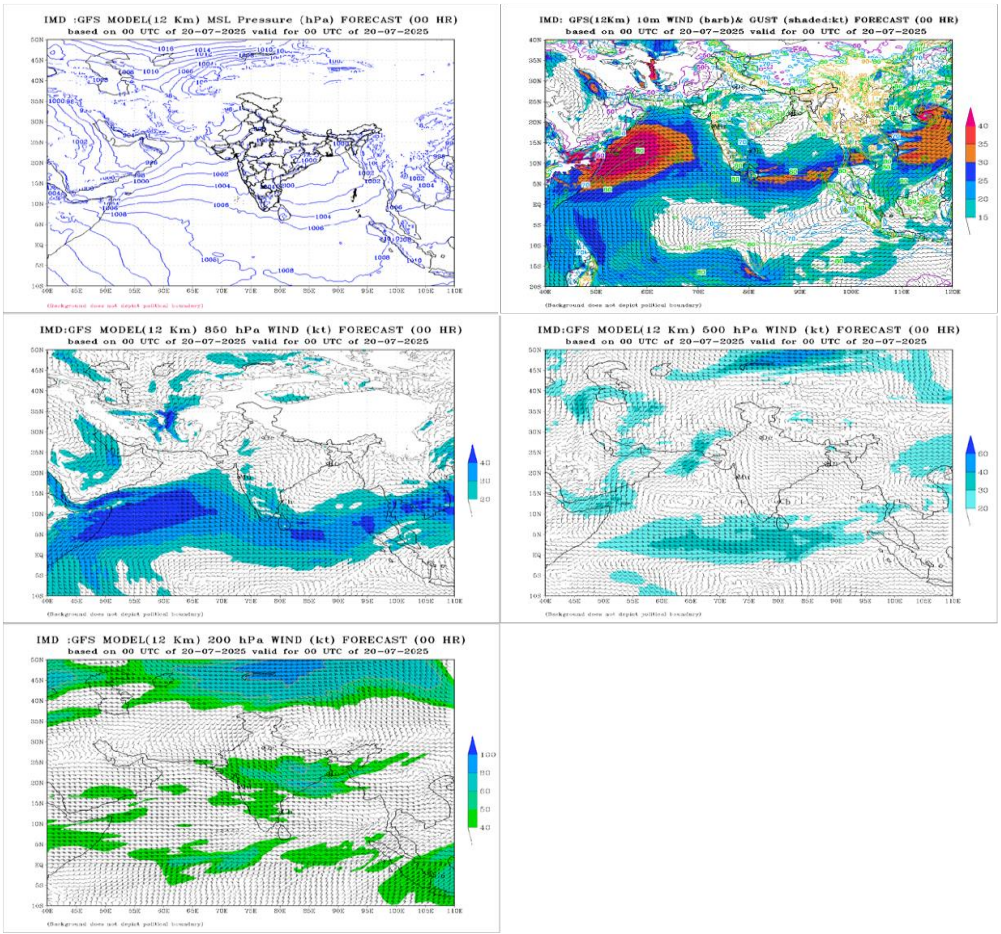


Fig. 2.6.3 (d): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 20th July 2025.

2.6.5 Realized Weather

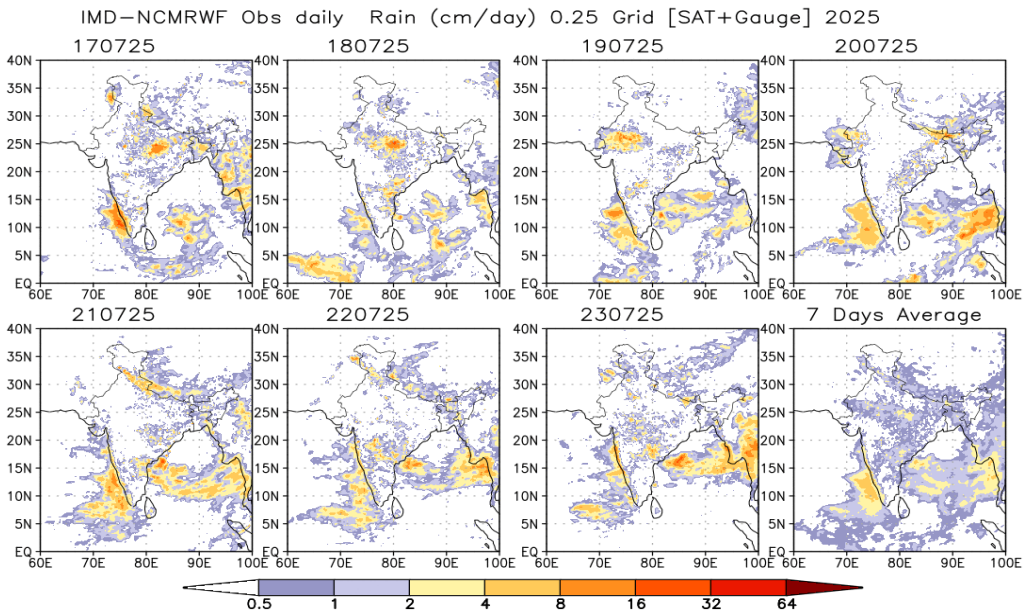


Fig. 2.6.4 (a): NCMRWF-IMD satellite gauge merged data plots of realized 24-hour accumulated rainfall from 17th to 23rd July, 2025

The day-by-day rainfall distribution (cm/day) associated with the deep depression based on IMD-NCMRWF satellite gauge merged data are depicted in **Fig. 2.6.4 (a and b)**.

The spatial distribution of rainfall clearly depicted that the zone of heavy rainfall or more was co-located around the centre of the depression. Accordingly, the heavy rainfall zone moved west-northwestwards along with the system. It was also evident that the maximum rainfall occurred in southern sectors of the depression as on day-to-day basis, the shaded area of maximum rainfall was noticed to be located south of the depression centre. It was also noted that the system induced heavy rainfall along west coast was realized on 17th but the rainfall activity reduced significantly as the system progressed westward reached over west Madhya Pradesh and Rajasthan. As the depression became less marked over west Rajasthan and neighbourhood, the rainfall activity over west coast resumed again from 21st July.

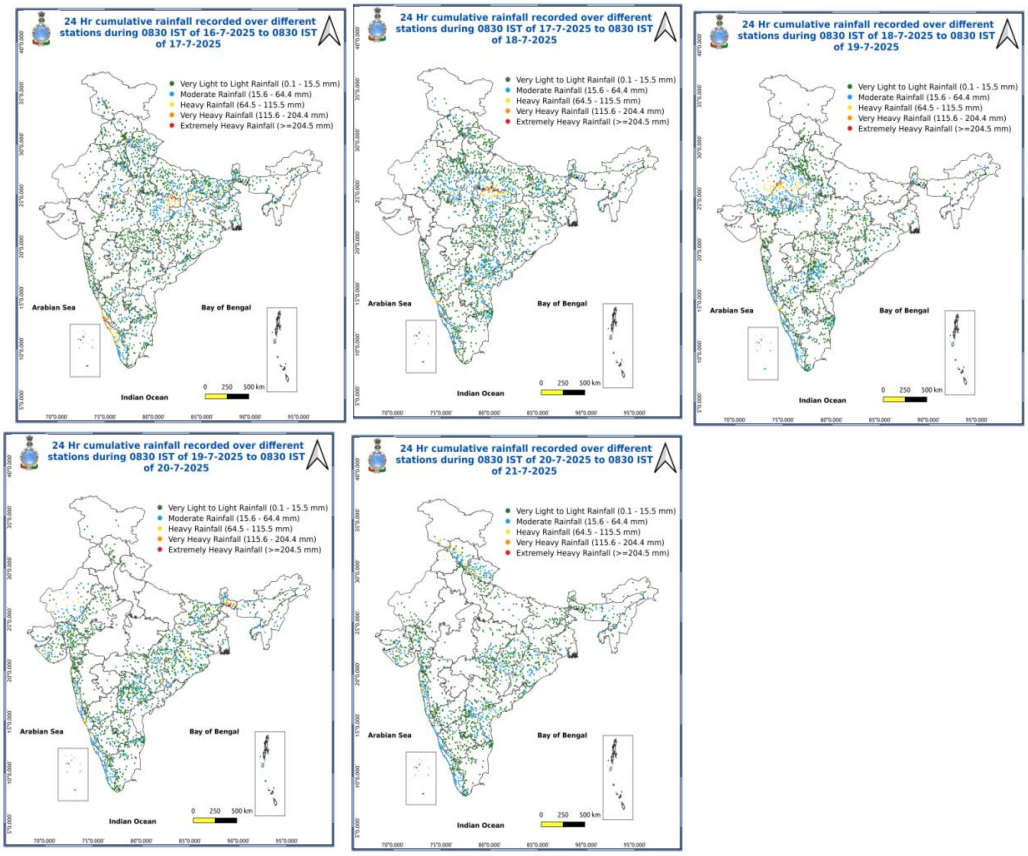


Fig. 2.6.4(b): Station wise rainfall data plots of realized 24-hour accumulated rainfall from 17th to 21st July, 2025.

Realised 24-hour heavy rainfall (≥ 7 cm) ending at 0300 UTC of date

<u>18.07.2025:</u>

EAST MADHYA PRADESH: Chahtarpur 31, Gaurihar (Chhatarpur) 27, Palera (Tikamgarh) 23, Lavkushnagar (Chhatarpur) 19, Rajnagar (Chhatarpur) 18, Ajaigarh (Panna) 17, Khajuraho Aero (Chhatarpur) 15, Satna (raghurajnagar) 14, Sohawal (Satna) 14, Birsingpur (Satna) 14, Nowgong (Chhatarpur) 13, Amarpatan (Satna) 13, Jatara (Tikamgarh) 13, Mohangarh (Tikamgarh) 13, Badamalhera (Chhatarpur) 13, Sirmaur (Rewa) 12, Nagode (Satna) 11, Majhgaon (Satna) 11, Panna 11, Khargapur (Tikamgarh) 11, Devendranagar

(Panna) 10, Naigarhi (Rewa) 10, Amanganj (Panna) 9, Bijawar (Chhatarpur) 9, Gonour (Panna) 9, Raipurkarchuliyan (Rewa) 9, Rampur Baghelan (Satna) 9, Tikamgarh-aws 9, Mangawan (Rewa) 9, Semariya (Rewa) 7, Baldevgarh (Tikamgarh) 7, Hanumana (Rewa) 7, Pawai (Panna) 7, Bilhari (Katni) 7, Teonthar (Rewa) 7, Badagaon Dhasan (Tikamgarh) 7, Orchha (Niwari) 7,

WEST MADHYA PRADESH: Bhanpura (Mandsaur) 18, Datia 13, Indergarh (Datia) 12, Bhander (Datia) 10, Seodha (Datia) 9, Mau (Bhind) 9, Guna 7, Khilchipur (Rajgarh) 7
EAST RAJASTHAN: Sangod (Kota) 17, Atru (Baran) 8, Nasirabad (Ajmer) 8, Ajmer (Ajmer) 8, Mandana (Kota) 8, Mangrol (Baran) 8, Ajmer Tehsil 7,
WEST RAJASTHAN: Pilibanga (Hanumangarh) 11, Bhadra (Hanumangarh) 7, Degana (Nagaur) 7,
EAST UTTAR PRADESH: Chilaghat (Banda)-21, Attarra (Banda)-20, Banda (Banda) 15,
WEST UTTAR PRADESH: Kulpahar (Mahoba) 17, Hamirpur Obsy (Hamirpur) 10, Talbehat (Lalitpur) 8,

19.07.2025:

EAST RAJASTHAN: Nainwa (Bundi) 23, Mangliawas (Ajmer) 19, Nasirabad (Ajmer) 18, Pratapgarh (Pratapgarh) 16, Pisagan (Ajmer) 15, Ajmer (Ajmer) 14, Sarmathura (Dholpur) 14, Kishangarh (Ajmer) 14, Pushkar (Ajmer) 13, Sarwar (Ajmer) 13, Ajmer Tehsil (Ajmer) 12, Deogarh (Rajsamand) 12, Nagrarfort (Tonk) 11, Indergarh (Bundi) 11, Masuda (Ajmer) 11, Geola (Ajmer) 11, Bhinay (Ajmer) 11, Kekri (Ajmer) 11, Malerainadunger (Sawai Madhopur) 10, Arai (distn Ajmer) 10, Lalsot (Dausa) 10, Kumbhalgarh (Rajsamand) 9, Pipalda (Kota) 9, Tatgarh (Ajmer) 9, Tonk Vanasthali (Tonk) 9, Gegal (Ajmer) 9, Khandar (Sawai Madhopur) 9, Bamanwas (Sawai Madhopur) 9, Sawaimadhopur Tesil (Sawai Madhopur) 8, Nayanagar/beawar (Ajmer) 8, Hurda (Bhilwara) 8, Raipur (Bhilwara) 8, Jawaja (Ajmer) 8, Todaraisingh (Tonk) 8, Dausa (Dausa) 8, Gangapur (Sawai Madhopur) 7, Mandana (Kota) 7, Nimbahera (Chittorgarh) 7, Mandrayal (Karauli) 7, Chothkabarwara (Sawai Madhopur) 7, Piplu (Tonk) 7, Vijaynagar (Ajmer) 7, Sapotra (Karauli) 7, Jhadol (Udaipur) 7, Bhim (Rajsamand) 7, Uniara / Aligarh (Tonk) 7, Sallopat (Banswara) 7.
WEST RAJASTHAN: Merta City (Nagaur) 23, Raipur (Pali) 14, Khivensar (Nagpur) 13, Degana (Nagaur) 11, Bhopalgarh (Jodhpur) 10, Bilara (Jodhpur) 9, Marwar Junction (Pali) 9, Sojat (Pali) 9, Luni (Jodhpur) 9, Pali (Pali) 8, Pachpadra (Barmer) 7, Jaitran (Pali) 7, Rohat (Pali) 7, Jodhpur Tehsil (Jodhpur) 7, Shergarh (Jodhpur) 7.
GUJARAT REGION: Danta (Banaskantha) 13, Palanpur (Banaskantha) 9.
WEST MADHYA PRADESH: Bairad (Shivpuri) 11, Karhal (Sheopur) 10, Badoda (Sheopur) 9, Kumbhraj (Guna) 8, Narwar (Shivpuri) 8, Mandsaur-aws (Mandsaur) 7, Alipur(jaura) (Morena) 7, Veerpur (Sheopur) 7, Jawad (Neemuch) 7.

20.07.2025:

SAURASHTRA & KUTCH: Ranavav (dist Porbandar), Porbandar 11 Each; Manavadar (dist Junagadh) 7.The forecast for heavy to extremely heavy rainfall episodes in association with the system is verified with the 24-hour accumulated rainfall realised at various stations.

2.7 Depression over Northwest Bay of Bengal during 25th July-27th July 2025

2.7.1 Life history of Depression

- Under the influence of upper air cyclonic circulation (Remnant of Tropical Cyclone "WIPHA") a low Pressure area formed over North Bay of Bengal in the early morning (0530 hrs IST/0000 UTC) of 24th July 2025.
- It lay as a well marked low pressure area over the same region in the evening (1730 hrs IST/ 12 UTC) of 24th July.
- It moved slowly west-northwestwards and concentrated into a Depression in the early morning (0530 hrs IST/0000 UTC) of 25th July over Northwest Bay of Bengal and adjoining areas of coastal West Bengal and Bangladesh.
- Continuing to move further wes-northwestwards, it crossed West Bengal & adjoining Bangladesh coasts in the morning (between 0730 to 0830 hrs IST/ 0200 UTC to 0300 UTC) of 25th July 2025 as a depression.
- Further moving west-northwestwards across West Bengal during the day, it lay over north Chhattisgarh and adjoining Jharkhand in the morning (0830 IST/0300 UTC) of 26th July 2025.
- Thereafter, it moved westwards across North Chhattisgarh and east Madhya Pradesh and weakened into a well-marked low-pressure area over northwest Madhya Pradesh and neighborhood in the early morning (0530 hrs IST/0000 UTC) of the 27th July 2025.

The observed track of the system is presented in Fig. 2.7.1. The best track parameters of the system are presented in Table 2.7.1.

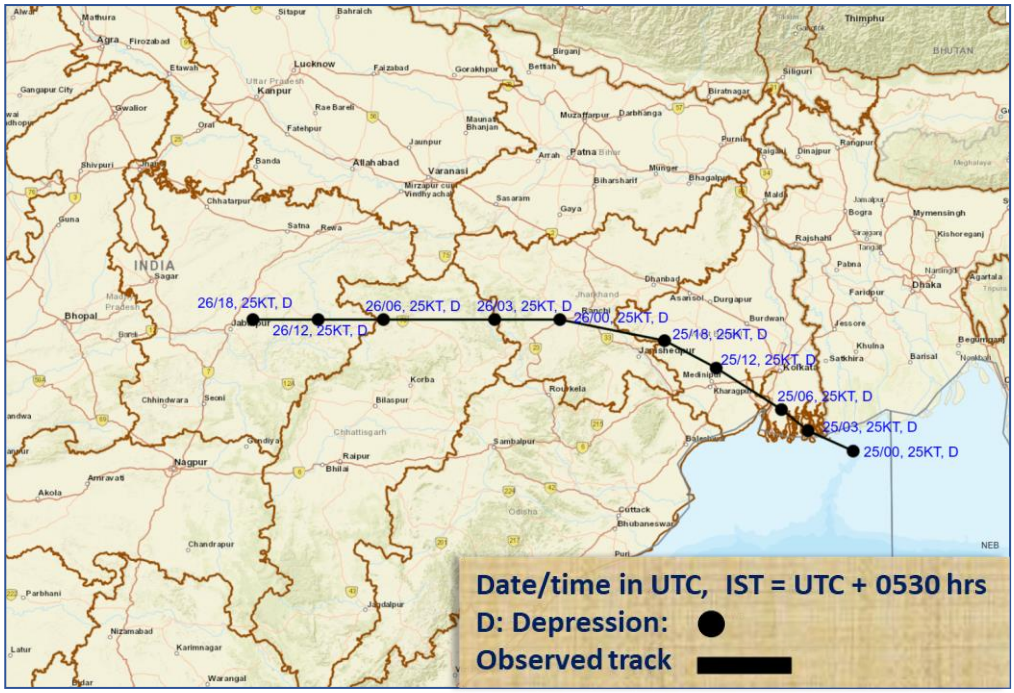


Fig. 2.7.1: Observed track of Depression over Northwest Bay of Bengal during 25th July-27th July 2025

Table 2.7.1: Best track positions and other parameters of the Depression over Northwest Bay of Bengal during 25th July-27th July 2025

Date	Time (UTC)	Lat. (^{0}N)	Long (^{0}E)	CI No	ECP (hPa)	ΔP (hPa)	MSW (kt)	Category
25.07.25	0000	21.4	89.5	1.5	988	4	25	D
	Crossed West Bengal & adjoining Bangladesh coasts near between 0200 and 0300 UTC of 25th August							
	0300	21.7	88.8	-	988	4	25	D
	0600	22.0	88.4	-	988	4	25	D
	1200	22.6	87.4	-	988	4	25	D
	1800	23.0	86.6	-	988	4	25	D
26.07.25	0000	23.3	85.0	-	988	4	25	D
	0300	23.3	84.0	-	990	3	20	D
	0600	23.3	82.3	-	990	3	20	D
	1200	23.3	81.7	-	990	3	20	D
	1800	23.3	81.0	-	992	3	20	D
27.07.25	0000	Weakened into a Well Marked Low Pressure Area Over Northwest Madhya Pradesh and neighbourhood						

KT: Knots (nautical mile per hour), 1 KT=1.85 kmph, D: Depression

2.7.2 Salient features

- The life period of the system was less than 48 hours against normal of 52 hours based on long period average of 1990-2013 for depression over BoB during monsoon season, which is below normal.
- Climatologically about 28 cyclonic disturbances (CDs) formed over the northwest BoB during the period of 1965-2024 in the month of July, out of which 27 were depressions (D) and 01 intensified into cyclonic storms (CS). Out of these, 6 crossed West Bengal coast.

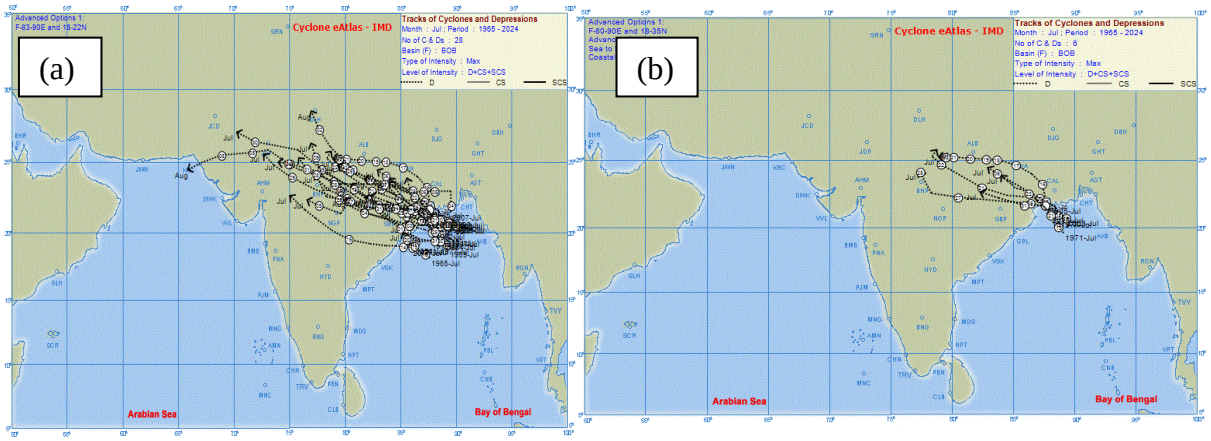


Fig. 2.7.2 (a) Tracks of Cyclonic disturbances over northwest BoB in the month of July during 1965-2024. **(b)** Tracks of Depression over Northwest BoB crossing the West Bengal coast in the month of July during 1965-2024.

2.7.3 Genesis, intensification and movement

Under the influence of upper air cyclonic circulation (Remnant of Tropical Cyclone "WIPHA") a low Pressure area formed over North Bay of Bengal in the early morning (0530 hrs IST/0000 UTC) of 24th July 2025.

On 24th July, the Madden–Julian Oscillation (MJO) index was located in phase 7 with an amplitude greater than 1 and remained close to the transition boundary between phases 7 and 8, with amplitude close to 1 during the subsequent three days. The NCICS-based zonal wind forecast indicated a strong westerly wind anomaly (~5 to7 mps) over the south Bay of Bengal (BoB) and an easterly wind anomaly (~3 to 5 mps) over the northern parts of the BoB and east India. At that time, an Equatorial Rossby Waves (ERW) was seen over the central BoB and a Kelvin wave over the north BoB. These features supported convective activity over the BoB and eastern parts of India. As per the satellite guidance at (1730 hrs IST/1200 UTC) of 24th July, the low-level vorticity at 850 hPa was about 100 x 10^{-6} s^{-1} to the southeast of system center, and it extended upto 500 hPa level. The low-level convergence was 10-20 x 10^{-6} s^{-1} to the south of system center. The upper-level divergence was about 5-10 x 10^{-6} s^{-1} to the south of system center. The mid-level vertical wind shear (VWS) of horizontal wind was low to moderate (5-15 kts) around the system center and was anticyclonic over the system area and along the predicted path, which were favorable conditions for intensification. The nearly east-southeasterlies prevailing in the middle to upper tropospheric levels and were steering the system nearly west-northwestwards. Under these favourable conditions, it intensified into a well marked low pressure area over the North Bay of Bengal in the evening (1730 hrs IST/ 12 UTC) of 24th July.

At 0000 UTC of 25th July, environmental conditions continued to be favourable with positive low-level vorticity around 100 × 10^{-5} s^{-1} over northeast BoB extending up to the 200 hPa level, low-level convergence of (15–20 × 10^{-5}) s^{-1} to the southeast of the system centre over Myanmar and adjoining east-central BoB, upper-level divergence of (5–10) × 10^{-5} s^{-1} over north and central BoB, and moderate vertical wind shear (15–20 kt) along the system area and predicted track. The east-southeasterlies prevailed in the middle to upper tropospheric levels. Based on INSAT-3D imagery, scattered to broken low and medium clouds with embedded intense to very intense convection lay over Odisha, Gangetic West Bengal, coastal Andhra Pradesh, South Bangladesh and north & central Bay of Bengal at 0300 UTC of 25th July. The satellite imagery thus showed shear pattern with convective clouds steered towards the southwest sector of the system. The minimum cloud top temperature (CTT) was minus 70^{0}C to 90^{0}C. Under these favourable conditions, the well marked low pressure area moved slowly west-northwestwards, concentrated into a Depression in the early morning (0530 hrs IST/0000 UTC) of 25th July over Northwest Bay of Bengal & adjoining areas of coastal West Bengal and Bangladesh coasts and crossed the West Bengal–Bangladesh coasts in the morning (between 0730 to 0830 hrs IST/ 0200 UTC to 0300 UTC) of 25th July. It subsequently traversed west–northwestwards across Gangetic West Bengal, Jharkhand and North Chhattisgarh during the following 24 hours.

At 0300 UTC on 25th July, the associated maximum sustained wind speed was 25 kt, gusting to 35 kt, with an estimated central pressure of 988 hPa. Sagar Island reported MSW 250^0/03 kt and MSLP 992.9 hPa, Canning reported an MSLP of 991.3 hPa, and Raidighi reported MSW 350/02 kt and MSLP 989.4 hPa.

At 1200 UTC of 25th July, based on INSAT-3D imagery, associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over Gangetic West Bengal, Odisha, coastal Andhra Pradesh, South Bangladesh and north & central Bay of Bengal. The minimum cloud top temperature is minus 70^{0}C to 90^{0}C.

At 0300 UTC on 26th July, the maximum sustained wind speed remained 25 kt, gusting to 35 kt, with an estimated central pressure of 991 hPa. Daltonganj reported MSW 900/04 kt and MSLP 991.8 hPa. The Low-level vorticity had decreased to around 80–90 × 10^{-6} s^{-1} over east India with vertical extension upto 200 hPa level while low-level convergence (10–15 × 10^{-6} s^{-1}) and upper-level divergence (05–10 × 10^{-6} s^{-1}) remained nearly unchanged. Vertical wind shear persisted at moderate levels (10–15 kt) over the system area and western sector. Mid-layer (500–850 hPa) easterly winds steered the system nearly westwards. Based on INSAT-3D visible imagery, associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over East Madhya Pradesh, Chhattisgarh and Vidarbha with minimum cloud top temperature as minus 70^0C to 90^0C and isolated moderate to intense convection over Bihar, Jharkhand & Odisha with minimum cloud top temperature as minus 30^0C to 50^0C.

Active monsoon conditions were prevailing at that time. There was warm moist air incursion into the system area from Arabian Sea and Bay of Bengal, which helped it to maintain its intensity over land. It therefore moved west-northwestwards along the seasonal monsoon trough across Gangetic West Bengal, North Chhattisgarh and east Madhya Pradesh and weakened into a well-marked low-pressure area over northwest Madhya Pradesh and neighborhood in the early morning (0530 hrs IST/0000 UTC) of the 27th July 2025.

The environmental features indicate that the system initially benefited from favourable conditions such as strong low-level vorticity over the north Bay of Bengal, moderate low-level convergence, positive upper-level divergence, and the presence of Equatorial Rossby Waves and a Kelvin wave, which collectively supported the formation and sustenance of the Depression. However, the Madden–Julian Oscillation remained in phase 7 with an amplitude greater than 1, which normally suppresses the convection over north Bay of Bengal. As the system progressed inland, environmental support weakened, with vorticity decreasing significantly, vertical wind shear remaining moderate, the convergence and divergence showed no notable improvement. The deep-layer easterly winds continued to steer the system nearly westwards, consistent with model guidance and isallobaric analysis. These evolving conditions indicate that while the environment was sufficient to maintain the system as a Depression, it was not favourable for further intensification, and the system was expected to continue its westward movement and gradually weaken into a well-marked low-pressure area.

2.7.4 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 22nd July. The system was monitored with the help of available 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.

2.7.5.1 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. 2.7.3(a) to 3(c)**.

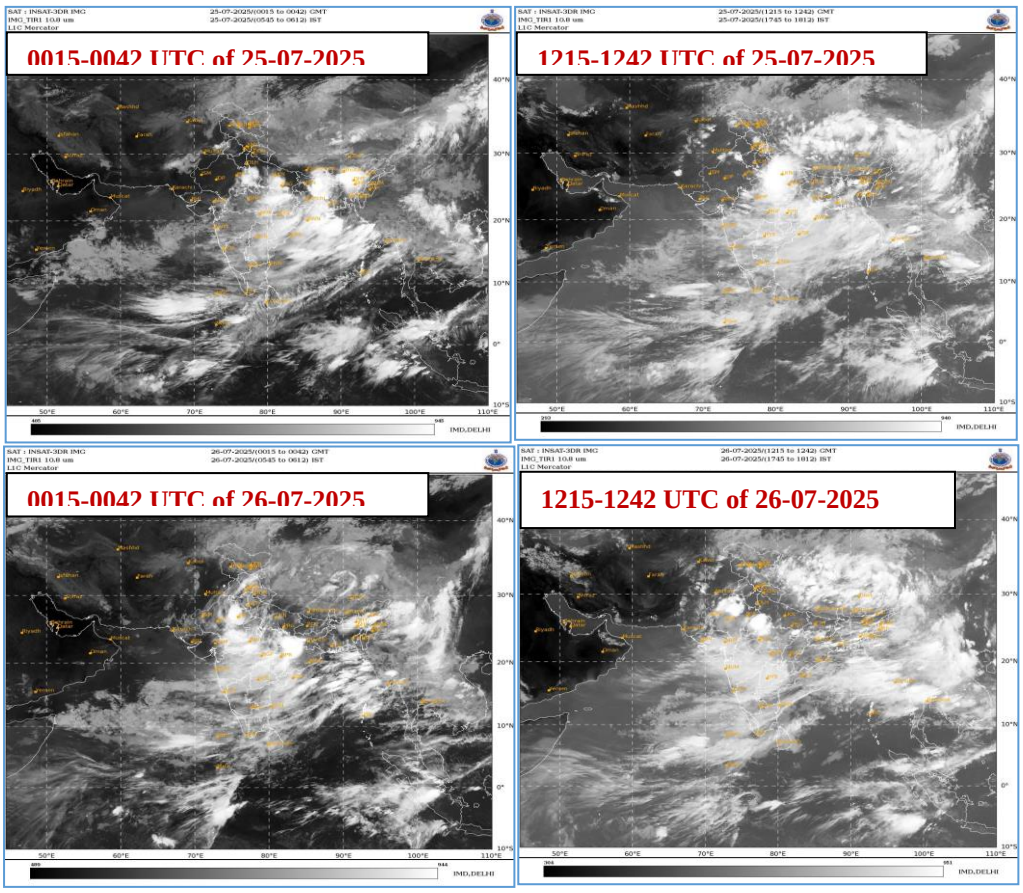


Fig. 2.7.3(a): INSAT-3D IR imageries during life cycle of Depression over Northwest Bay of Bengal during 25th July-27th July 2025

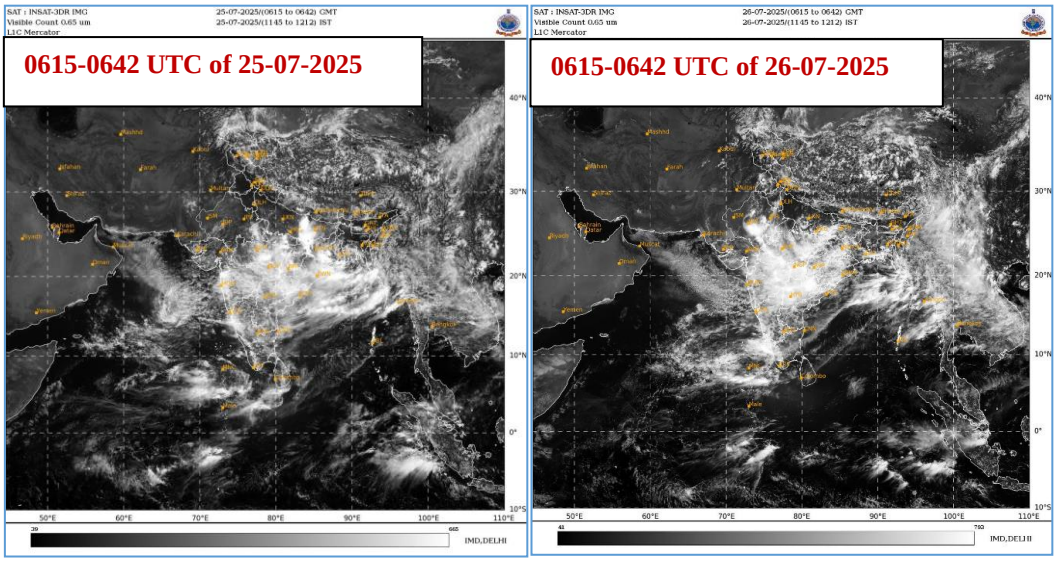


Fig. 2.7.3(b): INSAT-3D Visible imageries during life cycle of Depression over Northwest Bay of Bengal during 25th July-27th July 2025.

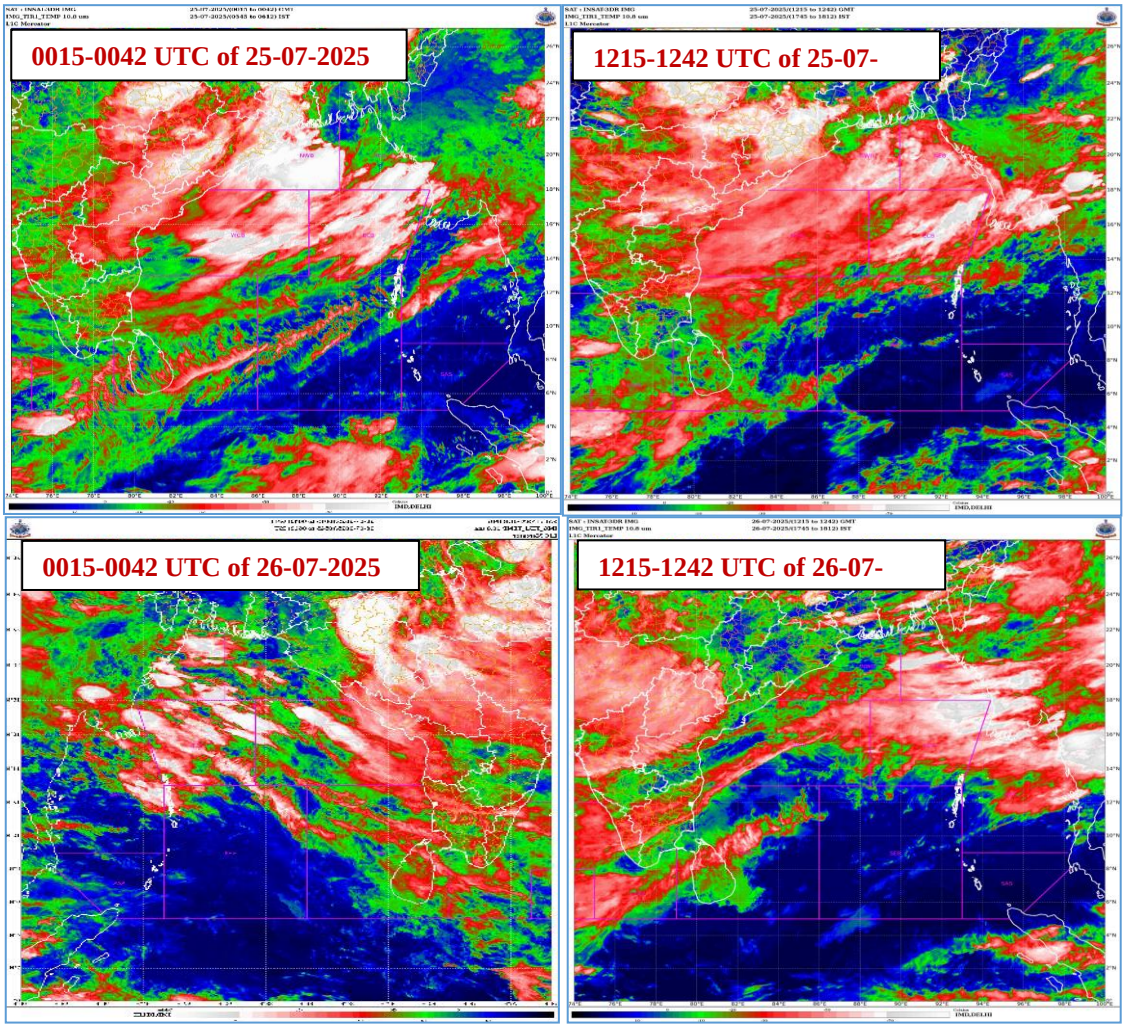


Figure. 2.7.3(c): INSAT-3D enhanced colored imageries during life cycle of Depression over Northwest Bay of Bengal during 25th July-27th July 2025

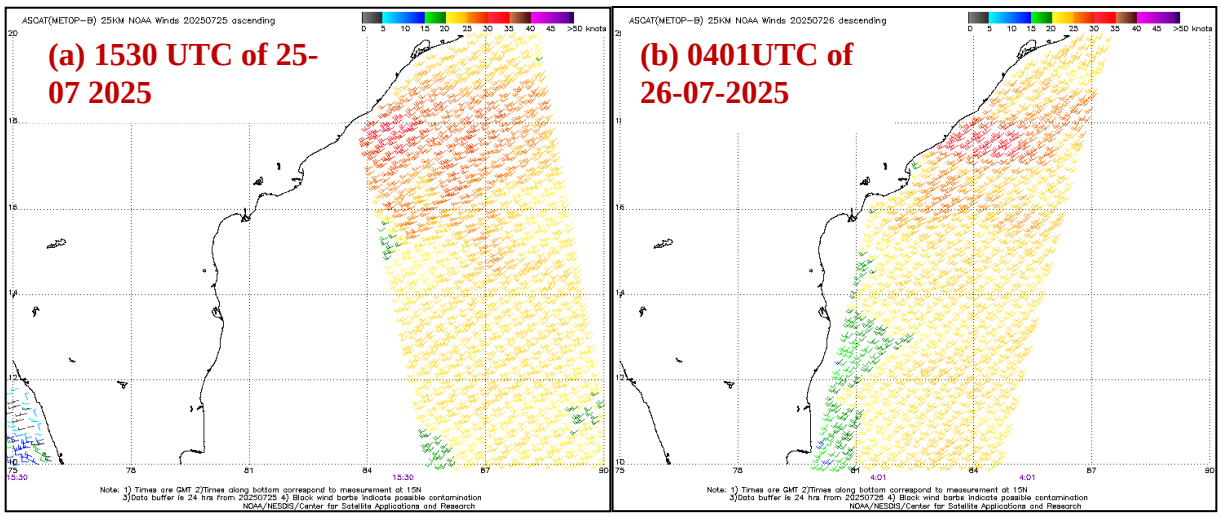


Fig. 2.7.4 (a), (b): ASCAT based Sea Surface winds of the depression over Northwest Bay of Bengal around (a) 1550 UTC of 25th July 2025 (b) 0401 UTC of 26th July 2025.

ASCAT winds showed stronger winds over northwest BoB and along and off Odisha coast to the south of the depression center in Fig. 2.7.4 (a) at 1520 UTC of 25th July with the peak winds around 25-30kts. (b) at 0401 UTC of 26th July with the peak intensity of 25-30kts.

2.7.5.2 Dynamical Features

IMD GFS (T1534) daily analyses of mean sea level pressure (MSLP) and winds at 10m, 850hPa, 500hPa and 200hPa from 25th July to 26th July are presented in **Fig. 2.7.5(a) to (b)** respectively.

The IMD GFS analysis fields at 0000 UTC of 25th July (Fig. 2.7.5(a)) indicated a depression over Northwest Bay of Bengal and adjoining areas of coastal West Bengal and Bangladesh coasts and associated upper air cyclonic circulation extended vertically upto 500hPa tilting southwards with height at 0000 UTC of 25th July. Thus, GFS reasonably captured the initial conditions on 25th July.

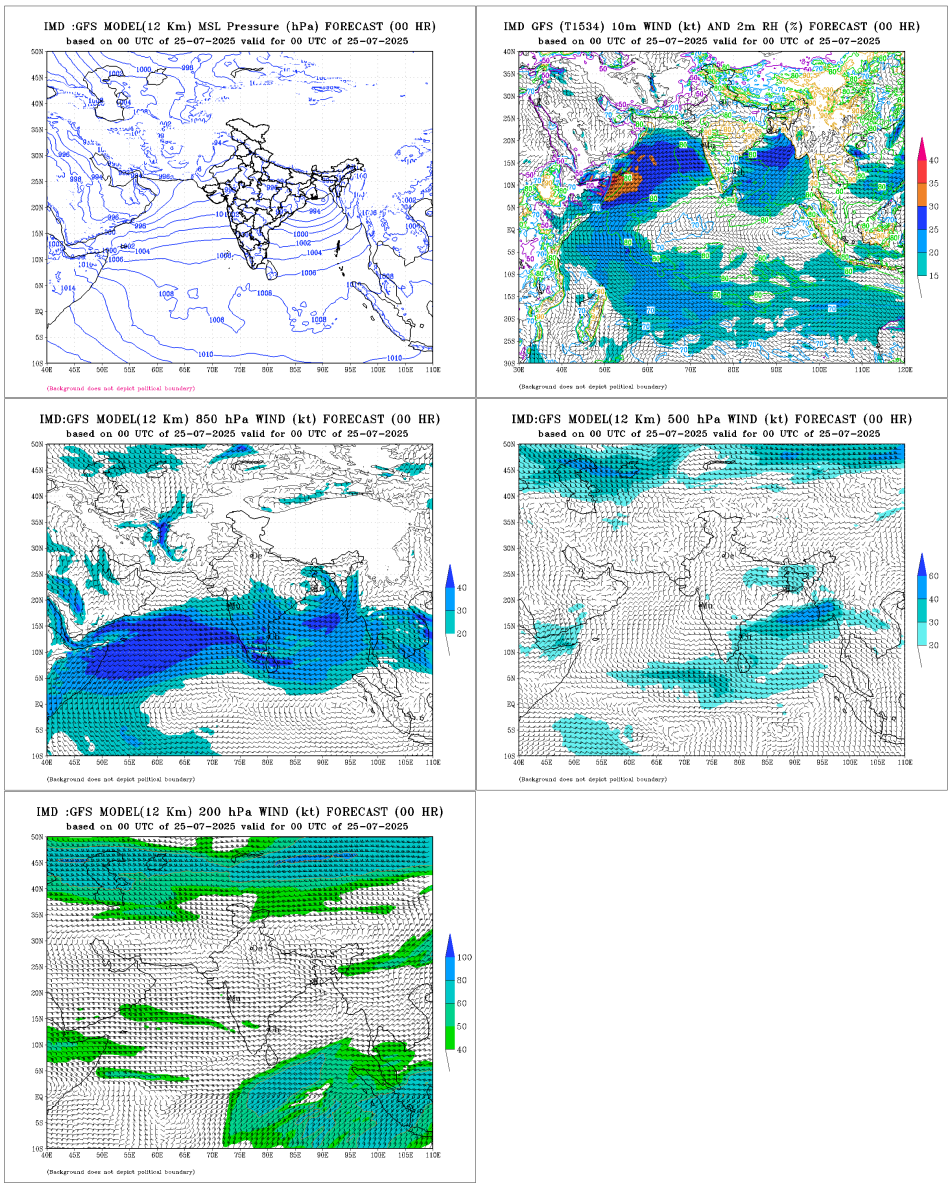


Fig. 2.7.5(a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 25th July 2025.

The MSLP and upper air wind analysis at 0000 UTC of 26th July indicated that depression maintained its intensity over Jharkhand and adjoining areas. The 10m wind indicates maximum winds speed of 20-25 kts along and off Odisha & north Andhra Pradesh coast adjoining westcentral BoB. The associated upper air cyclonic circulation extended vertically upto 500 hpa tilting southwards with height.

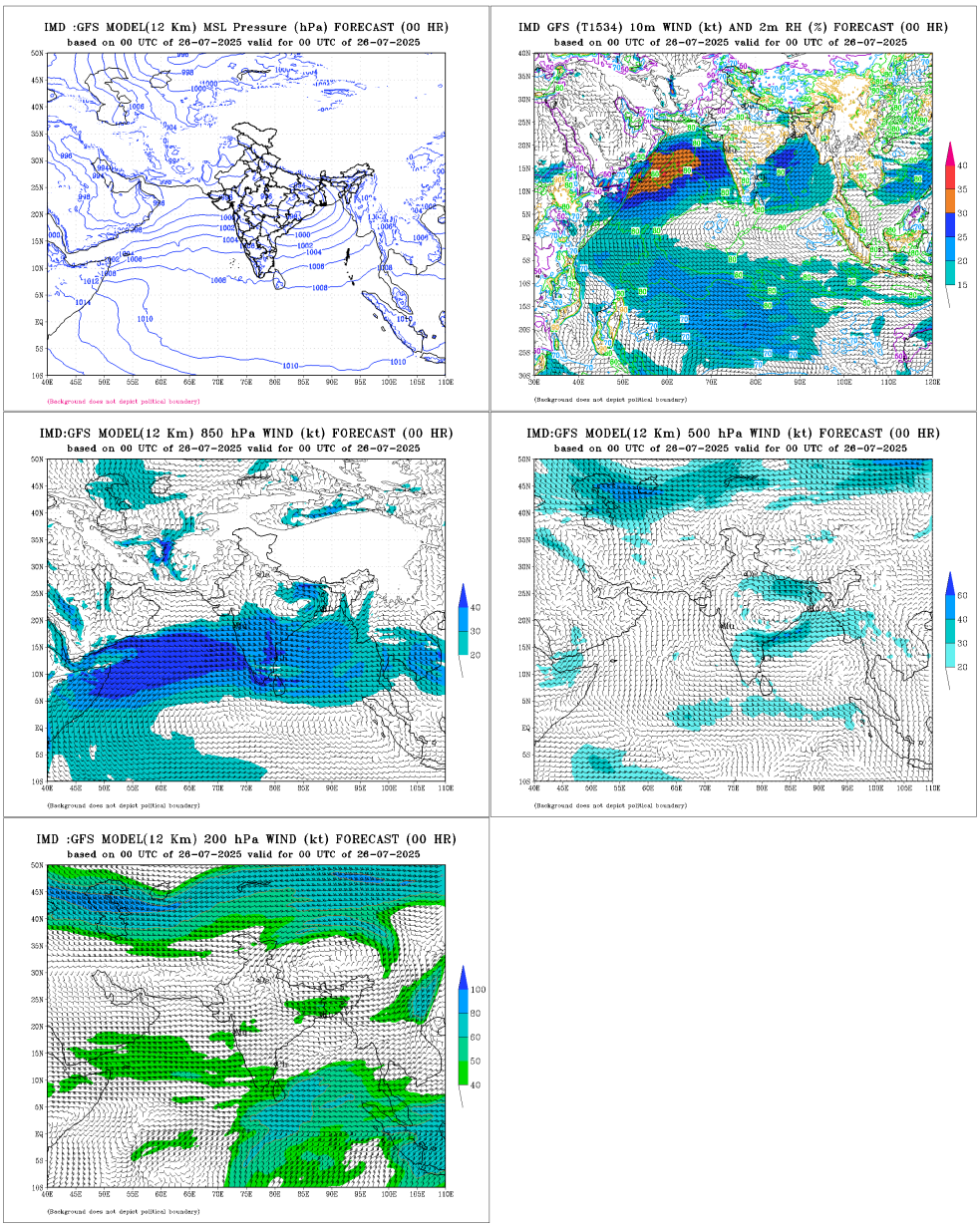


Fig. 2.7.5 (b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 26th July 2025

2.7.6 Realized Weather

2.7.6.1 Rainfall

Rainfall associated with the depression based on IMD-NCMRWF satellite gauge merged data is presented in Fig. 2.7.6. It was seen that heavy to very heavy rainfall bands were noticed in the spatial distribution of rainfall which was mainly around the system center during 25th July to 26th July. The rainfall intensity was highest in the rainband close to center.

There was also outer rainband far from the system center showed areas of heavy rainfall both days. The rainfall distribution pattern on 25th July indicated a zone of heavy to very heavy rainfall over land (West Bengal, north coastal & Interior Odisha) due to movement of system over land. The rainfall distribution associated with outer band ceased to exist after depression entered and travelled inland. However, light to moderate rainfall at most places with isolated heavy rainfall occurred over West Bengal, Jharkhand, Chhattisgarh, Sub-Himalayan West Bengal, Mizoram & Tripura, Meghalaya, Vidarbha, West Rajasthan, West Uttar Pradesh.

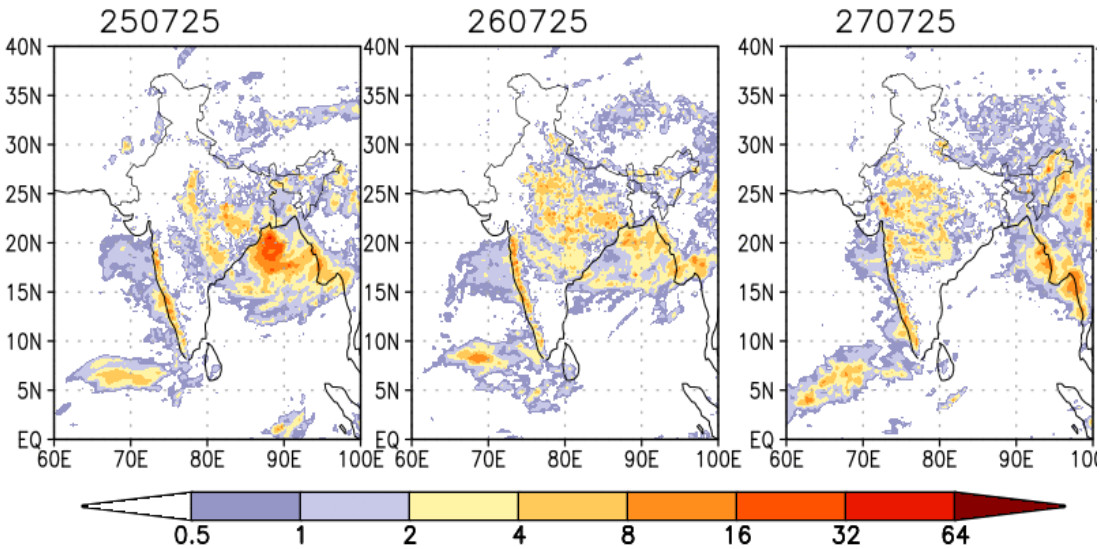


Fig. 2.7.6: NCMRWF-IMD satellite gauge merged data plots of realized 24-hours accumulated rainfall (cm/day) from 25th July to 27th July 2025.

Realized 24-hour heavy rainfall (≥ 7 cm) ending at 0300 UTC/0830 IST of dated: -

<u>26.07.2025 / 0830</u>

Madhya Maharashtra: Mahabaleshwar 26; Lonavala Agri 18; Radhanagari 15; Ozharkheda 14; Harsul 11; Shahuwadi, Igatpuri 10 Each; Chandgad, Trimbakeshwar 8 Each; Girna Dam 7.

Chhattisgarh: Kusmi 20; Samari 14; Labhandih, Raipur, Dongargarh, Pratappur 13 Each; Balrampur, Raipur City 12 Each; Mukdega, Odagi 11 Each; Mana–Raipur AP, Doura Kochali 10 Each; Ahiwara, Pithora, Tongpal, Chando, Pondi Bachra, Bade Bacheli, Kunkuri, Baloda Bazar 9 Each; Mandir Hasoud, Bhilai, Arang, Belargaon 8 Each; Shankargarh, Ramanujnagar, Bilha, Marwahi, Bhaiyathan, Mahasamund, Charama, Raigarh, Ratanpur, Rajnandgaon 7 Each.

Jharkhand: Ghatsila, Manjhari 19 Each; Kuru, Majhgaon, Tantnagar, Hatgamharia 12 Each; Mandar 11; Chaibasa, Chandil, Arki, Goilkera, Musabani, Saryu, Sisai 10 Each; Latehar Balumat AWS, Gudri, Sonua, Kumardungi, Garu 9 Each; Jamshedpur, Diyakel Khunti AWS 8 Each; Latehar, Kolebira, Jamshedpur AP, Kharsema, Simdega, Gumla, Anandpur, Dhalbhumgarh, Gurabandha, Bharno 7 Each.**Odisha:** Muruda 18; Bahalda 17; Baripada, Jamda 16 Each; Suliapada 14; Kusumi 13; Tensa, Gudvela 13 Each; Tiring, Raruana, Kaptipada 12 Each; Sukruli 11; Rasagovindapur, Jharbandh, Rairangpur, Samakhunta, Champua 10 Each; Saintala, Karanjia, Joda, Bijatala, Balimundali, Betanati 9 Each; Paikmal 8; Swampatna, Balisankara, Jhumpura, Nawana, Chandua–Kuliana, Kantamal, Laikera, Sharpada 7 Each.

East Madhya Pradesh: Bajag 18; Gadarwara, Mawai 14 Each; Sidhi–Gopadbanas 13; Singrauli AWS 12; Kotma, Baldevgarh, Lanji, Pushprajgarh 11 Each; Lalburra, Rithi, Jaitpur 9 Each; Mehadwani, Venkatnagar, Khargapur, Harrai 8 Each; Orchha, Mohgaon, Sarai 7 Each.

Gujarat Region: Kaprada 17; Silvassa 15; Vapi 13; Madhbun 11; Khanvel 9; Nanipalson 8; Daman AWS 8.

East Rajasthan: Dausa 16; Bayana 10; Choth Ka Barwara SR, Sarmathura SR 8 Each; Anta SR, Udaipurwati, Bassi 7 Each.

West Madhya Pradesh: Udaipura 16; Biaora, Badi 14 Each; Pipariya 11; Sohagpur 10; Satwas, Pachmarhi, Kumbhraj, Mehgaon, Bareli, Goharganj 9 Each; Bairad, Gwalior, Sultanpur, Chachoda 8 Each; Narwar, Budhni 7 Each.

Vidarbha: Armori, Gadchiroli, Desaiganj 9 Each; Salekasa, Gondia AP, Dhanora, Gondia 8 Each; Amgaon, Kurkheda, Nagbhir, Saoli, Chikhalda 7 Each**.**

Gangetic West Bengal: Midnapore, Mohanpur, Midnapore (CWC) 9 Each; Amta, Dum Dum, Canning, Uluberia 7 Each**.**

27th July 2025/0830

Tamil Nadu, Puducherry & Karaikal: Avalanche 26; Upper Bhavani 18; Chinnakalar 17; Naduvattam 16; Cincona 8; Valparai PTO, Upasi Tea Research AWS, Sholayar, Glenmorgan 7 Each;

Gujarat Region: Vadgam 23; Dharoi Colony 18; Kathalal, Siddhpur 17 Each; Modasa 16; Kaprada, Talod 13 Each; Dharampur, Mahemdavad, Dahegam 12 Each; Satlasana, Lunawada, Palanpur, Mahesana 10 Each;

East Madhya Pradesh: Pushprajgarh 22; Dindori-aws 10; Waraseoni 9; Balaghat-aws, Niwari, Matiyari 8 Each; Nainpur, Nagode, Bajag, Palera, Prithvipur, Sohawal, Gaurihar 7 Each;

Madhya Maharashtra: Mahabaleshwar 20; Lonavala ARG 15; Radhanagari, Gaganbawada 13 Each; Igatpuri 11; Peth 9; Chandgad, Harsul - Fmo 8 Each;

West Madhya Pradesh: Sailana 17; Jhabua-aws, Agar 13 Each; Shivpuri 12; Ratlam-aws, Tarana, Kumbhraj 11 Each; Datia-aws, Dhar-aws 10 Each; Badnawar, Sardarpur, Petlawad, Bhimpur, Badarwas 9 Each; Atner, Makdone 8 Each;

East Rajasthan: Khushalgarh 14; Sajjangarh SR 11; Sarmathura SR 10; Chothkabarwara SR, Nasirabad 9 Each; Shergarh SR, Bhungra SR, Sallopat SR, Bari, Jagpura SR, Reodar SR 8 Each; Sapau SR, Srinagar SR, Sapotra, Nithuwa SR, Kekri SR, Arnod SR, Kishanganj 7 Each;

Chhattisgarh: Bhanupratappur 10; Bade Bacheli 9; Aundhi 7;

West Uttar Pradesh: Mahroni 8;

Vidarbha: Kurkheda, Gondia, Armori 8 Each; Dhanora, Korchi 7 Each;

West Rajasthan: Raipur SR, Jaitran 7 Each.

2.7.6.2 Reported Wind dated: -

25.07.2025

ASCAT winds showed stronger wind influence along and off Odisha coast adjoining northwest BoB in the south of the depression center as shown in Fig. 2.7.4(a) at 1520 UTC of 25th July with the peak winds around 45-55 kmph.

26.07.2025

Squally wind with speed reaching 30-40 gusting to 50 kmph ere reported over Jharkhand, North Chhattisgarh and East Madhya Pradesh on 26th July, as the system moved across these states.

2.8 Depression over Northwest Bay of Bengal & adjoining westcentral Bay of Bengal and north Andhra Pradesh-south Odisha coasts (18th-19th August 2025)

2.8.1. Introduction

- Under the influence of an upper air cyclonic circulation over westcentral and adjoining northwest Bay of Bengal (BoB) off north Andhra Pradesh and south Odisha coasts, a low-pressure area (LPA) formed over the same region in the forenoon (0830 hrs IST/0300 UTC) of 17th August, 2025.
- It moved in west-northwestwards direction and intensified into a well marked low pressure area (WML) over westcentral & adjoining northwest BoB and adjoining north Andhra Pradesh-south Odisha coasts in the morning (0530 hrs IST/0000 UTC) of 18th August.
- It continued to move in the same direction and concentrated into a Depression over northwest and adjoining westcentral BoB & north Andhra Pradesh - south Odisha coasts in the same evening (1730 hrs IST/1200 UTC) of 18th August.
- It then moved north-northwestwards and crossed South Odisha coast close to Gopalpur during 2330 hrs IST (1800 UTC) of 18th & 0230 hrs IST of 19th August (2100 UTC of 18th August) as a depression.
- Thereafter, it moved west-northwestwards across south interior Odisha and weakened into a WML over central parts of Chhattisgarh & neighbourhood in the evening (1730 hrs IST/1200 UTC) of 19th August.
- The observed track of the system is presented in Fig. 2.8.1. The best track parameters of the system are presented in Table 2.8.1.

Table 2.8.1: Best track positions and other parameters of the Depression over Northwest Bay of Bengal during 18th August-19th August 2025.

Date	Time (UTC)	Lat.	Long.	C.I. No.	ECP	ΔP	MSW (kt)	Category
18.08.2025	1200	18.9	85.0	1.5	994	3	20	D
	1800	19	84.9	1.5	996	3	20	D
		Crossed south Odisha coast near 19.3°N & 84.8°E close to Gopalpur during 2330 hrs IST of 18th - 0230 hrs IST of 19th August						
19.08.2025	0000	19.3	84.8	-	996	3	20	D
	0300	19.8	84.0	-	996	3	20	D
	0600	20.0	83.3	-	996	3	20	D
	1200	Weakened into a well-marked low-pressure area over central parts of Chhattisgarh & neighbourhood						

KT: Knots (nautical mile per hour), 1 KT=1.85 kmph, D: Depression.

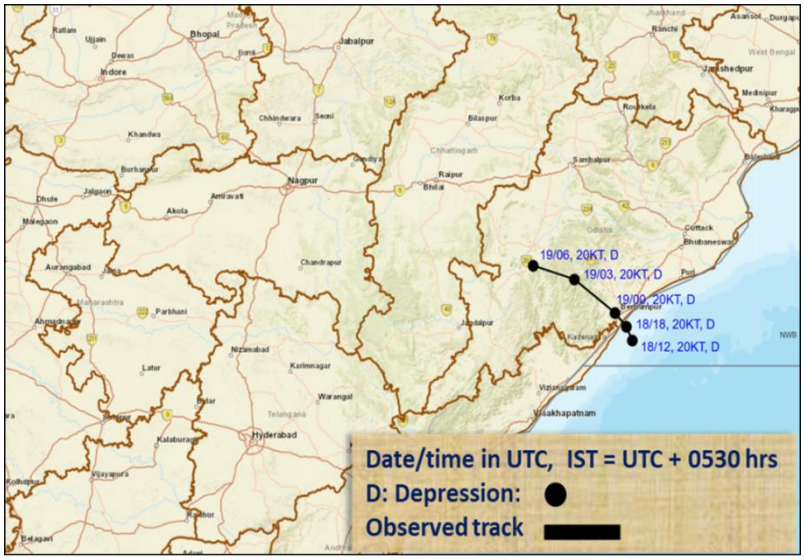


Fig. 2.8.1: Observed track of Depression over Northwest Bay of Bengal during 18th–19th August 2025

2.8.2 Salient features of the system

- The system had a very brief life period (24 hours) which is below normal against normal life period of 55 hours for depressions over BoB during monsoon season based on the data during the period 1990-2013.
- Climatologically, about 1 depression develops over the BoB during the month of August with formation of about 58 depressions in last 60 years during 1965-2024 over BoB Fig. 2.8.2 (a). Out of these, 34 crossed Odisha coasts (58%) during the month of August Fig. 2.8.2 (b).

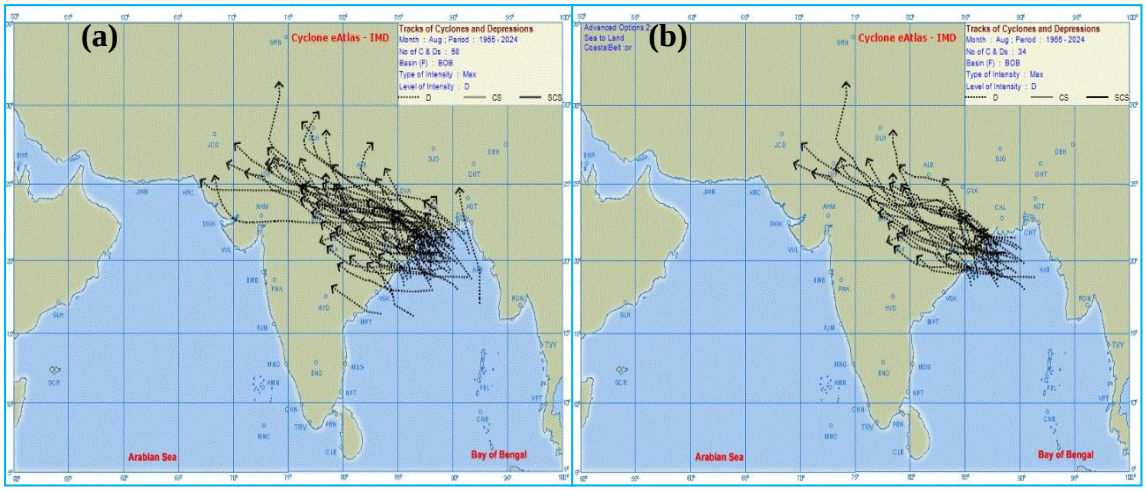


Fig. 2.8.2: (a) Tracks of depressions over BoB and (b) tracks of depressions crossing Odisha coast in the month of August during 1965-2024.

2.8.3 Genesis, intensification and movement

Under the influence of an upper air cyclonic circulation over westcentral and adjoining northwest BoB off north Andhra Pradesh and south Odisha coasts, an LPA formed over the same region in the forenoon (0830 hrs IST/0300 UTC) of 17th August, 2025. On 17th August, the Madden Julian Oscillation (MJO) index was in phase 4 with amplitude more than 1 and it was likely to move to phase 4 during next 24 hours. The MJO phase and amplitude favoured increase in convective clouds over the BoB region. The NCICS based forecasts for zonal winds indicated strong easterly winds (~ 7 to 9 mps) over north BoB and strong westerly winds (~ 7 to 9 mps) over the central & south BoB along with Equatorial Rossby Wave (ERW) also over the BoB. The low-level relative vorticity was about 70- 80 X 10^{-6} s^{-1} over westcentral BoB with vertical extension upto 500 hPa level. The low-level convergence was around 10 X 10^{-6} s^{-1} to the southwest of the system. The upper-level divergence was around 30 X 10^{-6} s^{-1} to the southwest of the system. Mid-level vertical wind shear (VWS) of horizontal wind was moderate to high 15-25 knots over system area. Thus, a favourable environment except VWS prevailed over the region and under these conditions, an LPA developed over westcentral and adjoining northwest BoB off north Andhra Pradesh and south Odisha coasts on 17th August.

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. 2.8.2. (a) to (c)**. During the entire life cycle, the clouds were organized in shear pattern.

At 0300 UTC of 17th August, based on INSAT-3D imagery, scattered to broken low and medium clouds with embedded intense to very intense convection lay over central & south Bay of Bengal and Andaman Sea. Scattered low and medium clouds with embedded moderate to intense convection lay over north Bay of Bengal.

Similar favourable features continued and while moving west-northwestwards, LPA further consolidated and lay as a WML over westcentral & adjoining northwest BoB in the morning of 18th August.

At 0300 UTC of 18th August, the associated maximum sustained wind speed is 10-15 kts gusting to 25 kt. The estimated central pressure is 998 hPa. Sea condition is moderate to rough over westcentral & adjoining northwest & southwest BoB. Gopalpur (43049) reported lowest mean sea level pressure (MSLP) of 995.8 hPa, pressure change in past 24 hours (P24) as -0.4 hPa, departure from normal (Dep) as -4.0 hPa and maximum sustained wind speed (MSW) of 90^0 / 08 kt. Kalingapatnam (43105) reported MSLP of 996.3 hPa, P24 as -0.4 hPa, Dep as -4.2 hPa and MSW of 250 ^{0} / 03 kt. Visakhapatnam (43150) reported reported MSLP of 997.4 hPa, P24 as -0.7 hPa, Dep as -4.2 hPa and MSW of 230 0 / 04 kt. Puri (43049) reported MSLP of 997.2 hPa, P24 as +0.5 hPa, Dep as -3.1 hPa and MSW of 90 ^{0} /18 kt. A ship near 19.0N/86.0E reported MSLP of 995 hPa and MSW of 120^0 /18 kt.

At 1200 UTC of 18th August, the MJO index was in phase 4 with amplitude more than 1 that favoured increase in convective clouds. As per guidance from NCICS CFS model, there was a prevalence of westerly wind anomaly (7-9 mps) over south Bay of Bengal (BoB), easterly wind anomaly (7-9 mps) over north BoB alongwith Equatorial Rossby wave (ERW) over central BoB on 18th August. The environmental conditions as per guidance from CIMSS, the low level vorticity was about 90- 100 X 10^{-6} s^{-1} over westcentral BoB and was extended upto 500 hPa

level. The low level convergence was around 20 X 10^{-6} s^{-1} to the northwest of system centre. The upper level divergence was around 30 X 10^{-6} s^{-1} to the southwest of system centre. Mid-level VWS of horizontal wind was moderate to high15-25 kt over system area.

Under these favourable features the well marked low pressure area over westcentral & adjoining northwest BoB concentrated into a depression over northwest & adjoining westcentral BoB at 1200 UTC 18th August and lay centered near latitude 18.9^{o}N and longitude 85.0^{o}E with MSW of 20 kt.

The depression gradually moved north-northwestwards and crossed south Odisha & adjoining north Andhra Pradesh coasts close to Gopalpurduring 2330 IST of 18th and 0230 ITS of 19th August. It then moved northwestwards and lay centered at 0830 IST/ 0300 UTC of 19th August over south interior Odisha near latitude 19.8^{o}N & longitude 84°E.

At 0300 UTC of 19th August, associated maximum sustained wind speed was 20 kt gusting to 30 kt and the estimated central pressure was 996 hPa. Sea condition was rough over westcentral & adjoining northwest & southwest BoB. Angul (42969) reported lowest mean sea level pressure (MSLP) of 997.4 hPa, pressure change in past 24 hours (P24) as -3.6 hPa, and maximum sustained wind speed (MSW) of 50^0 / 02 kt. Puri (43053) reported MSLP of 999.8 hPa and MSW of 180°/04 kt. Bhawanipatna (43042) reported MSLP of 999.1 hPa, P24 as -1.9 hPa.

As per guidance from satellite, the low level vorticity was about 60-70 X 10^{-6} s^{-1} over westcentral BoB and another zone of positive vorticity about 60-70 X 10^{-6} s^{-1} was seen over Chhattisgarh (to the west of system centre). The positive vorticity zones extended upto 500 hPa level. The low level convergence was around 15 X 10^{-6} s^{-1} to the southwest of system centre. The upper level divergence was around 20 X 10^{-6} s^{-1} to the southwest of system centre and another zone to the southeast of system centre. Mid-level VWS of horizontal wind was moderate to high (15-25 kt) over system area and along the forecast path.

At 0300 UTC of 19th August, INSAT 3DS indicated vortex over south coastal Odisha and neighbourhood with poorly defined centre. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over south Gangetic West Bengal, south Chhattisgarh, south coastal Odisha, Vidarbha, Telangana, nortwest & westcentral Bay of Bengal. Minimum cloud top temperature (CTT) is minus 70 to 90 ^{0}C. Moderate to intense convection lay over Odisha and north coastal Andhra Pradesh (Minimum CTT is minus 50 to 70 ^{0}C).

At 1200 UTC of 19th August, associated maximum sustained wind speed was 20 kt gusting to 30 kt and the estimated central pressure is 996 hPa at 1200 UTC of 19th August. Rajnandangaon (42948) reported lowest mean sea level pressure (MSLP) of 996.0 hPa, pressure change in past 24 hours (P24) as -4.3 hPa, Pressure Departure of -5.2 hPa and maximum sustained wind speed (MSW) of 270^0/02 kt.

The MJO index was in phase 4 with amplitude more than 1 favouring increase in convective clouds over Bay of Bengal. As per guidance from CIMSS, the low level vorticity decreased in past 6 hours and was about 50-60 X 10^{-6} s^{-1} over Chhattisgarh and extended towards northwest & westcentral Bay of Bengal. The positive vorticity zone was extended upto 200 hPa level. The low level convergence was around 15-20 X 10^{-6} s^{-1} to the southwest of system centre. The upper level divergence was around 30 X 10^{-6} s^{-1} to the southwest of system centre. Mid-level (VWS of horizontal wind was high > 25 kt over system area and along the forecast

path. Due to the land interaction after the landfall and moisture cutoff along with increase in wind shear, the depression over Odisha weakened into a well marked low pressure area over central parts of Chhattisgarh & neighbourhood at 1200 UTC of 19th August.

At 1200 UTC of 19th August, based on INSAT-3D imagery, associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over Odisha, Chhattisgarh, Jharkhand & adjoining south Bihar, Madhya Pradesh, Vidarbha, Telangana, northwest & westcentral Bay of Bengal. Minimum cloud top temperature (CTT) was minus 70 to 90 ^{0}C. Moderate to intense convection lay over north coastal Andhra Pradesh (Minimum CTT is minus 50 to 70 ^{0}C).

2.8.4 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 August. The system was monitored with the help of available 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.

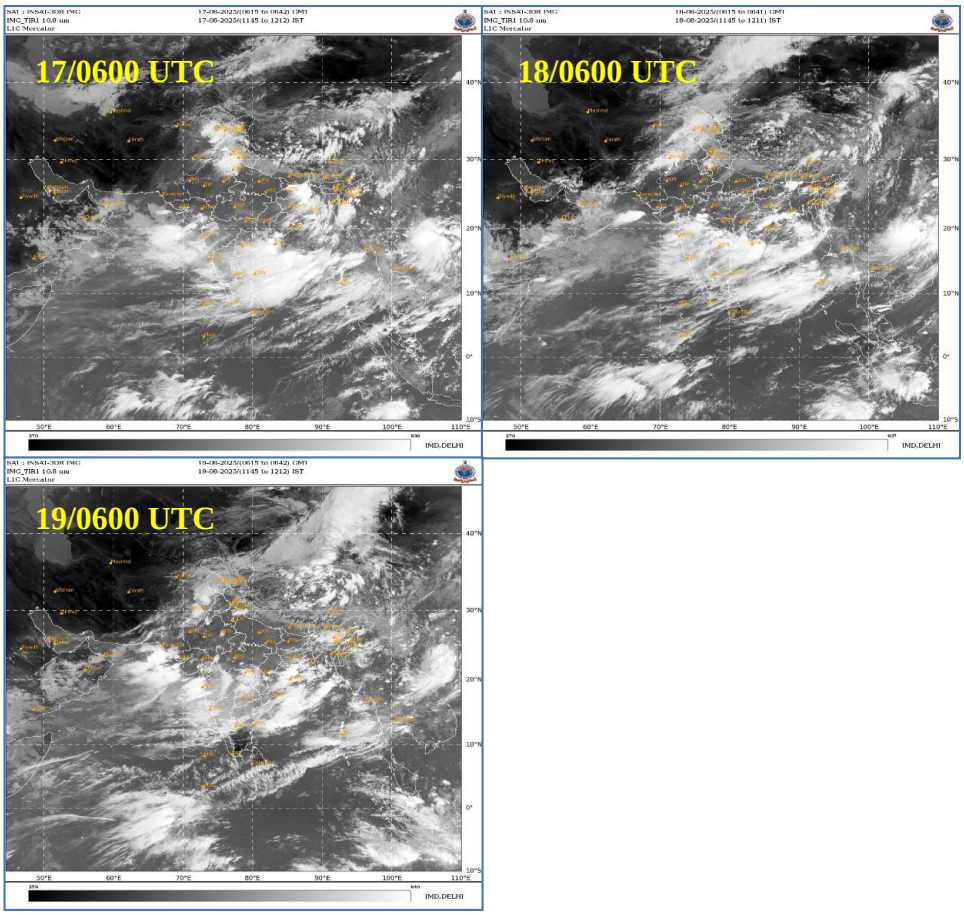


Fig. 2.8.2(a): INSAT-3D Visible imageries during life cycle of Depression over northwest & adjoining westcentral Bay of Bengal during 17th August - 19th August 2025.

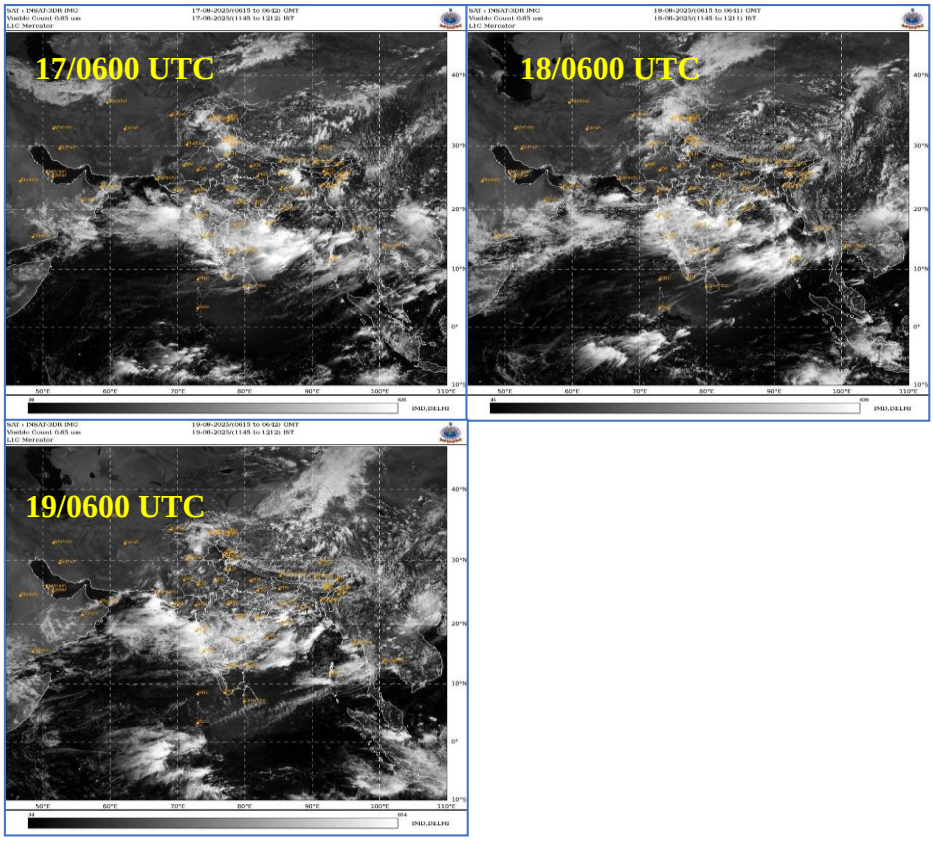


Fig. 2.8.2(b): INSAT-3D IR imageries during life cycle of Depression over northwest & adjoining westcentral Bay of Bengal during 17th August - 19th August 2025.

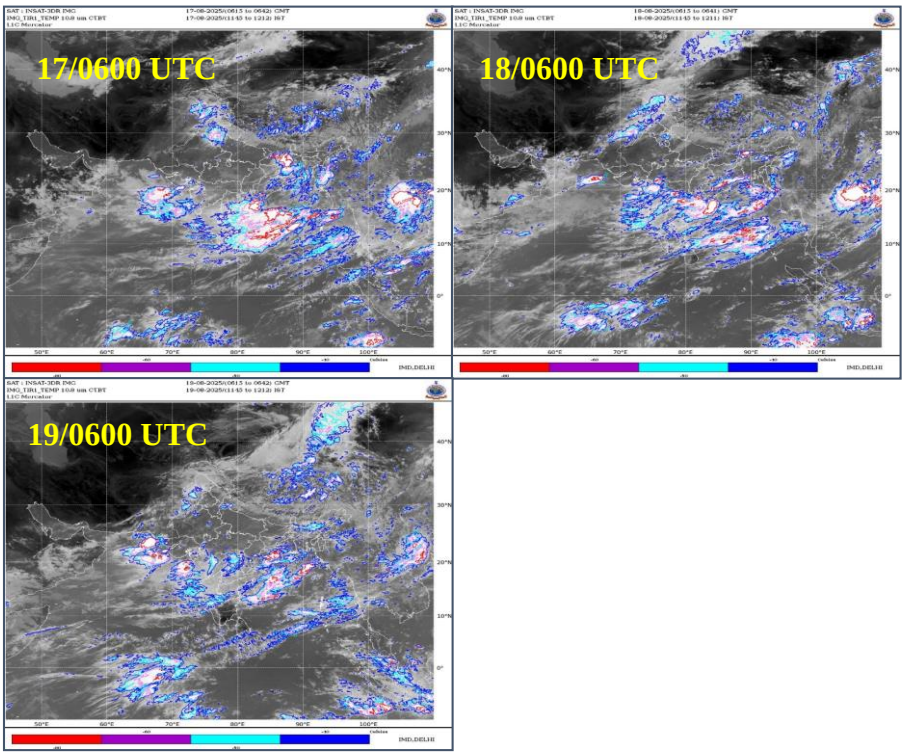


Fig.2.8.2(c): INSAT-3D CTBT imageries during life cycle of Depression over northwest & adjoining westcentral Bay of Bengal during 17th August - 19th August 2025.

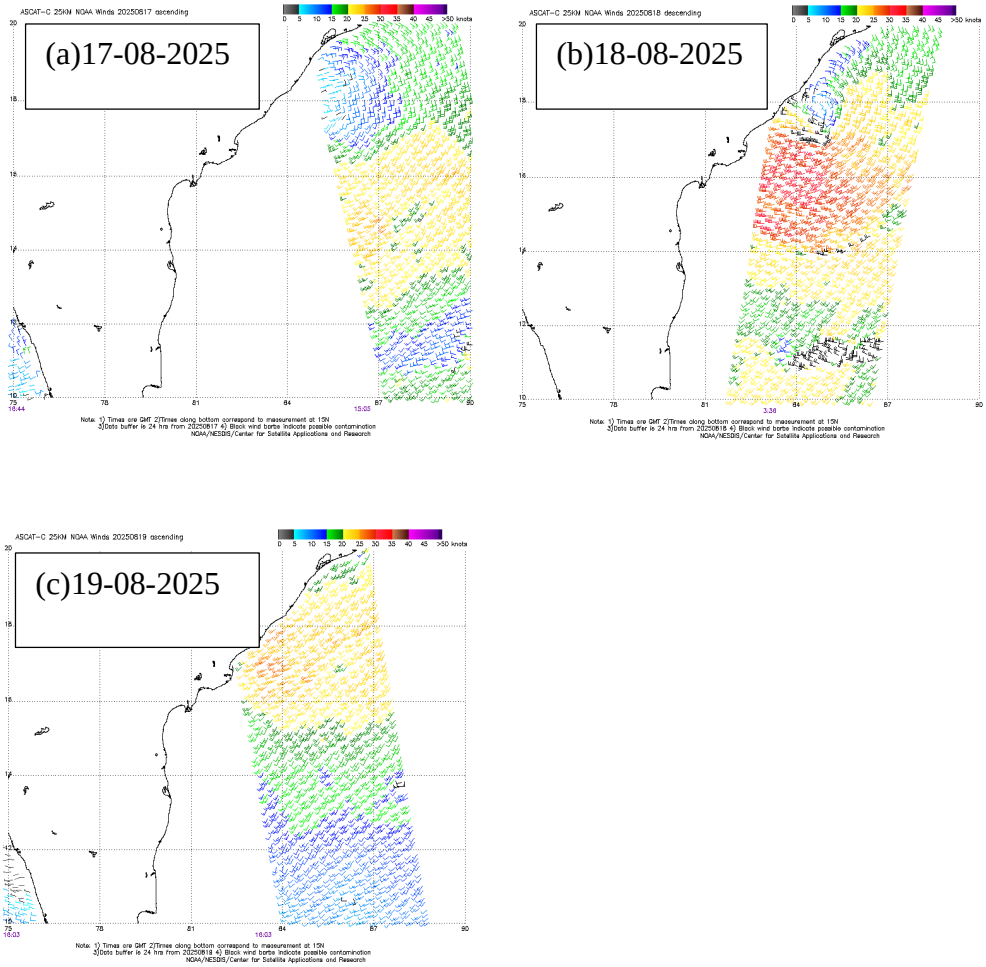


Fig. 2.8.3: ASCAT based sea surface winds at (a) 15 UTC of 17th, (b) 0300 UTC of 18th and (c) 1600 UTC of 19th August 2025.

ASCAT winds showed a low-pressure area over the westcentral and adjoining northwest BoB, with a peak wind speed of around 20 kt on 17th August. On 18th August, ASCAT winds clearly indicated a depression over the northwest and adjoining west-central Bay of Bengal, centered near 18.4°N/84.8°E. The ASCAT winds on 19th August clearly showed the system over land, with strong winds observed along the north Andhra Pradesh and south Odisha coasts.

2.8.5 Dynamical Features

IMD GFS (T1534) model daily analyses of mean sea level pressure (MSLP) and winds at 850, 500 and 200 hPa levels from 17th August - 19th August are presented in **Fig. 2.8.4 to Fig.2.8.6** respectively.

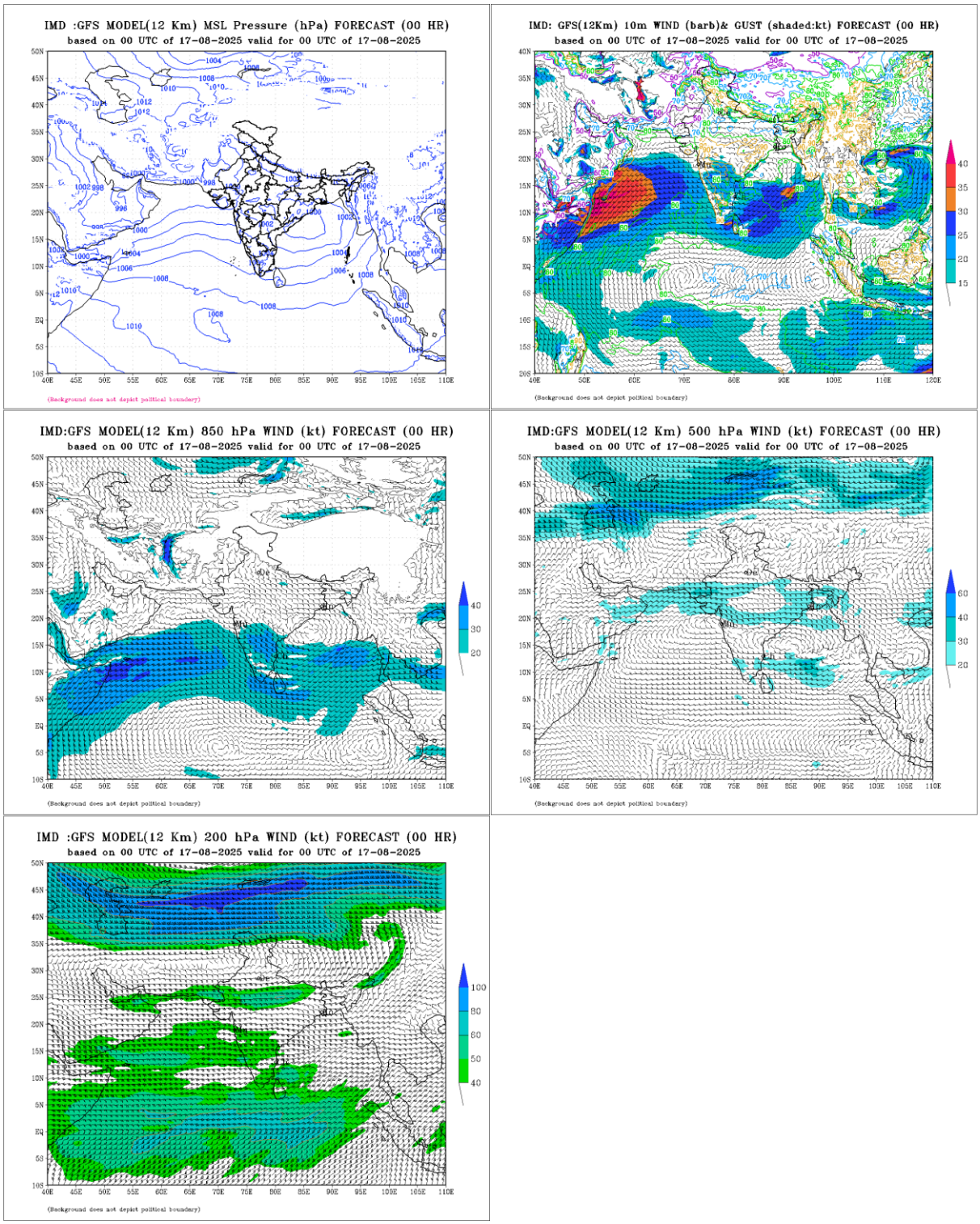


Fig. 2.8.4: IMD GFS (T1534) mean sea level pressure (MSLP), 850, 500 and 200 hPa levels based on 0000 UTC of 17th August 2025

The MSLP and upper air wind analysis field on 17th August indicated that a low pressure area over westcentral & adjoining northwest BoB and north Andhra Pradesh - south Odisha coasts near 18.1°N/82.5°E with associated cyclonic circulation extending upto 500 hPa level and tilting southwestwards with height.

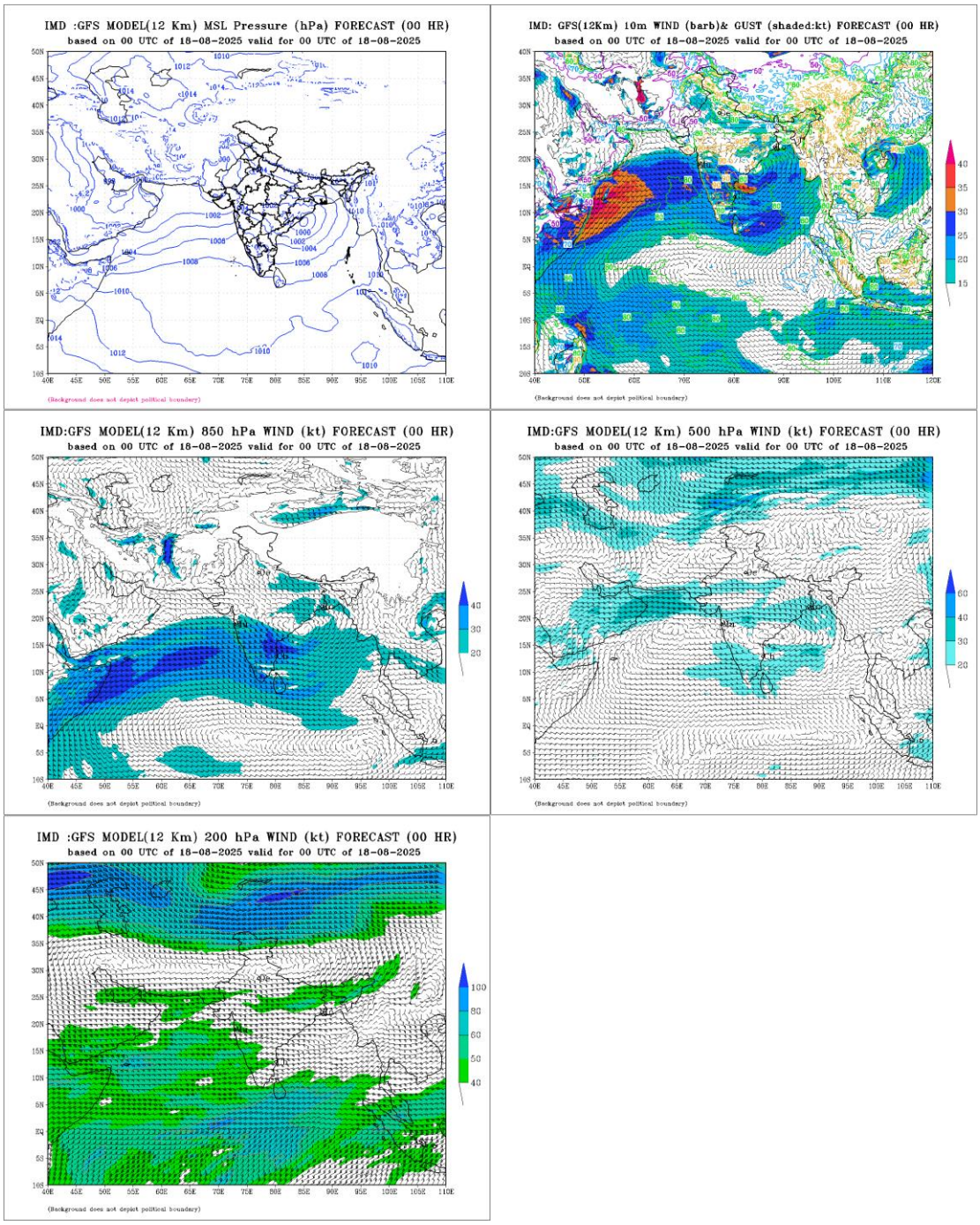


Fig. 2.8.5: IMD GFS (T1534) mean sea level pressure (MSLP), 850, 500 and 200 hPa levels based on 0000 UTC of 18th August 2025

The MSLP analysis field on 18th August indicated a depression near18°N/82.5°E. At that time, it was a well marked low pressure area. Actually, based on the best track the system intensified into a depression and was located at 18.9°N/85.0°E at 1200 UTC of 18th August. Thus, GFS over-estimated the intensity on 18th August. It also indicated that the system vertically extended up to 500 hPa level tilting southwestward with height

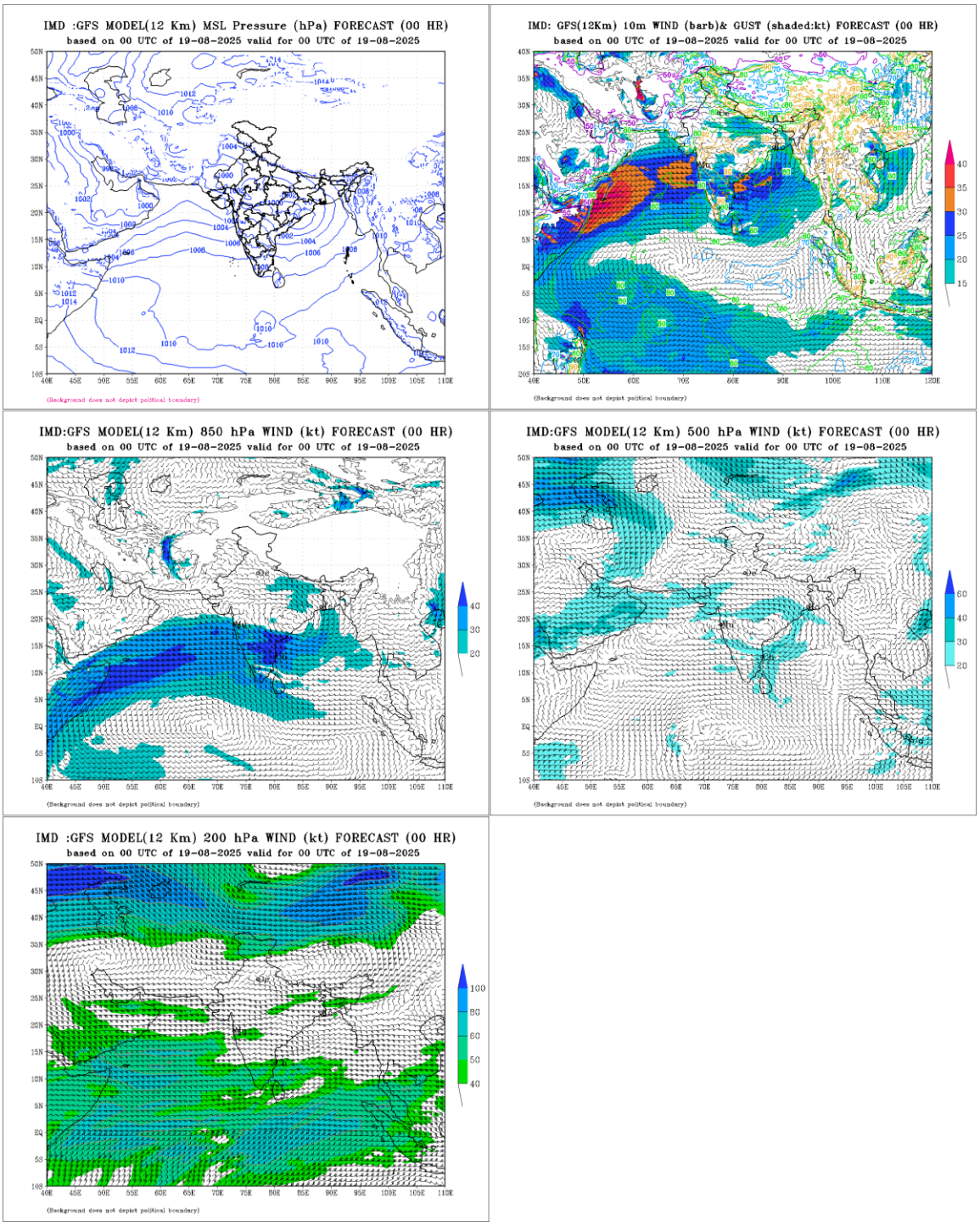


Fig. 2.8.6: IMD GFS (T1534) mean sea level pressure (MSLP), 850, 500 and 200 hPa levels based on 0000 UTC of 19th August 2025

The MSLP analysis field on 19th August indicated that the system crossed the south Odisha coast close to Gopalpur in the early morning and lay centered at 19.1°N/84.7°E. Actually, based on the best track the system was located at 19.3°N/84.8°E at 0000 UTC of 19th August. Thus, GFS model well captured the initial conditions on 19th August. It also indicated that the system vertically extended up to 500 hPa level tilting southwestward with height

2.8.6 Realized Weather

Rainfall associated with the depression based on IMD-NCMRWF satellite gauge merged data are depicted in Fig.2.8.7. It is seen that heavy to very heavy rainfall occurred at isolated places over coastal Andhra Pradesh and coastal Odisha on 18th August, heavy to very heavy rainfall at isolated places over Chhattisgarh and Telangana on 19th August.

Light to moderate rainfall at a few places with heavy to very heavy rainfall at isolated places occurred over Madhya Pradesh, Chhattisgarh and Odisha on 20th August.

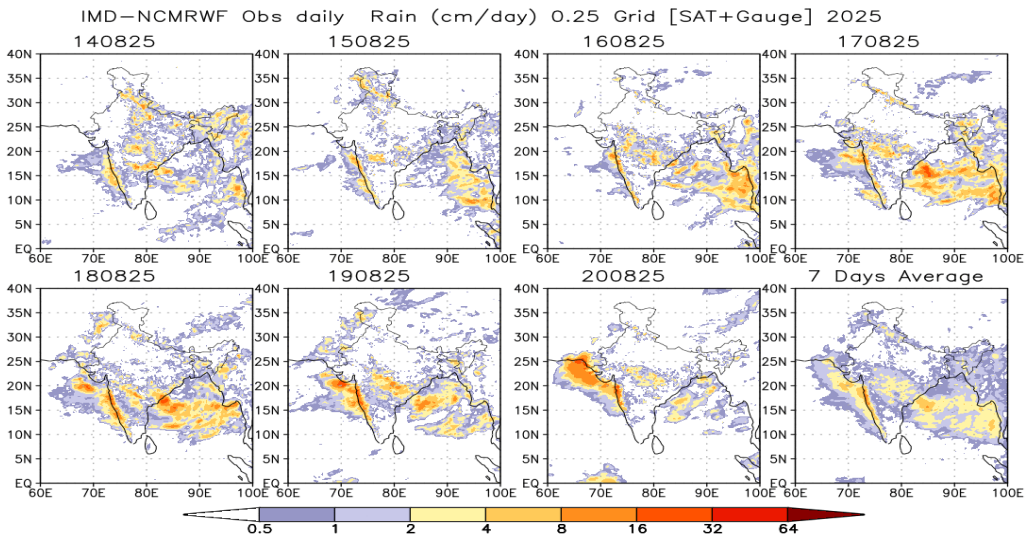


Fig. 2.8.7: NCMRWF-IMD satellite gauge merged data plots of realized 24 hours accumulated rainfall ending at – UTC during 14th to 20th August 2025.

24 hours accumulated rainfall (≥ 7 cm) ending at 0830 hrs IST of date is presented below:

18.08.2025 / 0830 hrs IST

ANDHRA PRADESH: Paderu (Alluri Sitharamaraju) 16, Chodavaram (Anakapalli) 14, Bheemunipatnam (Vishakhapatnam), Vepada (Vizianagaram) 13 each, Anakapalle (Anakapalli) 12, Narsipatnam (Anakapalli) 11, Visakhapatnam 11 each, Yelamanchili (Anakapalli), Visakhapatnam (Vishakhapatnam) 10 each, Mandasa (Srikakulam) 8, Srungavarapukota (Vizianagaram) 8, Mentada (Vizianagaram), Ranastalam (Srikakulam), Tuni (Kakinada), Bondapalle (Vizianagaram) 7 each,

ODISHA: Kotpad – 13

TELANGANA: Wal (Siddipet) 23, Alladurg (Medak) 22, Kowdipalle (Medak) , Pitlam (Kamareddy) 17 each, Venkatapuram (Mulugu) , Yellareddy (Kamareddy) , Tekmal (Medak) , Kotgiri (Nizamabad) 15 each, Atmakur M (Y. Bhuvanagiri) 14, Regode (Medak) , Narsapur (Medak) , Varni (Nizamabad) , Bodhan (Nizamabad) 13 each, Papannapet (Medak) 12, Birkoor (Kamareddy) 11, Gajwel (Siddipet) , Hathanoora (Sangareddy) , Dindigul (M. Malkajgiri) 1, Devaruppal (Jangaon) 10 each, Jogipet (Sangareddy) , Yadagirigutta (Y. Bhuvanagiri) , Banswada (Kamareddy) , Naga Reddipet (Kamareddy) , Shamirpet (M. Malkajgiri) , Medak (Medak) , Bhuvanagiri (Y. Bhuvanagiri) , Chegunta (Medak) 9 each, Yeda

Palle (Nizamabad) , Jagadevpur (Siddipet) , Yadagirigutta() (Y. Bhuvanagiri) , Wanaparthy (Wanaparthy) 8 each, Narayankhed (Sangareddy) , Jukkal (Kamareddy) , Narayanpet (Narayanpet) , Madnur (Kamareddy) , Peddamandadi (Wanaparthy) , Kothakota (Wanaparthy) , Medchal (M. Malkajgiri) , Damaragidda (Narayanpet) , Narmetta (Jangaon) 7 each.

MARATHAWADA: Ahmedpur (Latur) 12, Udgir - Imd Parttime (Latur) , Kinwat (Nanded) 11 each, Udgir (Latur) 10, Kandhar (Nanded) 9, Parli Vaijnath (Beed) 8, Manjlegaon (Beed) , Naigaon Khairgaon (Nanded) 8 each, Bhokar (Nanded) , Himayatnagar (Nanded) , Chakur (Latur) , Palam (Parbhani) , Degloor - Fmo (Nanded) 7 each.

MADHYA MAHARASHTRA: Gaganbawada (Kolhapur) 14, Radhanagari (Kolhapur) 13, Mahabaleshwar-((Satara) 12, Shahuwadi (Kolhapur) , Lonavala_ (Pune) 7 each.

KONKAN & GOA: Savarde- (Ratnagiri) 28, Mhasla (Raigad) 21, Dapoli_ (Ratnagiri), Wakwali_ (Ratnagiri) 19 each, Kankavli (Sindhudurg), Khed (Ratnagiri) 17 each, Sangameshwar Devrukh (Ratnagiri) 16, Harnai ((Ratnagiri) , Ratnagiri – (Ratnagiri) 15 each, Rajapur (Ratnagiri) , Mao (South Goa) , Lanja (Ratnagiri) 13 each, Roha (Raigad), Panvel_ (Raigad) 12 each, Mandangad (Ratnagiri), Tbia (Thane), Chiplun (Ratnagiri), Guhagarh (Ratnagiri), Vaibhavwadi (Sindhudurg), Poladpur (Raigad), Sawantwadi (Sindhudurg) 11 each, Mapusa (North Goa), Shriwardhan (Raigad) 10, Devgad (Sindhudurg), Santacruz - (Mumbai Suburban), Pernem (North Goa), Canacona (South Goa), Bhira - (Raigad) 10 each, Quepem (South Goa), Matheran (Raigad) 9, Mahad (Raigad), Rameshwar_ (Sindhudurg), Mangaon (Raigad), Mormugao - Pmo Imd (South Goa), Tala (Raigad) 9 each, Dabolim N.a.s.- Navy (South Goa), Kudal (Sindhudurg), Pen (Raigad), Murud (Raigad), Panjim - ((North Goa), Sudhagad Pali (Raigad) 8 each, Awalegaon - (Sindhudurg), Mulde_ (Sindhudurg), Thane (Thane), Vasai (Palghar) 7 each.

19.08.2025 / 0830 hrs IST

CHHATTISGARH: Narayanpur (Narayanpur) 14, Aundhi (Mohala Manpur Chowki) 10, Bastanar (Bastar) 8, Darbha (Bastar) 8, Bhairamgarh (Bijapur) 8, Nangur (Bastar), Katekalyan (Dantewada), Jagdalpur (Bastar) 7 each,

TELANGANA: Venkatapuram (Mulugu) 15, Wankdi (Kumaram Bheem) 12, Tadwai Mlg (Mulugu), Nawabpet (Vikarabad) 11 each, Adilabad (Adilabad) 9, Kerameri (Kumaram Bheem) 8, Bhiknur (Kamareddy) 8.

MADHYA MAHARASHTRA: Gaganbawada (Kolhapur) 26, Radhanagari (Kolhapur) 22, Mahabaleshwar (Satara) 17, Shahuwadi (Kolhapur) 16, Lonavala (Pune) 15, Kolhapur/karvir (Kolhapur) 7, Kagal (Kolhapur) 7

KONKAN & GOA: Matheran (Raigad) 25, Mhasla (Raigad) 25, Tala (Raigad) , Santacruz - Imd Obsy (Mumbai Suburban) 24 each, Savarde-arg (Ratnagiri) 24, Dapoli (Ratnagiri), Vaibhavwadi (Sindhudurg) 23 each, Roha (Raigad) , Vasai (Palghar) , Mangaon (Raigad) , Tbia (Thane) 22 each, Lanja (Ratnagiri), Shriwardhan (Raigad), Panvel (Raigad) 21 each, Pen (Raigad) 19, Rajapur (Ratnagiri) , Sudhagad Pali (Raigad) 18 each, Karjat (Raigad) , Mandangad (Ratnagiri) , Thane (Thane) 17 each, Wada (Palghar), Poladpur (Raigad) 16, Mahad (Raigad) 16 each, Khed (Ratnagiri), Chiplun (Ratnagiri), Bhiwandi (Thane) 15 each, Ratnagiri - (Ratnagiri), Sanguem (South Goa), Uran (Raigad) 14 each, Ambernath (Thane), Sangameshwar Devrukh (Ratnagiri), Khalapur (Raigad), Devgad (Sindhudurg), Wakwali (Ratnagiri) 13 each, Guhagarh (Ratnagiri), Harnai Imd Obsy (Ratnagiri), Kankavli (Sindhudurg), Palghar (Palghar), Ulhasnagar (Thane), Quepem (South Goa), Rameshwar (Sindhudurg) 12 each, Murbad (Thane), Colaba (Mumbai City), Vikramgad (Palghar),

Canacona (South Goa) 11 each, Mulde (Sindhudurg), Alibag - (Raigad), Kudal (Sindhudurg) 10 each, Murud (Raigad), Sawantwadi (Sindhudurg) 9 each, Awalegaon - Arg (Sindhudurg), Kalyan (Thane) 8 each, Pernem (North Goa), Ponda (North Goa), Talasari (Palghar) 7 each,
SAURASHTRA & KUTCH: Sutrapada (Gir Somnath) 29, Diu (Diu) 15, Veraval_aws(Gir Somnath), Kodinar (Gir Somnath) 13 each, Gir Gadhada (Gir Somnath) 12, Mangrol(j) (Junagadh), Veraval (Gir Somnath) 11 each, Talala (Gir Somnath), Malia (Junagadh), Una (Gir Somnath) 7 each,
GUJARAT REGION: Umergam (Valsad) 11, Deesa (Banaskantha) 8, Silvassa (Dadara & Nagar Haveli) 7, ODISHA: Kotpad (Koraput) 15, Kashinagar (Gajapati) 11, Paralakhemundi (Gajapati), Papadahandi (Nawarangpur) 9 each, Boden (Nawapara) 8, Lamataput (Koraput), Raighar (Nawarangpur), Jhorigam (Nawarangpur) 8 each, Koraput (Koraput) 7,

20.08.2025 / 0830 hrs IST
Chhattisgarh: Bhanupratappur (Kanker), Durgkondal (Kanker) 8 Each; Gobra Nawapara (Raipur) ;
Telangana: Palawancha (B. Kothagudem), Kothagudem (B. Kothagudem), Yellandu (B. Kothagudem) 7 each;
Vidarbha: Bhamragad (Gadchiroli), Gondia AP (Gondia); East Madhya Pradesh: Paraswada (Balaghat), Keolari (Seoni), Baihar (Balaghat), Kirnapur (Balaghat) 8 each;
Madhya Maharashtra: Tamini (Pune) – 57; Lonavala (Pune) 43; Mahabaleshwar (Satara) 30; Radhanagari (Kolhapur), Gaganbawada (Kolhapur) 17 Each; Igatpuri (Nashik) 16; Vadgaon Maval (Pune) 15; Shahuwadi (Kolhapur) 12; Ozharkheda (Nashik), Velhe (Pune) 10 Each; Talegaon (Pune), Chinchwad - (Pune), Trimbakshwar (Nashik), Harsul - Fmo (Nashik), Goti/bhudad (Kolhapur) 9 Each; Paud Mulshi (Pune), Ambegaon Ghodegaon (Pune), Junnar (Pune) 8 Each; Bhor (Pune) 7;
Konkan & Goa: Matheran (Raigad) 44; Panvel (Raigad), Karjat (Raigad), Bhiwandi (Thane) 23 Each; Thane (Thane), Vikramgad (Palghar), Tala (Raigad), Savarde- (Ratnagiri) 22 Each; Santacruz (Mumbai Suburban), Pen (Raigad), Vasai (Palghar) 21 each; Wada (Palghar) 20; Tbia (Thane), Jawhar (Palghar), Khalapur (Raigad), Palghar (Palghar) 19 Each; Sudhagad Pali (Raigad), Mhasla (Raigad) 18 each; Talasari (Palghar), Ambernath (Thane), Poladpur (Raigad) 17 each; Mokheda - Fmo (Palghar) 16; Roha (Raigad), Sangameshwar Devrukh (Ratnagiri), Dahanu (Palghar) 15 each; Mangaon (Raigad), Mandangad (Ratnagiri), Chiplun (Ratnagiri), Kalyan (Thane), Vaibhavwadi (Sindhudurg) 14 each; Shahapur (Thane), Murbad (Thane), Khed (Ratnagiri), Uran (Raigad), Dapoli (Ratnagiri) 13 each; Guhagarh (Ratnagiri), Ulhasnagar (Thane) 12 each; Murud (Raigad), Colaba (Mumbai City), Kudal (Sindhudurg), Mulde (Sindhudurg), Mahad (Raigad), Wakwali (Ratnagiri), Kankavli (Sindhudurg) 11 each; Ratnagiri (Ratnagiri), Rajapur (Ratnagiri) 10 Each; Sawantwadi (Sindhudurg), Awalegaon - (Sindhudurg), Quepem (South Goa) 9 each; Shriwardhan (Raigad), Ponda (North Goa), Devgad (Sindhudurg) 8 Each; Harnai (Ratnagiri), Malvan (Sindhudurg), Pernem (North Goa), Dabolim N.a.s.- Navy (South Goa), Lanja (Ratnagiri) 7 each;
Saurashtra & Kutch: Kalyanpur (Devbhoomi Dwarka) 26; Dwarka (Devbhoomi Dwarka) 20; Porbandar (Porbandar) 17; Sutrapada (Gir Somnath) 13; Diu (Diu), Jafrabad (Amreli) 11 Each; Rajula (Amreli), Talala (Gir Somnath), Una (Gir Somnath) 10 each; Mahuva(b) (Bhavnagar), Kodinar (Gir Somnath) 9 each; Gir Gadhada (Gir Somnath) 8; Mendarda (Junagadh), Vanthali (Junagadh), Veraval (Gir Somnath) 7 Each;
Gujarat Region: Khanvel (Dadara & Nagar Haveli) 17; Madhbun (Dadara & Nagar Haveli) 10; Daman (Daman), Umergam (Valsad) 8 each; Vapi (Valsad), Silvassa (Dadara & Nagar Haveli), Daman (Daman) 7 each;

2.9 Deep Depression over north Gujarat and adjoining southwest Rajasthan (06th - 10th September, 2025)

2.9.1 Introduction

- A low-pressure area lay over north Chhattisgarh and neighbourhood on 5th September.
- It moved west-northwestwards and concentrated into a depression over Southwest Rajasthan and neighbourhood at 1800 UTC of 06th September, 2025.
- It followed a sinusoidal wave like path, intensified into a Deep Depression over southeast Pakistan at 0600 UTC of 7th September.
- It moved across south Pakistan, emerged into northeast Arabian Sea on 10th September.
- Thereafter it moved nearly westwards & weakened into a well-marked low pressure area over northwest Arabian Sea and adjoining southwest Pakistan at 0000 UTC of the 11th September, 2025.
- The observed track of the deep depression is presented in **Fig. 2.9.1**. The best track parameters of the system are presented in **Table. 2.9.1**.

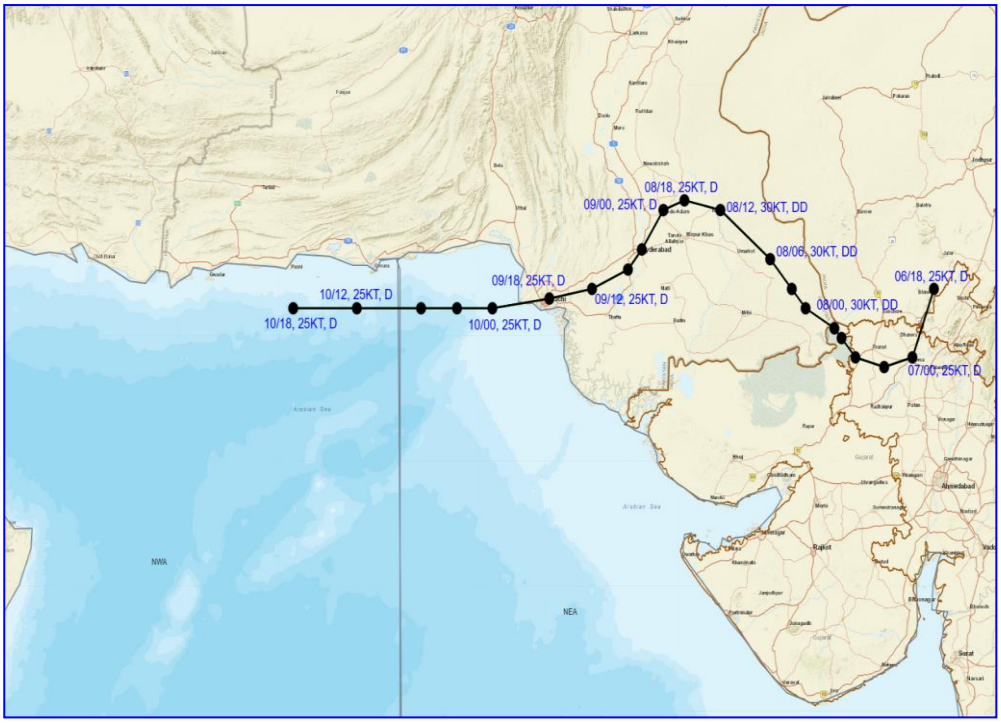


Fig.2.9.1: Observed track of land Deep Depression over southwest Rajasthan & neighbourhood during 6th -10th September, 2025

Table 2.9.1: Best track positions and other parameters of the Land Deep Depression over Southwest Rajasthan and neighbourhood during 6th – 10th Sep, 2025

Date	Time (UTC)	Lat. (^{0}N)	Long. (^{0}E)	C.I. No.	ECP (hPa)	ΔP (hPa)	MSW (kt)	Category
06-09-2025	1800	25.0	72.5	-	998	4	25	D
07.09.2025	0000	24.3	72.2	-	998	4	25	D
	0300	24.2	71.8	-	998	4	25	D
	0600	24.3	71.4	-	996	5	30	DD
	1200	24.5	71.2	-	995	6	30	DD
	1800	24.6	71.0	-	995	6	30	DD
08.09.2025	0000	24.8	70.7	-	995	6	30	DD
	0300	25.0	70.5	-	995	6	30	DD
	0600	25.3	70.2	-	995	6	30	DD
	1200	25.8	69.5	-	995	6	30	DD
	1800	25.9	69.0	-	997	4	25	D
09.09.2025	0000	25.8	68.7	-	998	4	25	D
	0300	25.4	68.4	-	998	4	25	D
	0600	25.2	68.2	-	999	4	25	D
	1200	25.0	67.7	-	999	4	25	D
	1800	24.9	67.1	-	999	4	25	D
		Emerged into northeast Arabian Sea around 2100 UTC of 9th September						
10-09-2025	0000	24.8	66.3	1.5	1000	4	25	D
	0300	24.8	65.8	1.5	1000	4	25	D
	0600	24.8	65.3	1.5	1000	4	25	D
	1200	24.8	64.4	1.5	1000	4	25	D
	1800	24.8	63.5	1.5	1001	3	20	D
11.09.2025	0000	Weakened into a well-marked low pressure area over northwest Arabian Sea and adjoining southwest Pakistan						

kt: Knots 1 kt=1.85 kmph, D: Depression, DD: Deep Depression

2.9.2. Salient features of the system

- The system had a life period of about 126 hours against normal of 80 hours in case of deep depression over the North Indian Ocean (NIO) based on data during 1990-2013.
- Climatologically, there were only two systems that formed over Indian mainland and emerged into northeast, eastcentral Arabian during the month of September during 1891-2024 (Fig. 2.9.2).

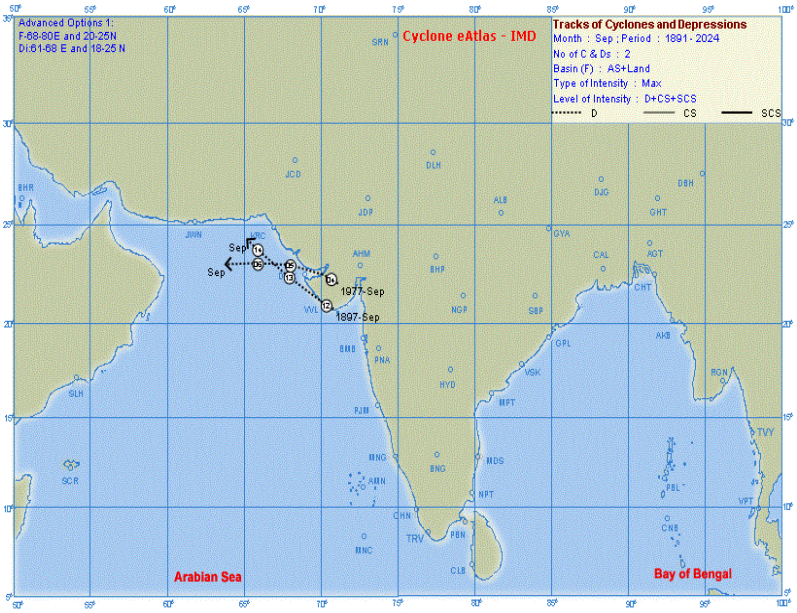


Fig. 2.9.2: Tracks of depressions over Indian mainland and emerged into Arabian Sea in the month of September during 1891-2024 within 20-25ºN/68-80ºE.

2.9.3 Genesis, intensification, weakening and movement

The remnant of well marked low (WML) pressure area over northwest Bay of Bengal, moved across north Odisha and lay over north Chattisgarh as a low-pressure area (LPA) on 0000 UTC of 4th September. It moved westnorthwestwards, intensified into a WML and lay over central parts of West Madhya Pradesh and adjoining East Rajasthan at 0300 UTC of the 5th September. Associated scattered to broken low and medium clouds with embedded moderate to intense convection lay over northwest Madhya Pradesh (minimum cloud to temperature was minus 70^0-90^0C).

It moved in same direction and lay over central parts of south Rajasthan at 0300 UTC of the 06th September as a WML. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over Southeast Rajasthan, Southwest Madhya Pradesh, West Vidarbha, North Madhya Maharashtra, North Konkan, Gujarat, Gulf of Kutch & Gulf of Cambay (minimum cloud to temperature 70^0C to -90^0C). The low-level vorticity was about 90-100 X 10^{-6} s^{-1} over central parts of south Rajasthan extending upto 500 hPa level. The low-level convergence was around 10 X 10^{-6} s^{-1} to the west of system centre. The upper-level divergence was around 20X10^{-6} s^{-1} near the system centre. Mid-level vertical wind shear (VWS) of horizontal wind was moderate (15 kt) over the system centre. Moderate wind shear with higher upper-level divergence compared to low level convergence supported further intensification of the system. The guidance from various numerical models indicated that Madden Julian Oscillation (MJO) was in phase 2 with amplitude close to 1. Under this favorable environment, it concentrated into a depression over north & adjoining southwest Rajasthan at 1800 UTC of 06th September.

The depression then moved nearly westwards and intensified into a deep depression at 0600 UTC of 07th September over the same region. Intense convection was sheared to the southwest of system centre. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over Gujarat, Gulf of Kutch, Gulf of Cambay, Southeast Pakistan, extreme South Rajasthan, west Madhya Pradesh, North

Konkan. Minimum cloud to temperature was -70^{0}C to -90^{0}C. The low-level vorticity increased and was about 180 X 10^{-6} s^{-1} over system area extending upto 200 hPa level. The low-level convergence was around 20 X 10^{-6} s^{-1} over system area. The upper-level divergence was around 20X 10^{-6} s^{-1} over the system area. Mid-level VWS of horizontal wind was moderate (15-20 kt) over the system area.

The deep depression over North Gujarat and adjoining Southwest Rajasthan moved slowly westnorthwestwards and lay centred at 0000 UTC of 08th September, over the Southeast Pakistan and adjoining Rajasthan & Kutch. The clouds were organised in shear pattern. Intense convection was sheared to the west and southwest of system centre. Depth of convection slightly decreased. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over South Pakistan, Gujarat, Gulf of Kutch, Gulf of Cambay, Southwest Rajasthan, west Madhya Pradesh, North Konkan. Minimum cloud to temperature was -70^{0}C to -80^{0}C. As per guidance from CIMSS, the low-level vorticity was unchanged and was about 160-180 X 10^{-6} s^{-1} over system area extending upto 200 hPa level. The low-level convergence has slightly increased and was around 20 X 10^{-}6 s^{-1} over system area. The upper-level divergence was the same and was around 20X 10^{-6} s^{-1} over the system area. Mid-level VWS of horizontal wind is moderate (10-15 kt) and anticlockwise over the system area. Poleward outflow showed decreasing trend. Deep level VWS of horizontal wind was moderate (15-20 kt) and clockwise over the system area. A trough in westerly near 65^{0}E was interacting with the system and was inhibiting its further westwards movement. These features indicated that system would exhibit slow movement and maintain its intensity for some more time. The guidance from NCICS CFS model indicated westerly wind anomaly (5-7 mps) over northeast Arabian Sea and adjoining Gujarat region alongwith strong easterly wind anomaly (5-7 mps) to its north over Pakistan & adjoining west Rajasthan. The model was also indicating prevalence of equatorial Rossby Wave (ERW) and MJO over Arabian Sea. Equatorial waves and MJO were also supporting the system to maintain its intensity.

The deep depression over Southeast Pakistan and adjoining Rajasthan & Kutch moved slowly northwestwards and lay centred at 0300 UTC of 08th September over the same region. At 0300 UTC of 8th Sep, intense convection was sheared to the west and southwest of system centre. Depth of convection slightly decreased. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over South Pakistan, Gujarat, Gulf of Kutch, Gulf of Cambay, Southwest Rajasthan, west Madhya Pradesh, North Konkan. Minimum cloud to temperature -70^{0}C to -80^{0}C. As per guidance from CIMSS, the low-level vorticity remained the same. The low-level convergence slightly decreased and was around 15 X 10^{-6} s^{-1} over system area. The upper-level divergence also slightly decreased and was around 10X 10^{-6} s^{-1} over the system area. Mid-level VWS of horizontal wind was moderate (10-15 kt) and anticlockwise over the system area. Poleward outflow showed decreasing trend. Deep level VWS of horizontal wind was moderate (15-20 kt) and clockwise over the system area. A trough in westerly near 65^{0}E was interacting with the system and was inhibiting its further westwards movement.

Continuing to move northwestwards under these environmental conditions, the deep depression weakened into a depression and lay over Southeast Pakistan and adjoining Rajasthan at 1800 UTC of 08th September. Intense convection was seen to the south of system centre. Scattered to broken low and medium clouds with embedded moderate to intense convection lay over South Pakistan with minimum cloud to temperature as (-50^{0}C to -

70^0C). Scattered to broken low and medium clouds with embedded weak to moderate convection lay over West Gujarat and Gulf of Kutch. As per guidance from satellite, low level winds indicated well defined circulation over south Pakistan. Southwesterly winds from Arabian Sea were feeding moisture into the core of the system. The low-level vorticity decreased and was about 100-120 X 10^{-6} s^{-1} over system area extending upto 200 hPa level. The low-level convergence was around 10 X 10^{-6} s^{-1} over system area. The upper-level divergence was around 10X 10^{-6} s^{-1} over the system area. Mid-level VWS of horizontal wind was moderate to high (20-25 kt) and clockwise over the system area. The guidance from NCICS CFS model indicated westerly wind anomaly (3-5 mps) over northeast Arabian Sea and adjoining Gujarat region alongwith easterly wind anomaly (3-5 mps) to its north over Pakistan & adjoining west Rajasthan.

The system moved nearly westwards and weakened into a WML on 0000 UTC of 11th September and lay over northwest Arabian Sea and adjoining southwest Pakistan. As per guidance from satellite, associated scattered to broken low and medium clouds with embedded moderate to intense convection over northwest Arabian Sea and adjoining Pakistan with minimum cloud to temperature as (-40^0C to -60^0C). The low-level vorticity decreased and was about 30-40 X 10^{-6} s^{-1} over system area extending up to 500 hPa levels. The low-level convergence also further decreased with no significant convergence over the system area. The upper-level divergence also decreased with no positive divergence over North Arabian Sea. The Deep and mid layer VWS of horizontal wind was 10-15 kts over north Arabian Sea. Warm moist air incursion into the core also decreased.

Under these environmental conditions, the WML weakened into a low-pressure area over the same region at 12 UTC of 11th September, 2025 and became less marked over northwest Arabian Sea at 0000 UTC of 12th September.

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 coloured imageries, visible/ IR, brightness temperature and water vapour imageries are presented in **Fig. 2.9.3**.

2.9.4 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 August. The system was monitored with the help of available satellite observations from INSAT 3DS 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.

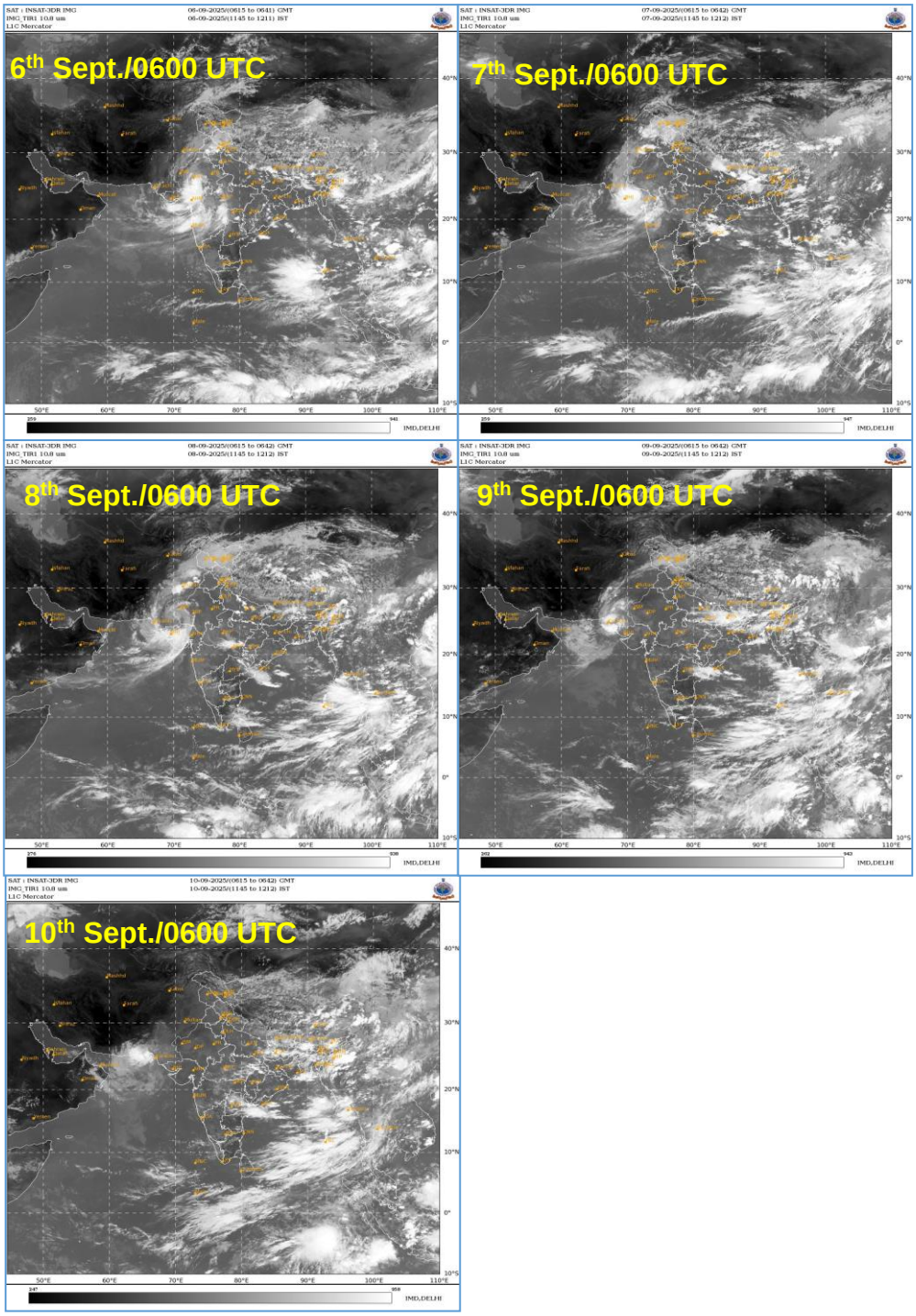


Fig. 2.9.3(a): INSAT-3D IR imageries during life cycle of Deep Depression of Arabian Sea during 06^{h} -10th September, 2025

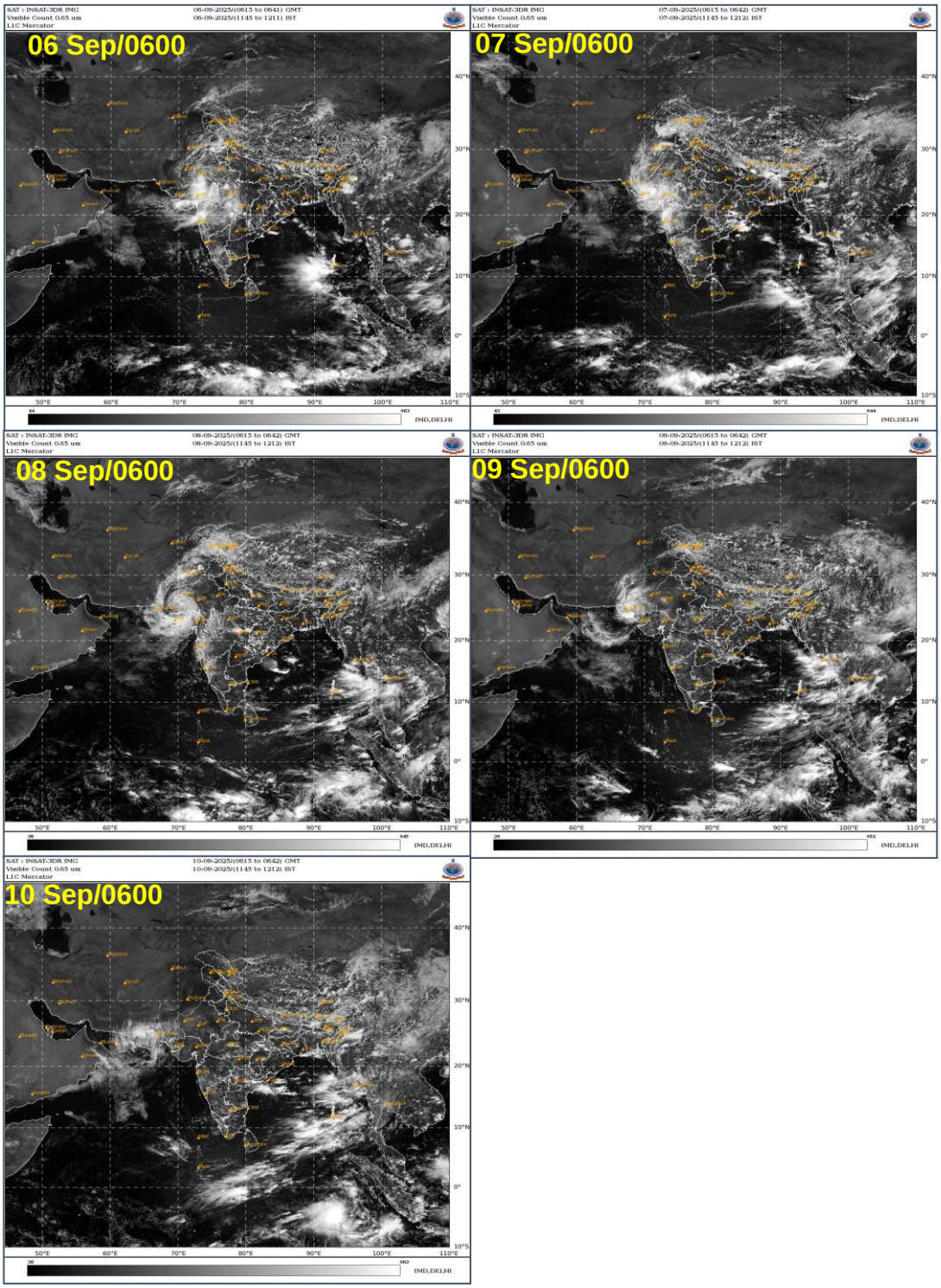


Fig. 2.9.3(b): INSAT-3D visible imageries during life cycle of Deep Depression of Arabian Sea during 06^{h} -10th September, 2025

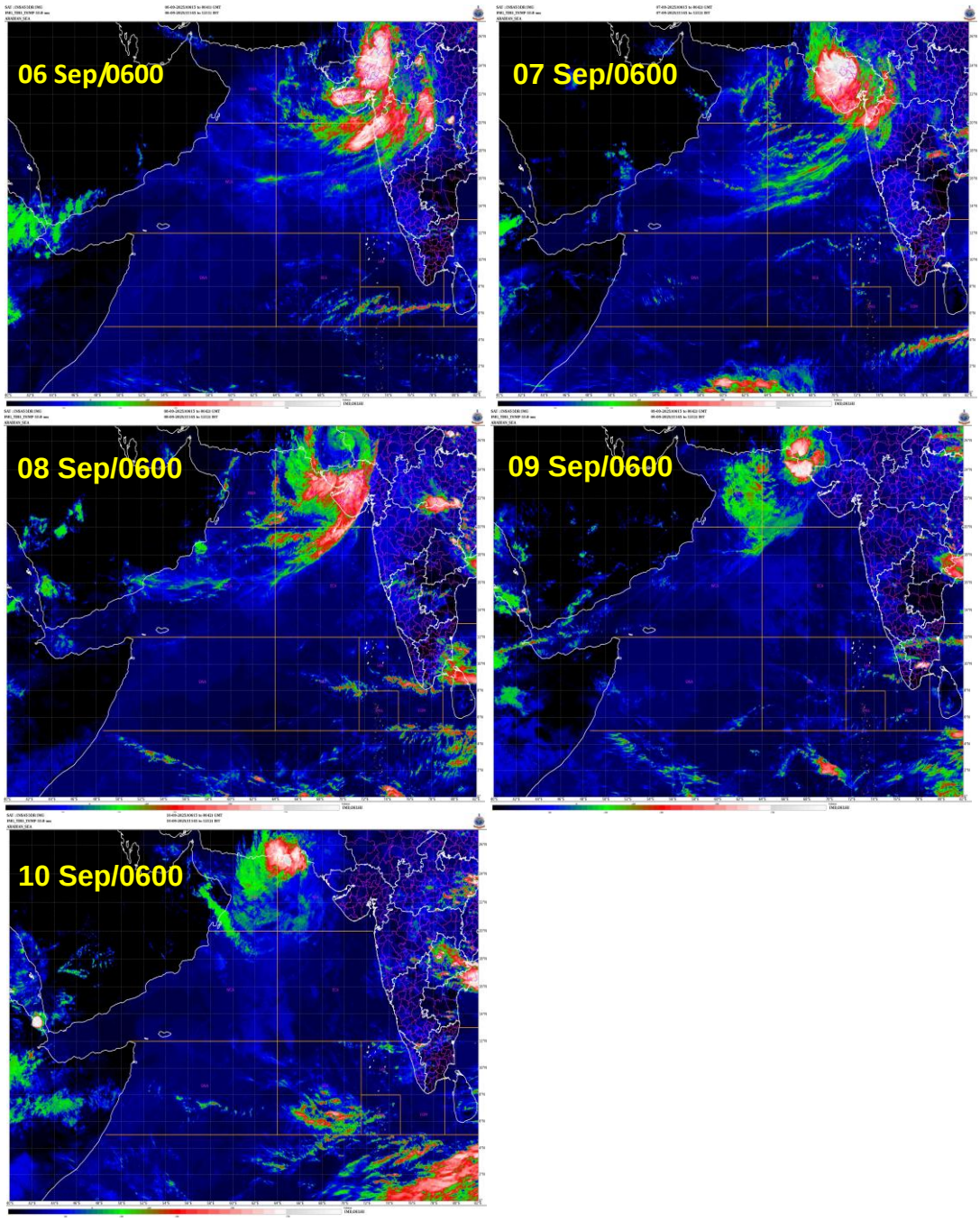


Fig. 2.9.3(c): INSAT-3D enhanced colored imageries during life cycle of Deep Depression of Arabian Sea during 06^{h} -10th September, 2025

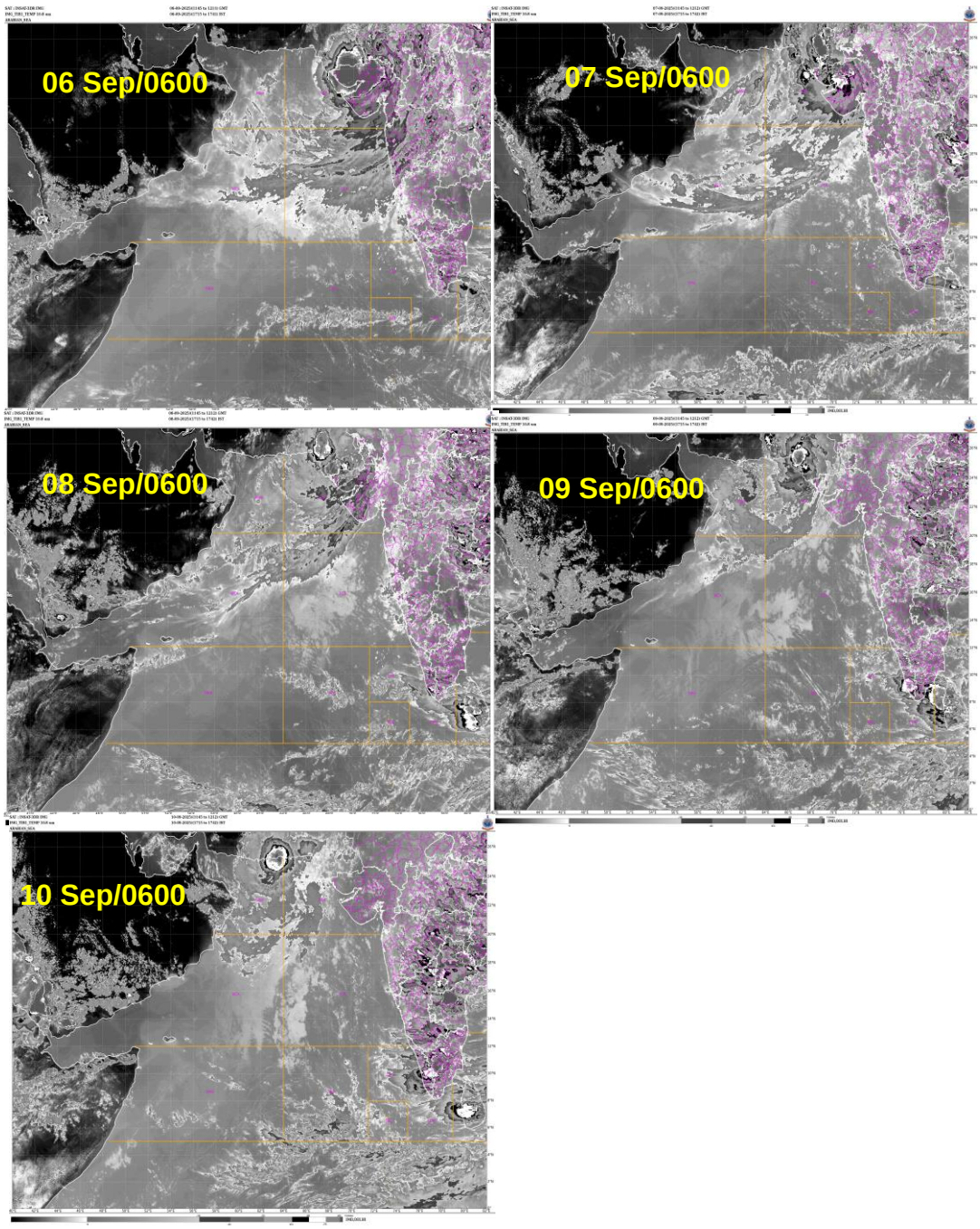


Fig. 2.9.3(d): INSAT-3D BD imageries during life cycle of Deep Depression of Arabian Sea during 06^{h} -10th September, 2025.

2.9.5 Dynamical Features

IMD GFS (T1534) model daily analyses of mean sea level pressure (MSLP) and winds at 850, 500 and 200 hPa levels from 6th - 10th August are presented in Fig. 2.8. **4.**

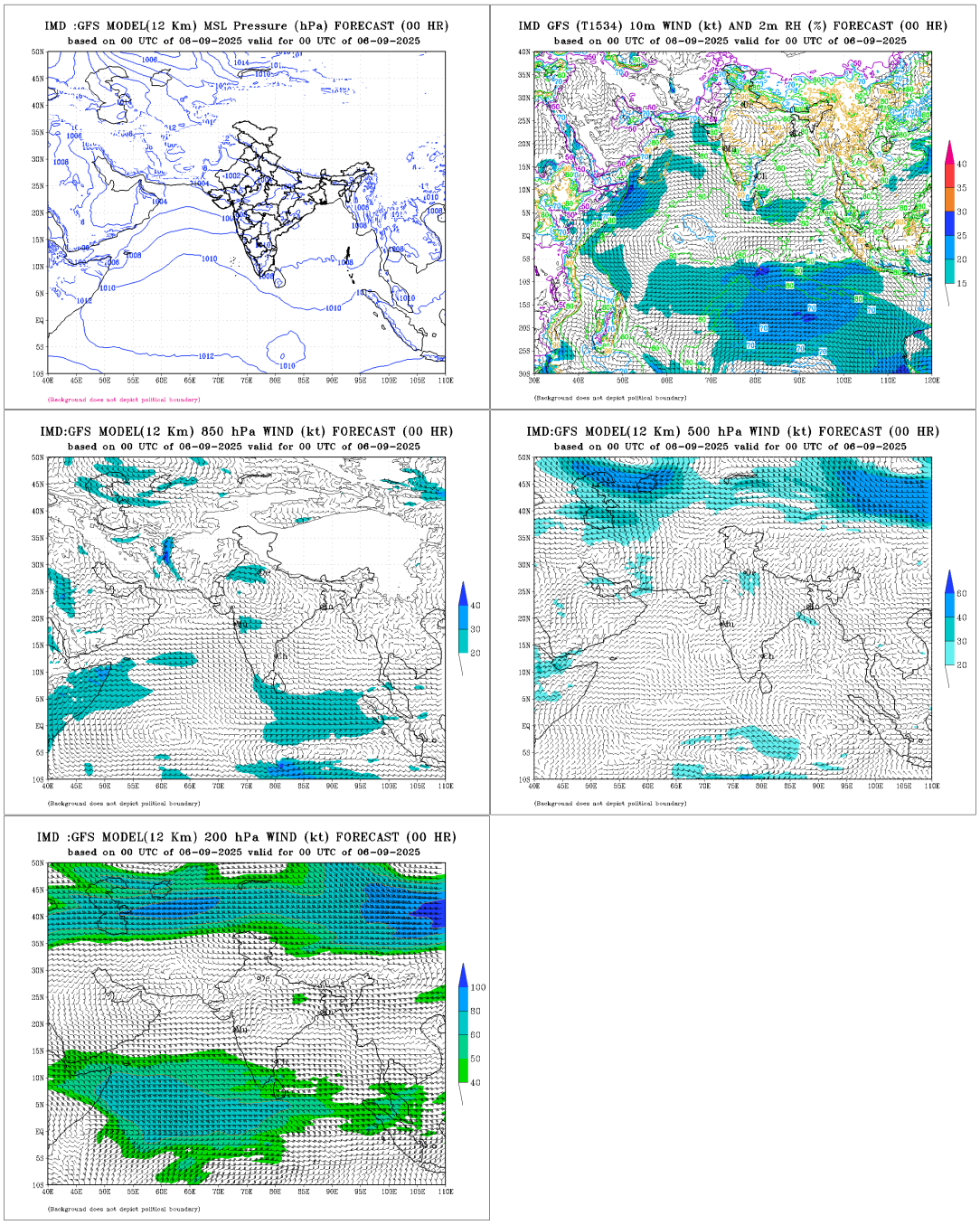


Fig. 2.8.4(a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 6th Sep 2025.

The MSLP and upper air wind analysis field on 6th September indicated a low pressure area over central parts of south Rajasthan with associated cyclonic circulation extending upto 500 hPa level and tilting southward with height.

The MSLP and upper air wind analysis field on 07th September indicated a depression over South Rajasthan and adjoining North Gujarat near 25N/72E with associated cyclonic circulation extending upto 500 hPa level and tilting southwestward with height.

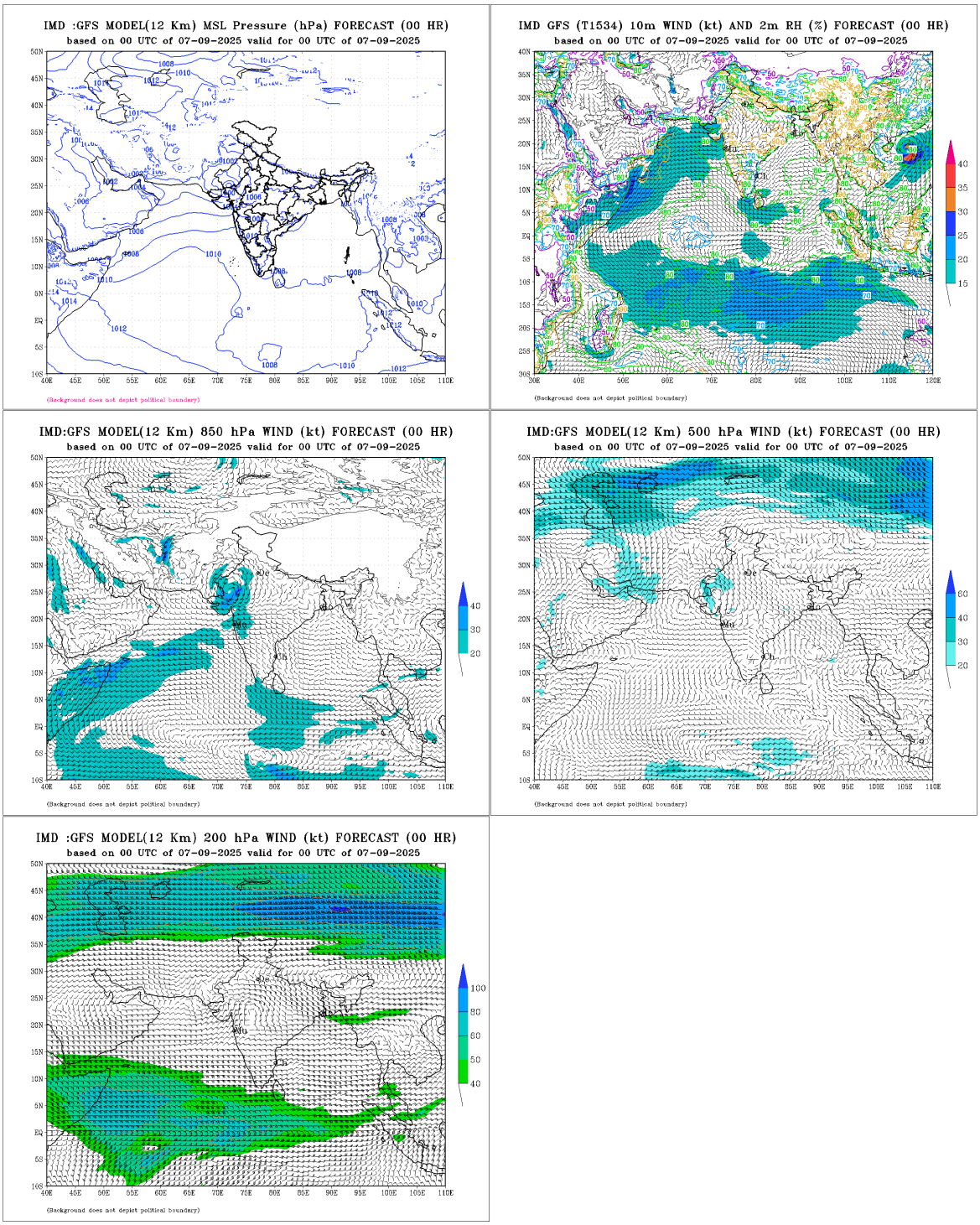


Fig. 2.8.4(b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 7th Sep 2025

The MSLP and upper air wind analysis field indicated deep depression or higher intensity system over southeast Pakistan & adjoining southwest Rajasthan near 25.2N/70.5E with

associated cyclonic circulation extending upto 500 hPa level and tilting southward with height. Actually, the system lay near 24.8N/70.7E as a deep depression.

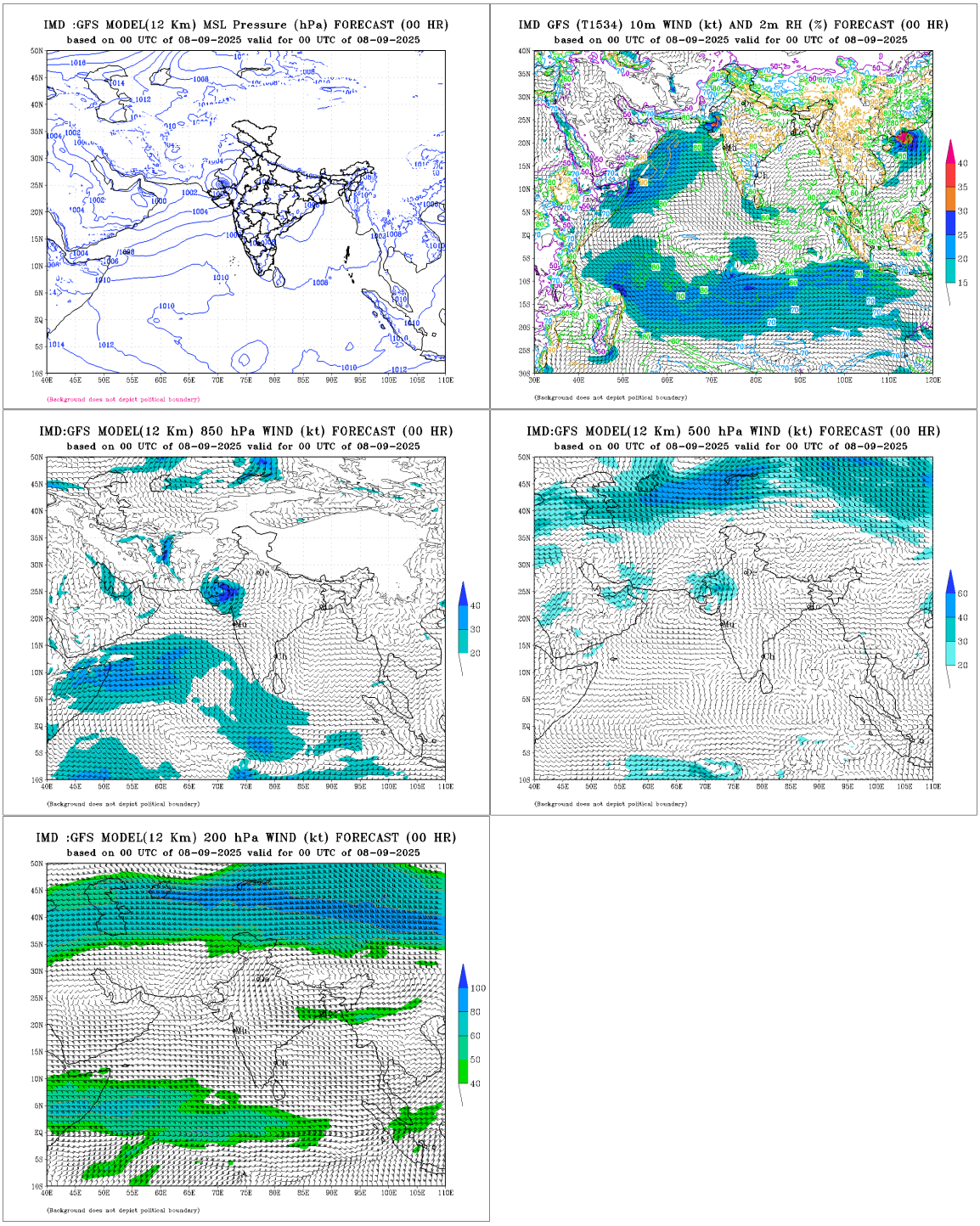


Fig. 2.8.4(c): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 8th Sep 2025

The MSLP and upper air wind analysis field on 09th September indicated weakening and the system lay as a depression over southeast Pakistan 25.5N/68.9E with associated cyclonic

circulation extending upto 200 hPa level and tilting southwestward with height. Actually, the system lay near 25.8N/68.7E as a depression.

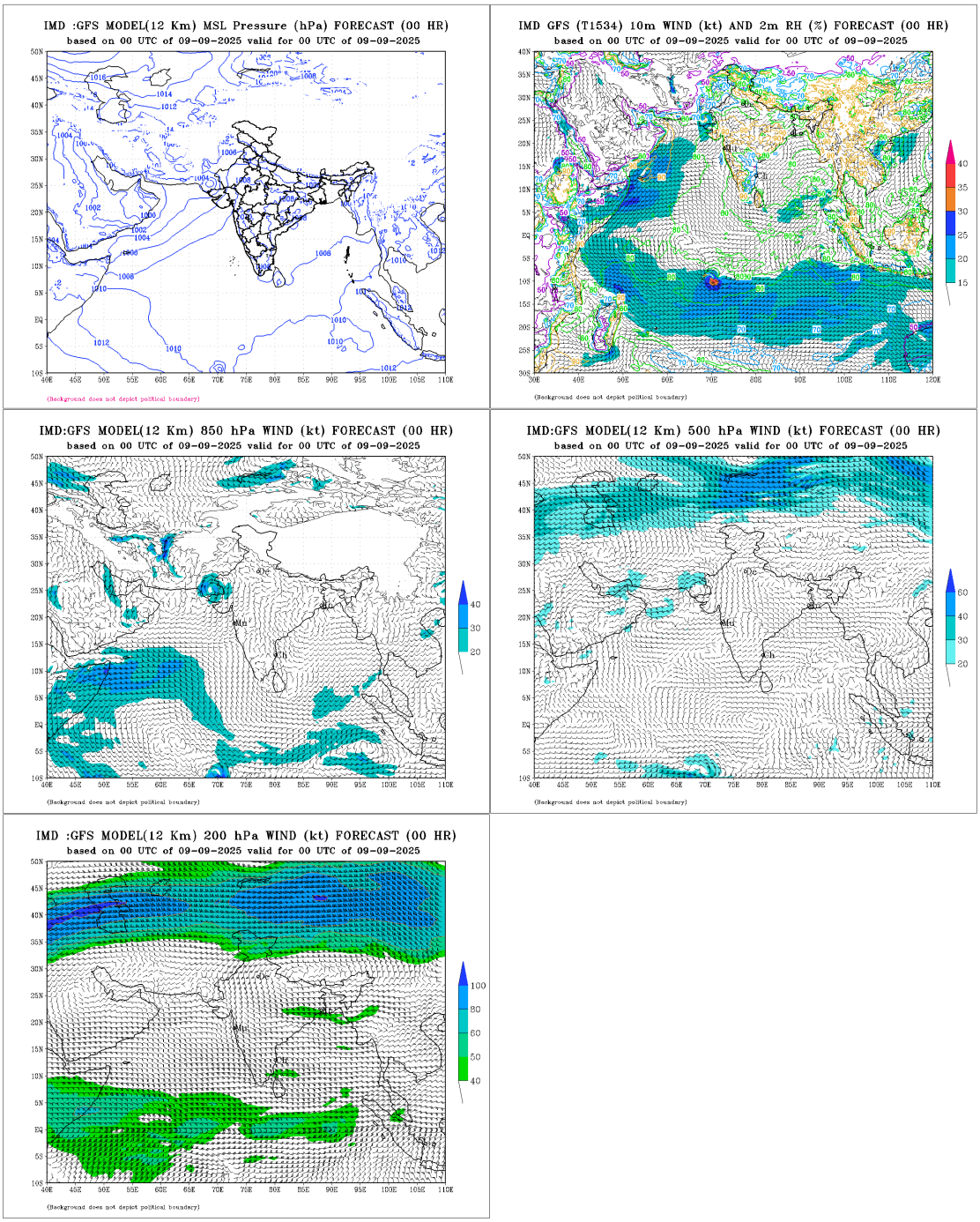


Fig. 2.8.4(d): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 9th Sep 2025

The MSLP and upper air wind analysis field on 10th September indicated weakening of the system and associated upper air cyclonic circulation at 850 hPa level lay over northeast Arabian Sea & adjoining south Pakistan. The associated cyclonic circulation extended upto 500 hPa level tilting southwestward with height.

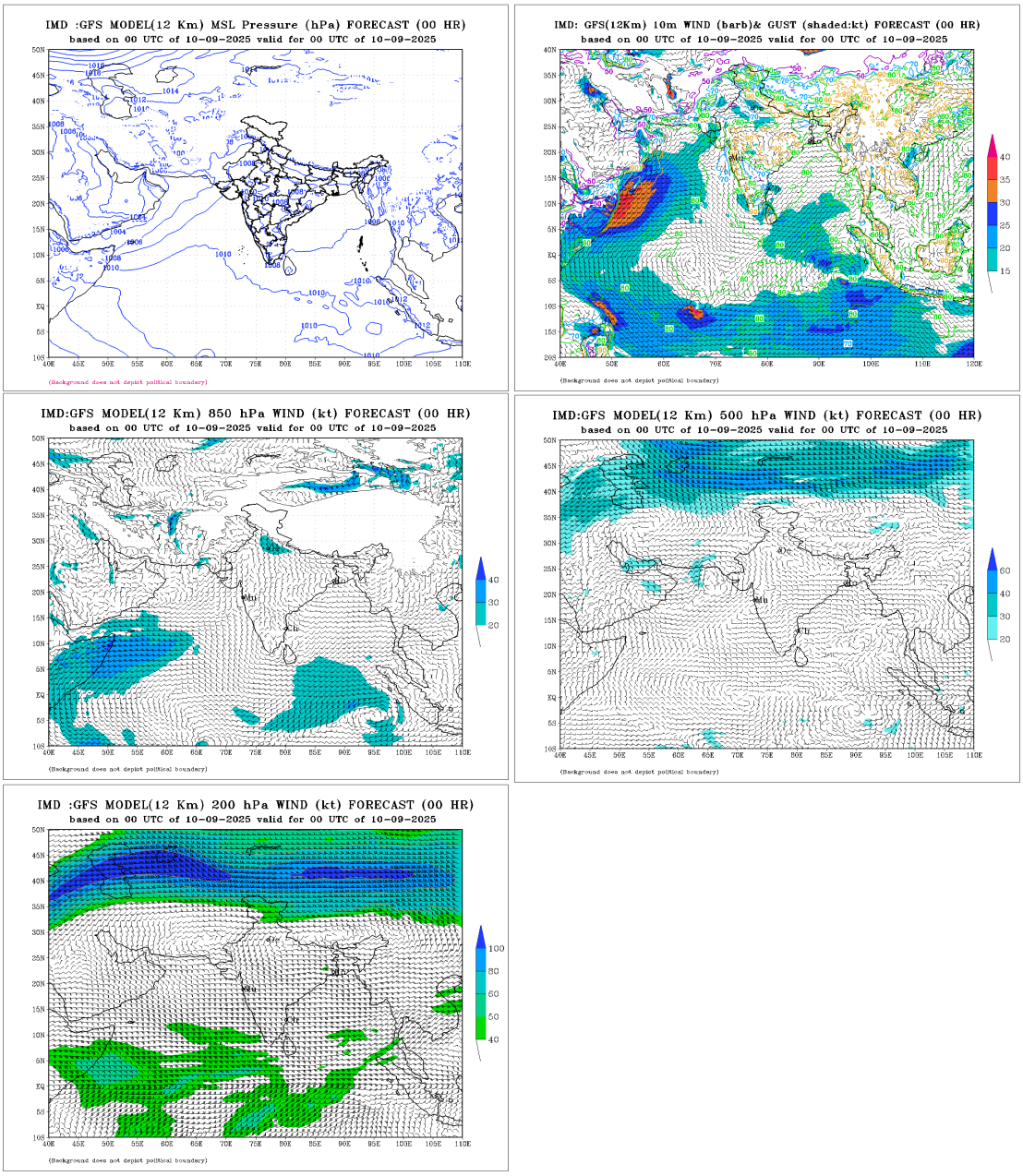


Fig. 2.8.4(e): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 10th Sep 2025

Thus, overall, IMD GFS captured the location and weakening correctly. However, during genesis & intensification stage, it over-estimated the intensity of the system.

2.8.7 Realised Weather:

Rainfall associated with the depression, based on IMD–NCMRWF satellite–gauge merged data, is shown in Fig. 2.8.5. Heavy to very heavy rainfall occurred at isolated places over Odisha and Chhattisgarh on 4th September, and over Madhya Pradesh on 5th September. On 6th September, heavy rainfall was reported at many places over Gujarat and southeast Rajasthan, which increased to most places over Gujarat and many places over Rajasthan on 7th September. Extremely heavy rainfall occurred at isolated places over north

Gujarat on 8th September, followed by heavy rainfall at isolated places over the same region on 9th September.

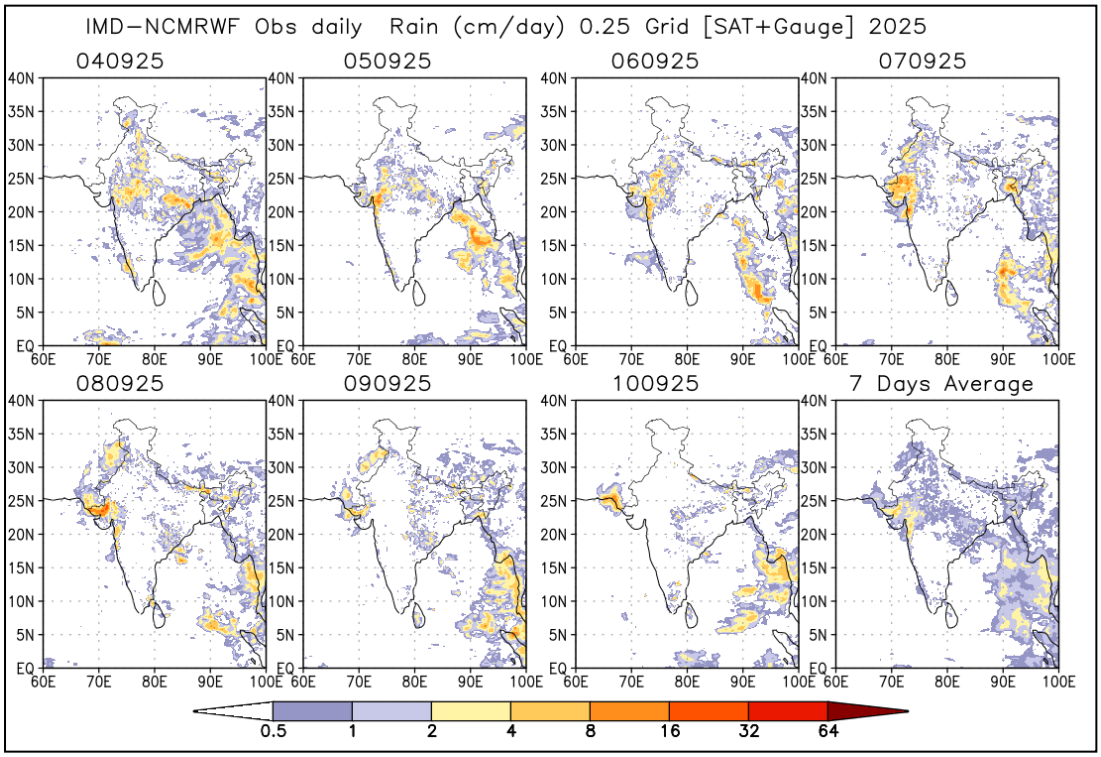


Fig. 2.8.5: NCMRWF-IMD satellite gauge merged data plots of realized 24-hour accumulated rainfall from 04th September to 10th September, 2025**.**

Realised 24 – hour heavy rainfall (≥ 7 cm) ending at 0300 UTC of date.

7th September/ 0300 UTC:

Gujarat Region: Madhbun 24; Kaprada 23; Silvassa 21; Nanipalson, Khanvel 17 Each; Po shina 15; Dharampur, Umergam 14 Each; Danta, Lakhani 12 Each; Santalpur 11; Wav, Prantij, Talod, Sanand, Palanpur, Satlasana, Kadi, Sagbara, Dharoi Colony 10 Each; Dantiwada, Radhanpur, Jhalod, Dhanera, Bhiloda, Himatanagar 9 Each; Khedbrahma, Pardi, Umerpada, Vapi, Patan, Mahesana, Modasa, Siddhpur, Bayad 8 Each; Khergam, Ukai, Patan, Suigam, Vijaynagar, Ghandinagar, Idar, Tharad, Abad City, Becharaji, Dhanpur, Daman, Dahod, Visnagar, Dolvan, Kheralu, Balasinor 7 Each.

Saurashtra & Kutch: Bhachau 11; Morbi, Botad 10 Each; Bachau 9; Paddhari, Malia & Miana 8 Each; Rapar, Tankara, Jamkandorna, Halvad 7 Each.

8th September/ 0300 UTC:

Gujarat Region: Suigam 40; Bhabhar 35; WAV 30; Tharad 29; Santalpur 20; Radhanpur 19; Deodar 14; Kaprada 11; Dahegam 10; Valsad & Valod 9 Each; Dharampur, Silvassa, Khergam, Madhbun, Idar 8 Each; Lakhani, Vyara, Talod, Vyara & Vapi 7 each.

Saurashtra & Kutch: Rapar 36; Bachau- 14; Malia-12; Kandla Airport, Gandhidham 10 Each; Anjar, Bhuj 9 Each; Lakhpat, Bhachau, Nakhatrana, Kandla New 8 each.

East Rajasthan: Mounntabu Tehsil 25.

West Rajasthan: Sanchore 12; Gudamalani 10.

9th September/ 0300 UTC:

Saurashtra & Kutch: Lakhpat 15, Nakhatrana 11, Bhachau 10, Gandhidham 8, Bhuj 8, Rapar 8, Bachau 7, Anjar 7;

Gujarat Region: Bhabhar 11.

2.10 Depression over northwest and adjoining westcentral Bay of Bengal off south Odisha-north Andhra Pradesh coasts (26th - 28th September, 2025)

2.10.1 Life History:

- An upper air cyclonic circulation has formed over coastal areas of central Myanmar and adjoining eastcentral Bay of Bengal in the middle tropospheric levels at 0300 UTC of 24th September. It moved westwards gradually and under its influence, a low-pressure area has formed over central parts of North and adjoining Central Bay of Bengal (BoB) in the evening (1730 hrs IST) of 25th September.
- It lay as a well-marked low-pressure area over northwest and adjoining central BoB in the morning (0530 hrs IST) of 26th September.
- It intensified into a depression over northwest BoB in the midnight (2330 hrs IST) of 26th September. It crossed Odisha coast close to Gopalpur during early morning hours (0430 hrs IST) of 27th September.
- It moved across Odisha, Chhattisgarh, Vidarbha during 27th-28th September and weakened into a well-marked low-pressure area over west Vidarbha and adjoining north Madhya Maharashtra in the forenoon (0830 hrs IST) of 28th September. It moved across North Madhya Maharashtra and emerged into Gulf of Cambay in the morning (0530 IST) of 29th September.
- The observed track of the system is presented in Fig.2.10.1. It delayed the withdrawal of monsoon from northwest & central India. It caused vigorous rainfall activity over Odisha, Andhra Pradesh, Telangana, Rayalaseema, Vidarbha, Maharashtra, Konkan & Goa, Madhya Pradesh, Rajasthan, and Gujarat during 26th-28th September.

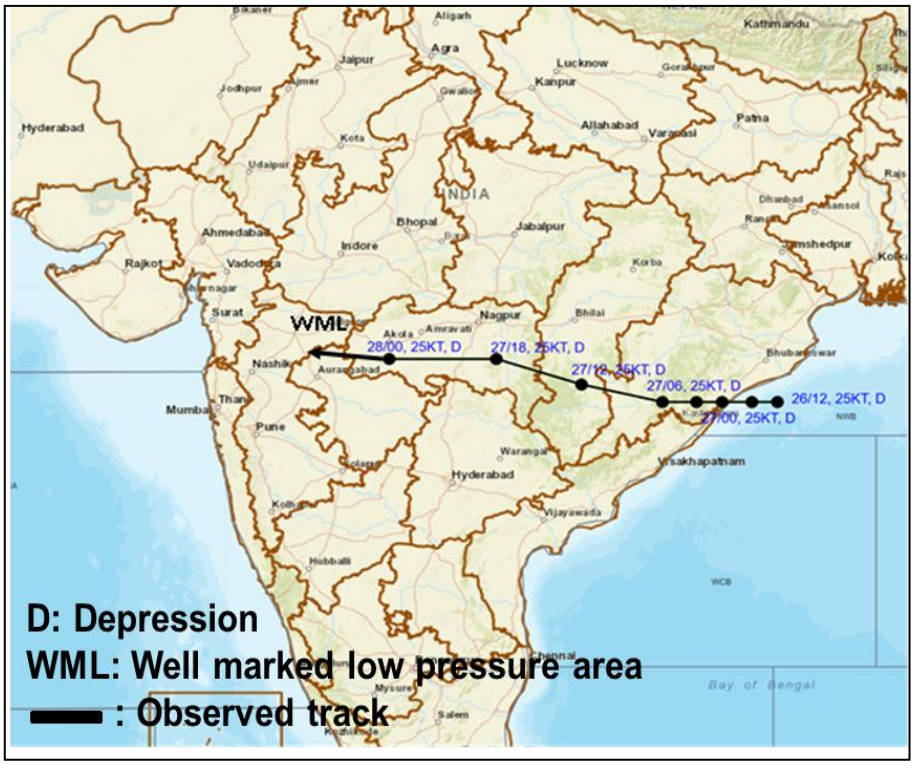


Fig.2.10.1: Observed track of Depression over northwest and adjoining westcentral Bay of Bengal off south Odisha-north Andhra Pradesh coasts during 26th - 28th September, 2025

Table 2.10.1: Best track of Depression over northwest and adjoining westcentral Bay of Bengal off south Odisha-north Andhra Pradesh coasts during 26th - 28th September, 2025

Date	Time (UTC)	Lat. (^{0}N)	Long.(^{0}E)	ECP (hpa)	ΔP (hPa)	C.I. No.	MSW (kt)	Category
26.09.2025	1200	19.3	86.1	996	3	1.5	25	D
	1800	19.3	85.5	998	4	1.5	25	D
27.09.2025	Crossed south Odisha coast near latitude 19.3°N and longitude 85.0°E close to Gopalpur around 0430 hrs IST of the 27th September (2300 UTC of 26th September) 2025							
	0000	19.3	84.8	998	4	-	25	D
	0300	19.3	84.2	998	4	-	25	D
	0600	19.3	83.4	998	4	-	25	D
	1200	19.7	81.5	999	3	-	20	D
	1800	20.3	79.5	999	3	-	20	D
28.09.2025	0000	20.3	77.0	999	3	-	20	D
	0300	Weakened into a well-marked low-pressure area over west Vidarbha and adjoining north Madhya Maharashtra						

kt: Knot (nautical mile per hour), 1 kt=1.85 kmph, D: Depression, Lat.: Latitude, Long.: Longitude, ECP: Estimated central pressure, ΔP: Pressure drop at centre, C.I. No.: Current intensity number, MSW: maximum sustained wind speed, Po: Pressure of outermost closed isobar

2.10.2 Salient features of the system

➢ The system had life period of about 72 hours.

➢ Climatologically, there were only four systems that formed over westcentral/northwest Bay of Bengal and crossed either Andhra Pradesh or Odisha coast in the month of September during 1891-2024 (Fig.2.10. 2).

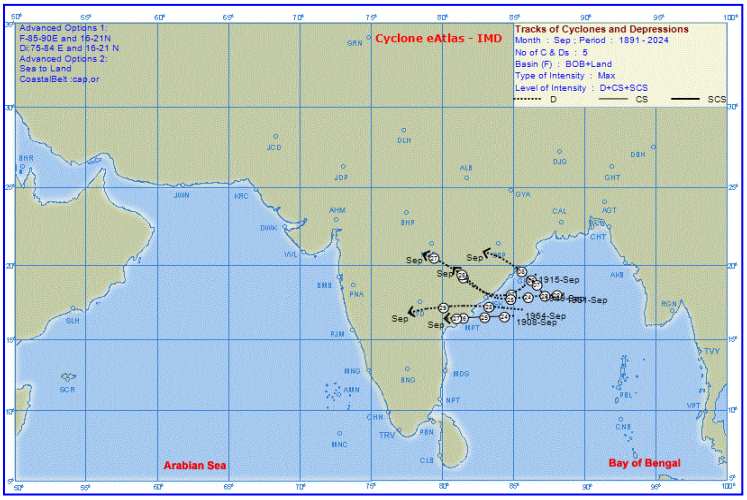


Fig.2.10.2: Tracks of depressions over Bay of Bengal and crossed Andhra Pradesh, Odisha coasts in the month of September during 1891-2024.

2.10.3 Monitoring

India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean and the depression was monitored since 21st September, about 7 days prior to formation of depression on 26th September. First information about the system was released in the weekly extended range outlook issued by IMD on 21st September, indicating formation of depression over north Odisha and adjoining northwest Bay of Bengal & Gangetic West Bengal around 27th September with low probability (1-33%). Anticipatory actions for the marine, scientific and disaster management communities were also issued at this stage. Actually, the depression has formed over the northwest and adjoining westcentral Bay of Bengal off south Odisha-north Andhra Pradesh coasts.

The depression was monitored with the help of available satellite observations from INSAT 3D and 3DR, SCAT SAT, ASCAT, microwave imageries and available ships, buoy observations and coastal observations in the region. Various global models and dynamical-statistical models run by Ministry of Earth Sciences (MoES) institutions including IMD, NCMRWF, IITM & INCOIS and guidance from models from various international agencies under bilateral arrangement were utilized to predict the genesis, track and intensity of the cyclone as well as associated severe weather. The forecasts were mainly based on multi-model ensemble technique developed by IMD further modulated by observations and forecaster's intervention at IMD. An indigenously developed digitized forecasting system of IMD was utilized for analysis and comparison of various observations and numerical weather prediction model's guidance, decision making process and warning products generation.

2.10.3.1 Monitoring through Satellite:

Typical satellite-based products utilised for monitoring the system are presented in Figs.2.10.3a to 3d respectively. At 0300 UTC of 26th September, 2025, a well-marked low-pressure area had formed over northwest and adjoining central Bay of Bengal. As per INSAT-3D imagery, the vortex was centred near 19.0°N/88.0°E. The intensity had been characterised as T1.0. Intense convection had been sheared to the west of the system centre. Multi-satellite winds had indicated stronger winds to the northwest of the system centre. Associated scattered to broken low and medium clouds with embedded intense to very intense convection had been lying over northwest & westcentral Bay of Bengal, east Orissa, coastal Gangetic west Bay of Bengal, and north coastal Andhra Pradesh. Minimum cloud top temperature had been –70 to –90 °C.

At 1200 UTC of 26th September, 2025, the system has intensified into depression and had been lying over northwest and adjoining westcentral Bay of Bengal off South Odisha–North Andhra Pradesh coasts. As per INSAT-3D imagery, the vortex was centred near 19.0°N/87.3°E. The intensity had been characterised as T1.5. Intense convection had been sheared to the west of the system centre. Multi-satellite winds had indicated stronger winds to the southeast and northeast of the system centre. Associated scattered to broken low and medium clouds with embedded intense to very intense convection had been lying over northwest & westcentral Bay of Bengal, east Orissa, coastal Gangetic west Bay of Bengal, and north coastal Andhra Pradesh. Minimum cloud top temperature had been –70 to –90 °C. OCEANSAT pass at 0625 UTC had indicated 25–33 kt winds to the northeast of the system centre.

At 0300 UTC of 27th September, 2025, the depression had been lying over south interior Odisha. As per INSAT-3D imagery, the vortex was centred near 19.2°N/84.6°E. Intense convection had been sheared to the west of the system centre. Multi-satellite winds had indicated stronger winds to the northwest sector. Associated scattered to broken low and medium clouds with embedded intense to very intense convection had been lying over Odisha, South Chhattisgarh, Vidarbha, North Telangana and North Coastal Andhra Pradesh. Minimum cloud top temperature had been –60 to –80 °C.

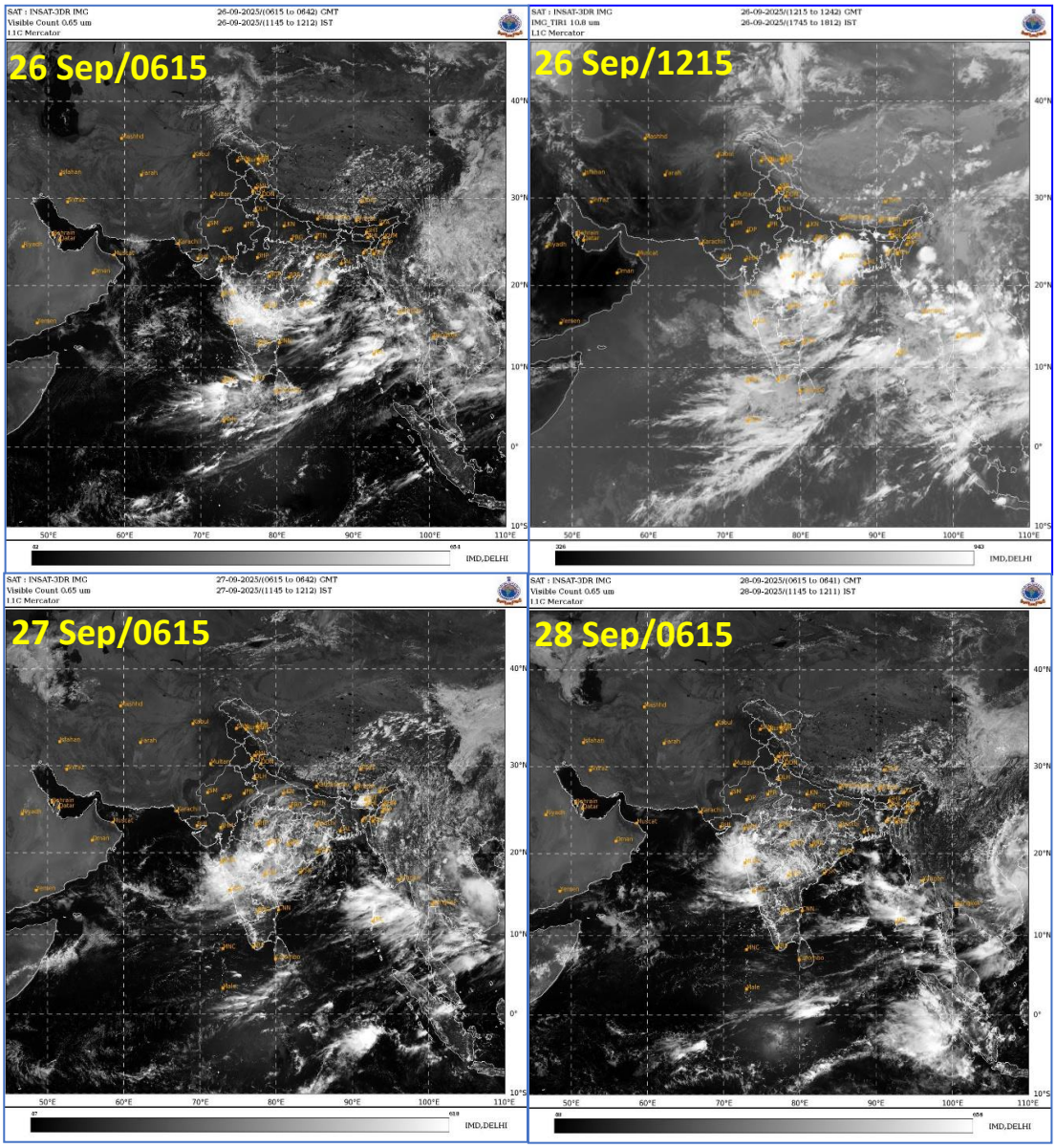


Fig.2.10.3(a): INSAT-3R Visible imageries during life cycle of Depression over southwest & adjoining northeast Bay of Bengal (26th - 28th September 2025).

At 1200 UTC of 27thSeptember, 2025, the depression had been lying over South Chhattisgarh and neighbourhood. As per INSAT-3D imagery, the vortex was centred near 19.2°N/82.0°E. Intense convection had been sheared to the west of the system centre. Associated scattered to broken low and medium clouds with embedded intense to very intense convection had been lying over South Uttar Pradesh, Odisha, Chhattisgarh, Vidarbha, Maharashtra, Telangana and North Coastal Andhra Pradesh, East Rajasthan. Minimum cloud top temperature had been –60 to –80 °C.

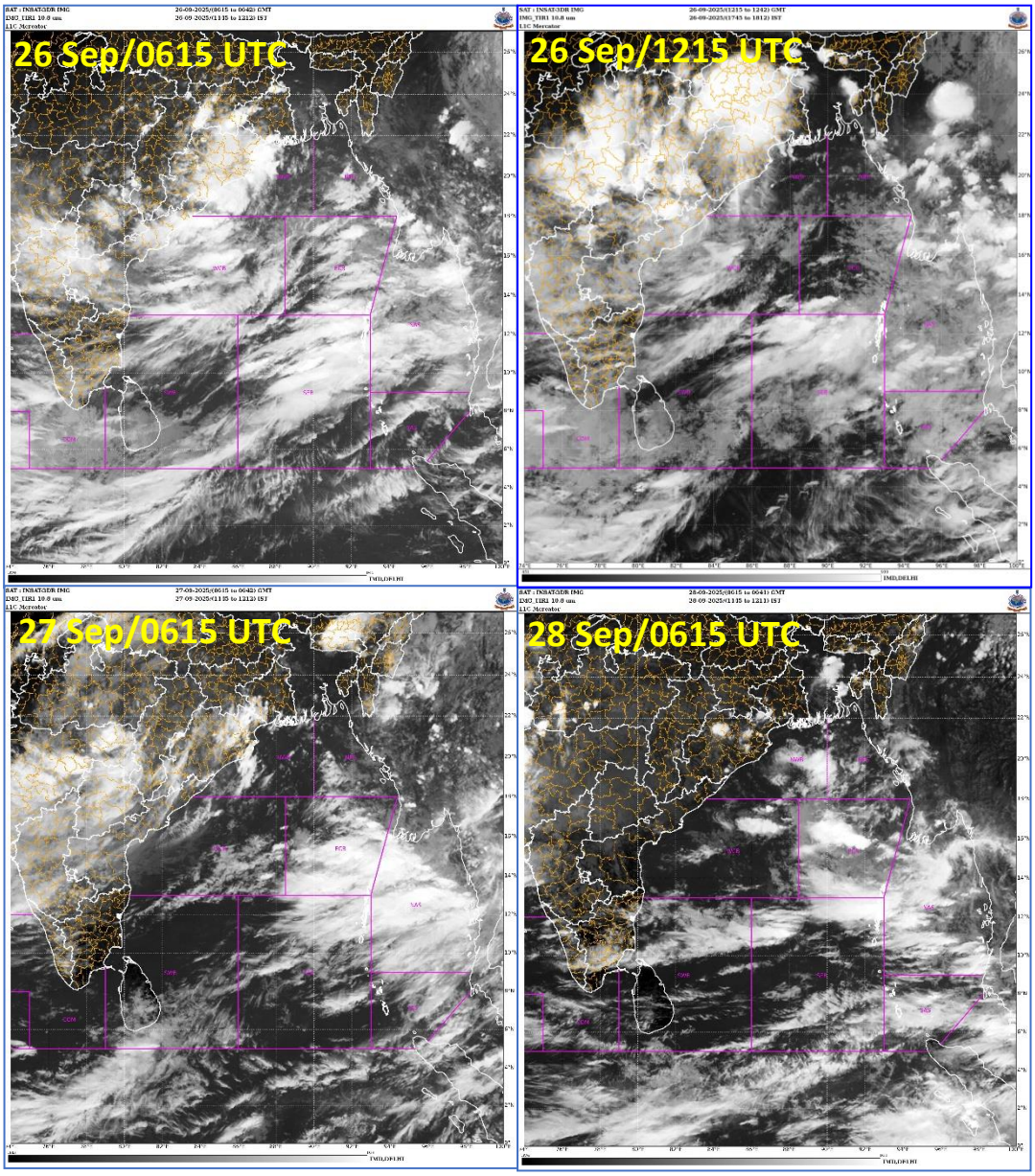


Fig.2.10.3(b): INSAT-3R IR imageries during life cycle of Depression over southwest & adjoining northeast Bay of Bengal (26th - 28th September 2025).

The system weakened into a well-marked low-pressure area by 0300 UTC of 28th September, 2025 and had been lying over West Vidarbha and adjoining North Madhya Maharashtra. As per INSAT-3D imagery, the vortex was centred near 20.3°N/76.5°E. Intense convection had been sheared to the west of the system centre. Associated scattered to broken low and medium clouds with embedded intense to very intense convection had been lying over Madhya Pradesh, Maharashtra, Konkan, Southwest Madhya Pradesh, Gujarat region, Gulf of Cambay, Eastcentral Arabian Sea off Maharashtra coasts (minimum cloud top temperature had been –70 to –90 °C) and moderate to intense convection had been lying over west Vidarbha, Saurashtra and Kutch, South Rajasthan (minimum cloud top temperature had been –40 to –60 °C).

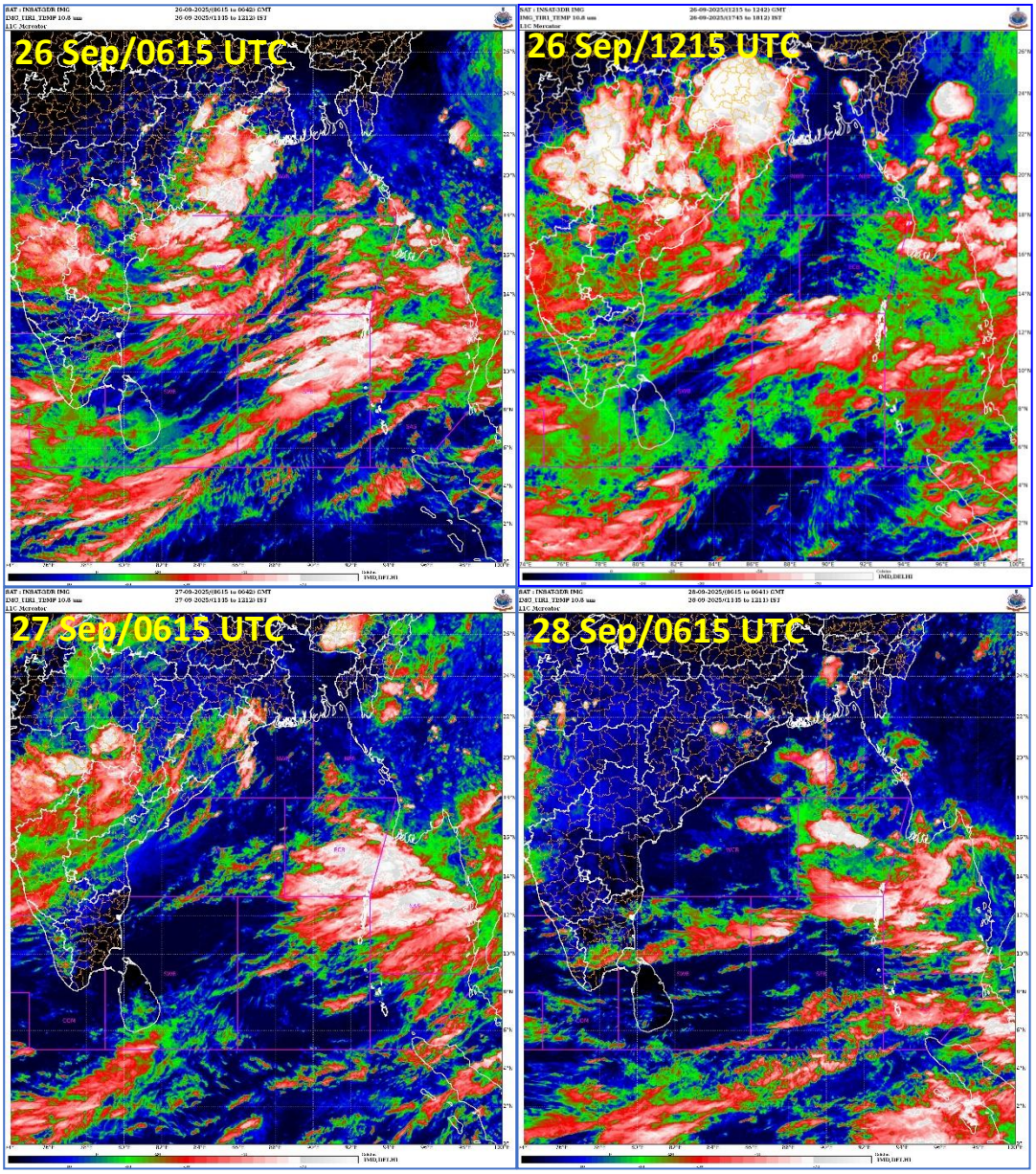


Fig.2.10.3(c): INSAT-3R NHC curve imageries during life cycle of Depression over southwest & adjoining northeast Bay of Bengal (26th - 28th September 2025).

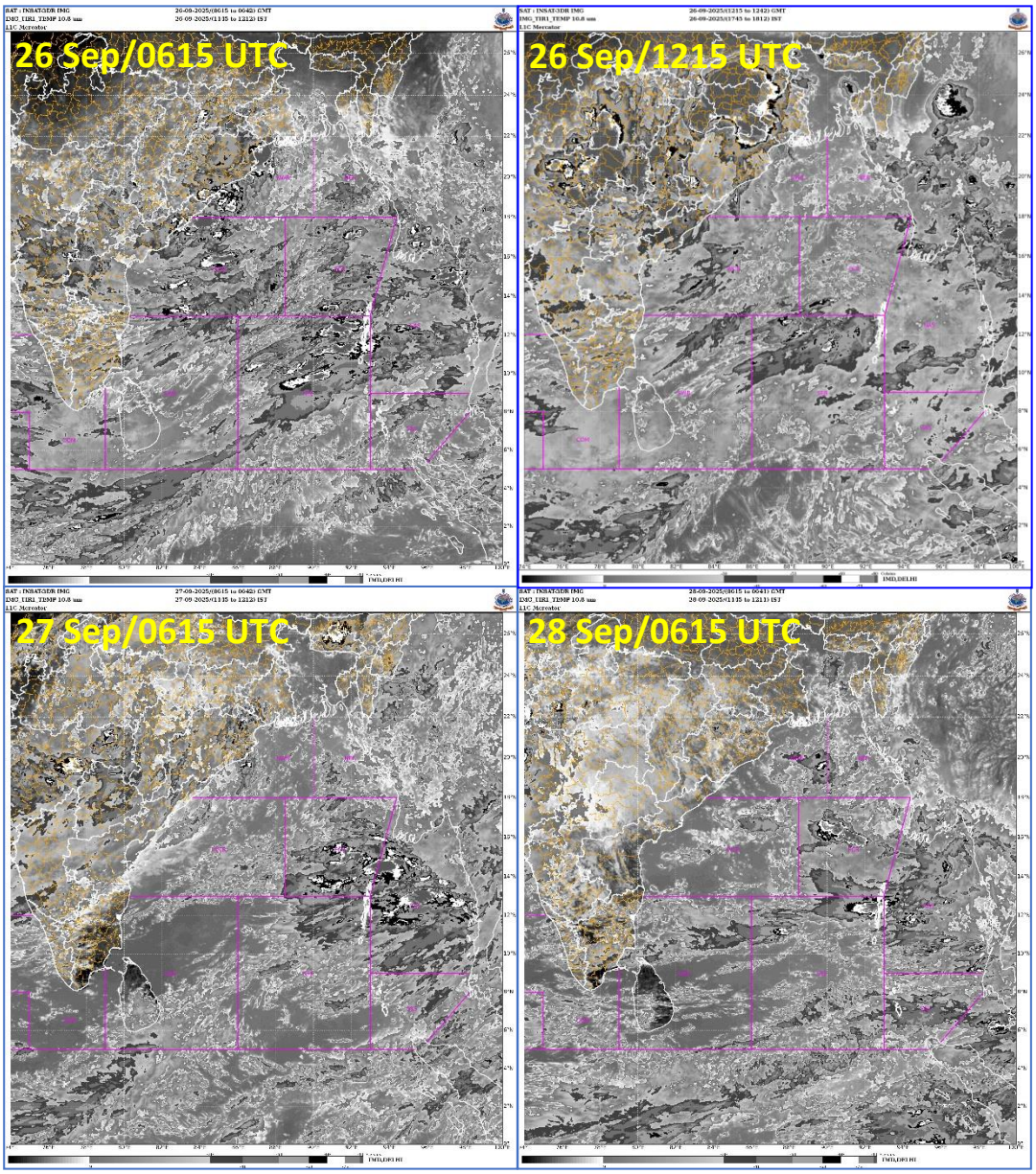


Fig.2.10.3(d): INSAT-3R BD-curve imageries during life cycle of Depression over southwest & adjoining northeast Bay of Bengal (26th - 28th September 2025).

2.10.3.2 Genesis, movement, Intensification and Weakening:

At 1200 UTC of 26 September 2025, the Madden–Julian Oscillation (MJO) was in phase 3 with amplitude less than 1 and was likely to continue in the same phase with decreasing amplitude, which was favourable for cyclogenesis over the Bay of Bengal (BoB). NCICS–CFS guidance indicated Equatorial Rossby Waves with enhanced low-level westerly wind anomalies (5–7 m s^{-1}) over the south and central BoB and easterly wind anomalies (1–3 m s^{-1}) over the northern BoB, leading to phase locking of equatorial waves and enhancement of genesis parameters. CIMSS diagnostics showed strong low-level cyclonic vorticity (~100 × 10^{-6} s^{-1}) extending up to 500 hPa, along with low-level convergence (~15 ×

10^{-6} s^{-1}) and upper-level divergence (10–20 × 10^{-6} s^{-1}). Easterlies in the middle and upper tropospheric levels steered the system westwards, while deep- and mid-layer vertical wind shear remained low (05–10 kt) and anticyclonic. Under these conditions, the well-marked low-pressure area over the northwest and adjoining central BoB moved west-northwestwards, intensified into a depression and lay centred at 1200 UTC of 26 September over the northwest and adjoining westcentral BoB off the south Odisha–north Andhra Pradesh coasts.

The depression moved nearly westwards and lay centred at 1800 UTC of 26 September over the northwest BoB close to the south Odisha coast. The MJO was in phase 2 with amplitude less than 1 and environmental conditions remained broadly similar. The system continued to move westwards and crossed the south Odisha coast near Gopalpur around 2300 UTC of 26 September.

At 0000 UTC of 27 September 2025, the depression lay centred over south coastal Odisha. The MJO remained in phase 3 with amplitude less than 1. CIMSS guidance indicated strong low-level vorticity (~100 × 10^{-6} s^{-1}) extending up to 400 hPa, with enhanced low-level convergence (~20 × 10^{-6} s^{-1}) shifting inland and upper-level divergence (~20 × 10^{-6} s^{-1}) to the west of the system. Easterlies in the middle and upper tropospheric levels steered the system westwards, while deep- and mid-layer vertical wind shear remained low to moderate (10–15 kt) and anticyclonic, which was favourable for maintenance of intensity. Total precipitable water imagery indicated warm, moist air incursion into the core from the BoB, though some dry air intrusion was noted far to the south.

The depression moved westwards and lay centred at 0300 UTC of 27 September over south interior Odisha, continued westwards to lie centred at 0600 UTC over south interior Odisha and adjoining north Andhra Pradesh and south Chhattisgarh, and thereafter moved west-northwestwards to lie centred at 1200 UTC over south Chhattisgarh and neighbourhood. During this period, the MJO was in phase 2 with amplitude less than 1. The system maintained low-level vorticity of about 70–80 × 10^{-6} s^{-1} extending up to 500 hPa, with low-level convergence of 05–10 × 10^{-6} s^{-1} over the system area and enhanced convergence of 10–15 × 10^{-6} s^{-1} to the west of the centre. Upper-level divergence of about 20 × 10^{-6} s^{-1} persisted to the west of the system centre. Easterlies to east-southeasterlies steered the system westwards to west-northwestwards, while mid-level vertical wind shear remained low to moderate (10–15 kt) and anticyclonic.

Thereafter, the depression over south Chhattisgarh and neighbourhood moved nearly westwards across south Chhattisgarh and Vidarbha and weakened into a well-marked low-pressure area over west Vidarbha and adjoining north Madhya Maharashtra at 0300 UTC of 28 September 2025. During this stage, low-level vorticity of about 70–80 × 10^{-6} s^{-1} extending up to 500 hPa, along with low-level convergence (~15 × 10^{-6} s^{-1}) and upper-level divergence (~20 × 10^{-6} s^{-1}) to the west of the system centre, persisted. The east-southeasterlies in the middle and upper tropospheric levels continued to steer the system west-northwestwards, while mid-level vertical wind shear remained moderate (10–15 kt) and anticyclonic.

2.10.4. Model Guidance:

IMD GFS (T1534) model daily analyses of mean sea level pressure (MSLP) and winds at 10m (surface), 850, 500 and 200 hPa levels from 26th August - 28th September are presented in **Fig. 2.10. 4a to 4c** respectively.

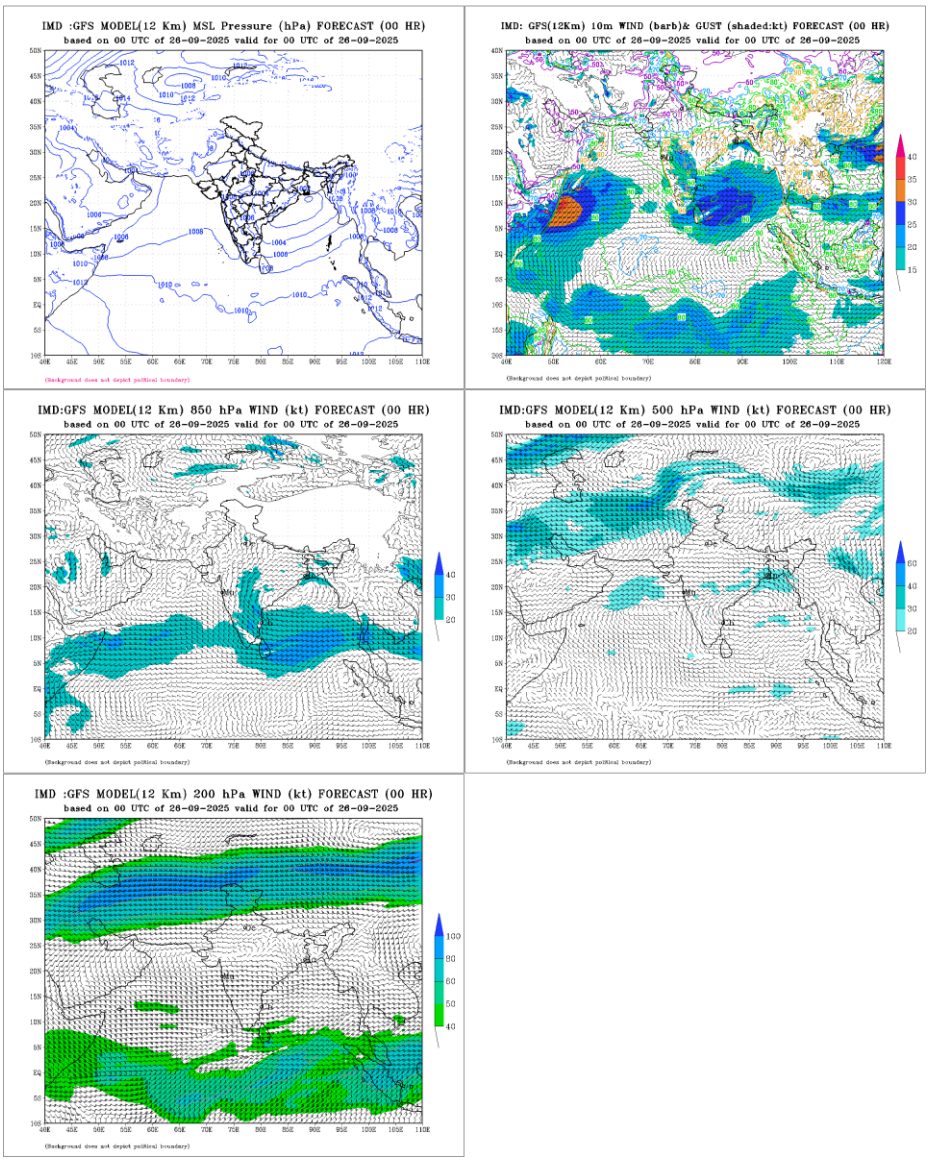


Fig. 2.10.4(a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 26th Sep 2025.

The MSLP and upper air wind analysis field on 26th September indicated that a low pressure area over northwest & adjoining westcentral BoB with associated cyclonic circulation extending upto 500 hPa level and tilting southwestwards with height. As per the best track, the intensity is of depression on the respective time over the same region. Hence, GFS is well estimated the location of the system, but underestimated the intensity.

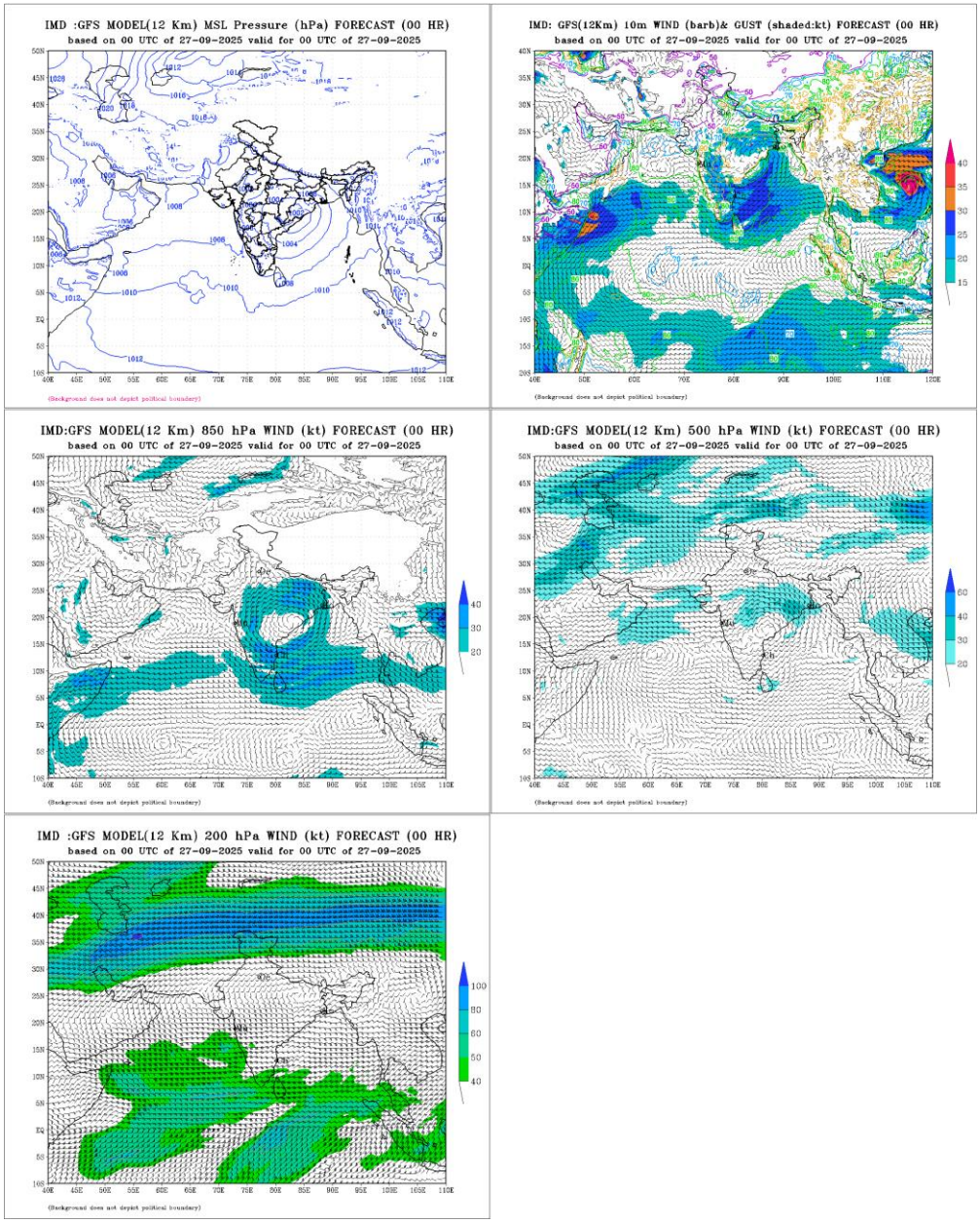


Fig. 2.10.4(b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 27th Sep 2025

The MSLP and surface wind analysis field on 27th September indicated a depression over coastal Odisha near 19.4ºN/84.5ºE. Actually, based on the best track depression it was located at 19.3°N/84.8°E at 0000 UTC of 27th September. Thus, GFS model was in close agreement with that of observed position and intensity. It also indicated that the system vertically extended up to 500 hPa level tilting west-southwestward with height.

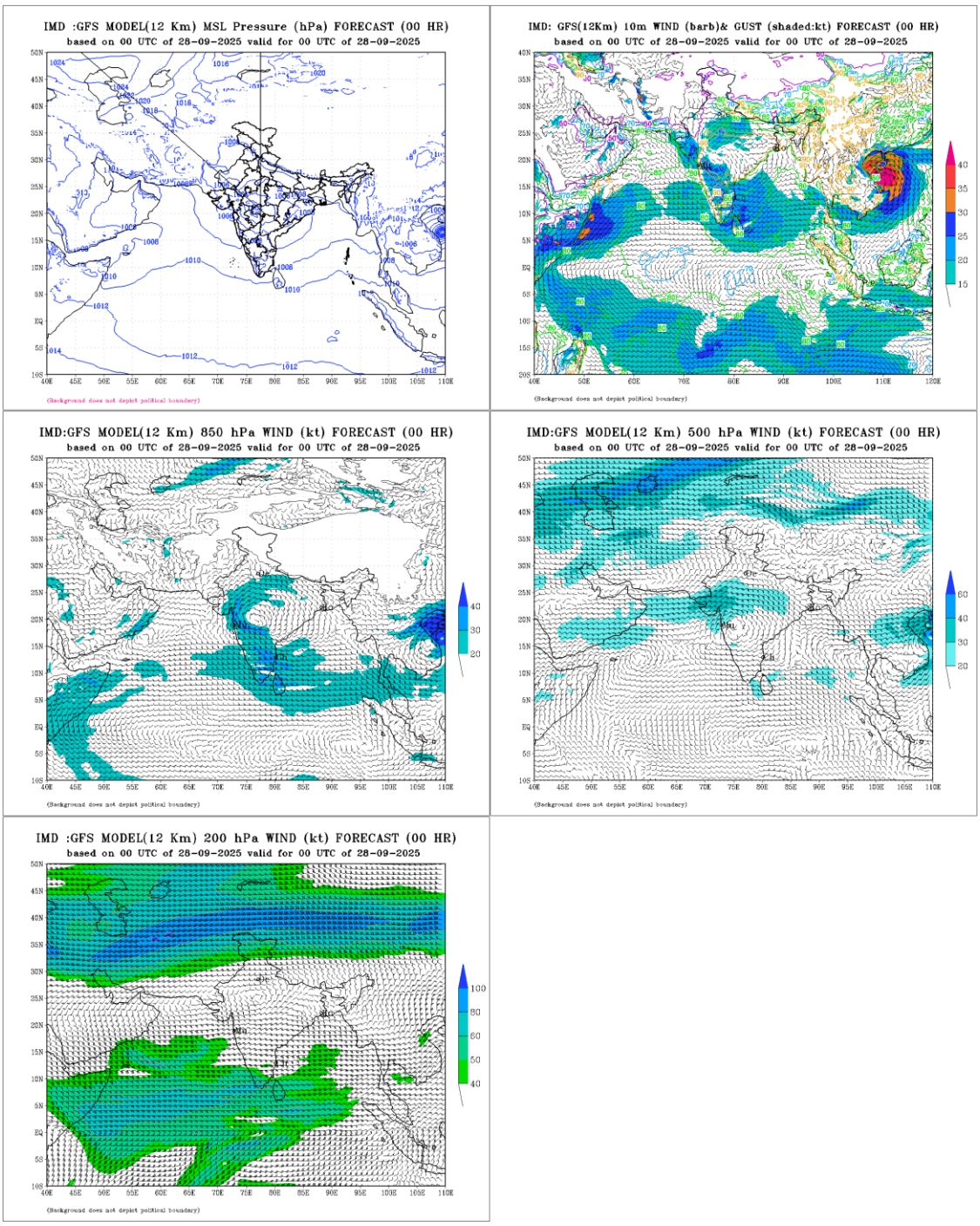


Fig. 2.10.4(c): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 28th Sep 2025

The MSLP and surface wind analysis field on 28th September indicated a depression over west Vidharba at 20.2ºN/77.0ºE. Actually, based on the best track depression it was located at 20.3°N/77.0°E at 0000 UTC of 28th September. Thus, GFS model was in close agreement with that of observed position and intensity. It also indicated that the system vertically extended up to 500 hPa level tilting west-southwestward with height.

2.10.4 Realised Weather:

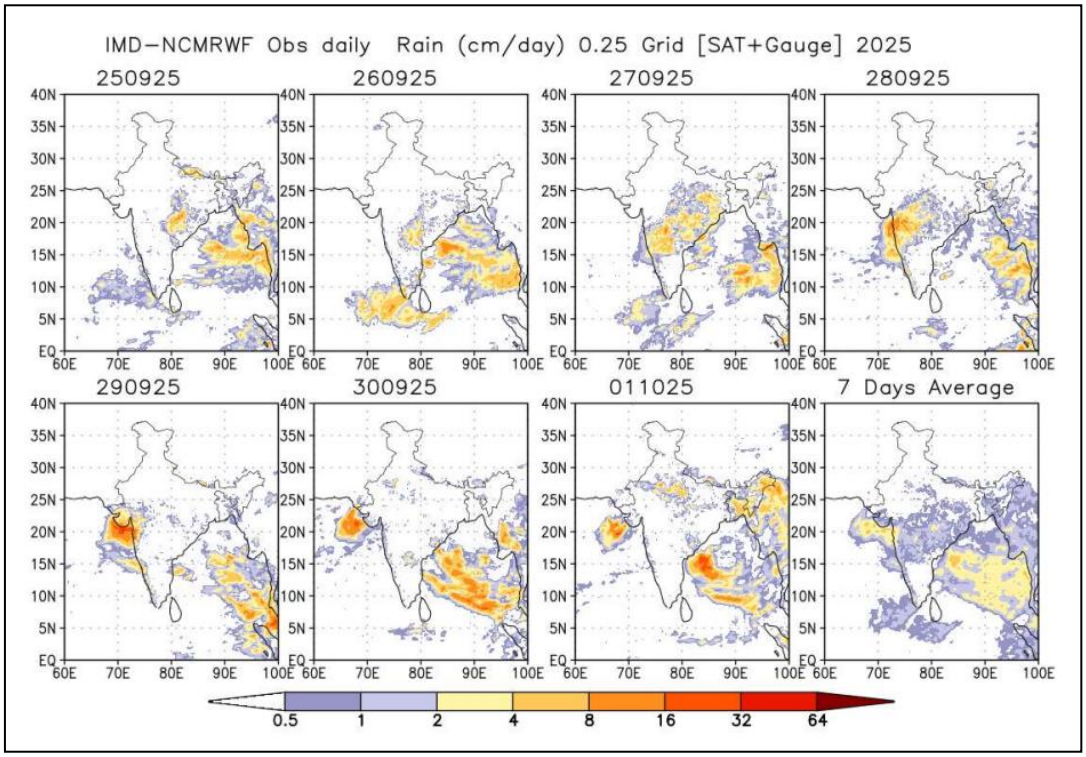


Fig.2.10.5: NCMRWF-IMD satellite gauge merged data plots of realized 24-hour accumulated rainfall from 25th September to 01st October, 2025.

Rainfall associated with the depression based on IMD–NCMRWF satellite–gauge merged data is depicted in Fig.2.10.5. On 25 September, heavy rainfall occurred at many places over the northern parts of the central Bay of Bengal (BoB) and at a few places over the northeast BoB. On 26 September, heavy rainfall occurred at some places over the north BoB and at many places over the east-central BoB, while very heavy rainfall was observed at a few places over the west-central BoB. On 27 September, heavy rainfall was recorded at many places over Odisha, south Chhattisgarh, Vidarbha, Madhya Maharashtra, and the Konkan region. On 28 September, heavy to very heavy rainfall occurred at many places over Madhya Maharashtra and the Konkan region, including along and off the Konkan and adjoining Karnataka coasts, with very heavy rainfall at a few places over north Konkan and along and off the north Konkan coast. On 29 September, heavy rainfall occurred at many places over Gujarat, while very heavy rainfall was observed at a few places over the east-central Arabian Sea, adjoining northeast Arabian Sea, and along and off the Gujarat and north Konkan coasts. On 30 September, heavy to very heavy rainfall occurred at isolated places over the northeast Arabian Sea and at a few places over the east-central Arabian Sea.

Detailed realised 24 – hour heavy rainfall (≥ 7 cm) ending at 0300 UTC of dated:

27.09.2025 /0830 hrs. IST

Marathawada: Ahmedpur (dist Latur) 17, Palam (dist Parbhani) 15, Loha (dist Nanded) 14, Chakur (dist Latur) 11, Gangakhed (dist Parbhani) 11, Naigaon Khairgaon (dist Nanded) and Aundha Nagnath (dist Hingoli) 10 each, Nilanga (dist Latur), Beed (dist Beed), Nanded- (dist Nanded) and Jalkot (dist Latur) 9 each, Kandhar (dist Nanded), Renapur (dist Latur), Ardhapur (dist Nanded) and Shirur Anantpal (dist Latur) 8 each, Vasmat (dist Hingoli), Udgir (dist Latur), Washi (dist Dharashiv), Kaij (dist Beed), Dharur (dist Beed) and Patoda (dist Beed) 7each;

Rayalaseema: Aspari (dist Kurnool) 13, Yemmiganur (dist Kurnool) 10, Dhone (dist Nandyal) 9, Alur (dist Kurnool) and Gudur (dist Kurnool) 8 each, Banaganapalle (dist Nandyal), Nandyal (dist Nandyal) and C Belagal (dist Kurnool) 7 each;

Telangana: Nawabpet (dist Vikarabad), Ghattu (dist Jogulamba Gadwal) and Kataram (dist J. Bhupalpally) 12 each, Mominpet (dist Vikarabad), Aiza (dist Jogulamba Gadwal), Chinna Chinta Kunt (dist Mahabubnagar) and Kondapur (dist Sangareddy) 11 each, Vicarabad (dist Vikarabad), Maldakal (dist Jogulamba Gadwal) and Gandeed (dist Mahabubnagar) 10 each, Kondurg (dist Rangareddy) and Venkatapuram (dist Mulugu) 9 each, Pargi (dist Vikarabad), Waddepalli (dist Jogulamba Gadwal), Hanwada (dist Mahabubnagar), Atmakur Wnp (dist Wanaparthy), Itikyal (dist Jogulamba Gadwal), Aswapuram (dist B. Kothagudem) and Peddapalle (dist Peddapalle) 8 each, Peddemul (dist Vikarabad), Bhadrachalam (dist B. Kothagudem), Narva (dist Narayanpet), Burgampadu (dist B. Kothagudem), Marpalle (dist Vikarabad), Banswada (dist Kamareddy), Chennur (dist Mancherial), Shadnagar(arg) (dist Rangareddy) and Horti Univ Mojerla(a) (dist Wanaparthy) 7 each;

Odisha: Salebhatta (dist Bolangir) 12, Aska (dist Ganjam), Umarkote (dist Nawarangpur), Patnagarh (dist Bolangir) & Jhorigam (dist Nawarangpur) 9 each and Turekela (dist Bolangir), Titlagarh (dist Bolangir), Dharakote (dist Ganjam), Danagadi (dist Jajpur) & Agalpur (dist Bolangir) 8 each, Gaisilet (dist Bargarh), Koksara (dist Kalahandi), Astaranga (dist Puri), Nawana (dist Mayurbhanj), Mathili (dist Malkangiri), Paikmal (dist Bargarh), Bijepur (dist Bargarh), Mahanga (dist Cuttack), Betanati (dist Mayurbhanj), Chandrapur (dist Rayagada), Bhawanipatna (dist Kalahandi), Nawapara (dist Nawapara), Barpalli (dist Bargarh), Ullunda (dist Sonepur) & Derabis (dist Kendrapara) 7 each;

Chhattisgarh: Marri Bangla Deori (dist Balod) 11, Rajnandgaon (dist Rajnandgaon), Bade Bacheli (dist Dantewada) and Chhotedongar (dist Narayanpur) 8 each, Dondilohara (dist Balod), Durgkondal (dist Kanker), Ambagarh Chowki (dist Mohala Manpur Chowki), Arjunda (dist Balod) and Tongpaal (dist Sukma) 7 each;

Madhya Maharashtra: Jeur (dist Sholapur) 11, Kavathe Mahakal (dist Sangli), Pandharpur (dist Sholapur), Miraj (dist Sangli) and Sangli - (dist Sangli) 7 each;

Konkan: Mhasla (dist Raigad) 10, Savarde- (dist Ratnagiri) 7;

Coastal Andhra Pradesh: Kunavaram (dist Alluri Sitharamaraju) 8;

Gangetic West Bengal: Purihansa (dist Purulia) 7;

28.09.2025 /0830 hrs. IST

Konkan: Palghar_ (dist Palghar) 18, Dahanu(dist Palghar) 13, Colaba (dist Mumbai), Murbad (dist Thane) and Thane (dist Thane) 12 each, Jawhar (dist palghar) and Mandangad (dist Ratnagiri), Vikramgad (dist Palghar) 11 each, Mangaon (dist Raigad)10, Khed (dist Ratnagiri), Pen (dist Raigad), Sudhagad Pali (dist Raigad), Wada (dist Palghar) and Shriwardhan (dist

Raigad) 9 each, Matheran (dist Raigad), Vasai (dist Palghar), Tala (dist Raigad), Santacruz (dist Mumbai Suburban), Mokheda (dist Palghar), Dapoli (dist Ratnagiri) , Mhasla (dist Raigad), Uran (dist Raigad), Poladpur (dist Raigad) and Tbia (dist Thane) 8 each, Karjat (dist Raigad), Talasari (dist Palghar), Mahad (dist Raigad), Wakwali (dist Ratnagiri), Harnai (dist Ratnagiri), Shahapur (dist Thane) and Savarde (dist Ratnagiri) 7 each,

Madhya Maharashtra: Surgana (dist Nashik) 17, Harsul (dist Nashik) 16, Nandgaon (dist Nashik) 15, Rahuri (dist Ahilyanagar) and Kopargaon (dist Ahilyanagar) 13 each, Shevgaon (dist Ahilyanagar) and Yeola (dist Nashik) 12 each, Nevasa (dist Ahilyanagar) 11, Shrirampur (dist Ahilyanagar) 11, Peth (dist Nashik) and Jamkhed (dist Ahilyanagar) 10 each, Ozharkheda (dist Nashik), Chalisgaon (dist Jalgaon), Lonavala (dist Pune) and Ahilyanagar - (dist Ahilyanagar) 9 each, Pathardi (dist Ahilyanagar), Bhadgaon (dist Jalgaon), Trimbakshwar (dist Nashik), Erandol (dist Jalgaon), Pimpalgaonbaswanti (dist Nashik), Pachora (dist Jalgaon) , Dindori (dist Nashik) and Niphad (dist Nashik) 8 each, Ambegaon Ghodegaon (dist Pune), Malegaon Camp (dist Nashik), Dharangaon (dist Jalgaon), Shahuwadi (dist Kolhapur), Savlivihir (dist Ahilyanagar), Chasi (dist Ahilyanagar), Nashik (dist Nashik), Sangola (dist Sholapur), Sinnar (dist Nashik) , Akole (dist Ahilyanagar), Jamner (dist Jalgaon), Nandurbar (dist Nandurbar), Mulher (dist Nashik), Igatpuri (dist Nashik), Devla (dist Nashik) and Talegaon (dist Pune) 7 each.

Gujarat Region: Nanipalson (dist Valsad) 15, Kaprada (dist Valsad) 12, Silvassa (dist Dadara & Nagar Haveli) 11, Madhbun (dist Dadara & Nagar Haveli) and Dangs (ahwa) (dist Dangs) 10 each, Waghai (dist Dangs) and Dang (dist Dangs) 8 each, Daman (dist Daman), Pardi (dist Valsad) and Subir (dist Dangs) 7 each,

Marathwada: Loha (dist Nanded) and Kannad (dist Chh. Sambhajinagar) 13 each, Vaijapur (dist Chh. Sambhajinagar) 12, Khultabad (dist Chh. Sambhajinagar) 11, Tondapur (dist Hingoli), Phulambri (dist Chh. Sambhajinagar) and Palam (dist Parbhani) 10 each, Patoda (dist Beed), Purna (dist Parbhani), Gangapur (dist Chh. Sambhajinagar), Dharur (dist Beed), Shirur Kasar (dist Beed), Washi (dist Dharashiv), Kallamnuri (dist Hingoli), Vasmat (dist Hingoli) and Mahur (dist Nanded) 9 each, Bhum (dist Dharashiv) , Ambejogai / Mominabad (dist Beed) , Beed (dist Beed) , Manjlegaon (dist Beed), Aundha Nagnath (dist Hingoli) and Bhokardan (dist Jalna) 8 each, Georai (dist Beed), Wadawani (dist Beed), Ambad (dist Jalna), Sengaon (dist Hingoli) and Soegaon (dist Chh. Sambhajinagar) 7 each,

West Madhya Pradesh: Khirkiya-arg (dist Harda) 11, Harda (dist Harda), Dolariya (dist Narmadapuram) ,Bhikangaon (dist Khargone) and Timarni (dist Harda) 7 each, Vidarbha: Umerkhed (dist Yeotmal) and Lonar (dist Buldhana) 9 each, Mahagaon (dist Yeotmal) 8, Sakoli (dist Bhandara), Digras (dist Yeotmal) and Sindkhed Raja (dist Buldhana) 7 each,

Odisha: Harichandanpur (dist Keonjhargarh) 8

29.09.2025 /0830 hrs. IST

Saurashtra & Kutch: Diu (dist Diu) 26; Sutrapada (dist Gir Somnath) 22; Mangrol(j) (dist Junagadh) 18; Una (dist Gir Somnath) 14; Kodinar (dist Gir Somnath) 13; Veraval (dist Gir Somnath), Talala (dist Gir Somnath), Keshod (dist Junagadh) 12 Each; Visavadar (dist Junagadh), Kalyanpur (dist Devbhoomi Dwarka) 10 Each; Khambhalia (dist Devbhoomi Dwarka), Malia (dist Junagadh) 9 Each; Gir Gadhada (dist Gir Somnath) 8; Amreli (dist Amreli), Mahuva (dist Bhavnagar), Bhesan (dist Junagadh), Bagasra (dist Amreli), Babra (dist Amreli) 7 Each;

Konkan & Goa: Talasari (dist Palghar) 24; Jawhar (dist Palghar), Palghar (dist Palghar) 18 Each; Vikramgad (dist Palghar), Wada (dist Palghar) 17 Each; Murbad (dist Thane) 14; Matheran (dist Raigad), Mokheda - (dist Palghar) 13 Each; Vasai (dist Palghar), Dahanu (dist Palghar) 12 Each; Bhiwandi (dist Thane) 11; Shahapur (dist Thane), Colaba (dist Mumbai City) 10 Each;

Panvel (dist Raigad), Canacona (dist South Goa), Ambernath (dist Thane) 9 Each; Santacruz (dist Mumbai Suburban), Tbia (dist Thane), Thane (dist Thane), Uran (dist Raigad) 8 Each; Mangaon (dist Raigad), Harnai (dist Ratnagiri), Karjat (dist Raigad), Pen (dist Raigad), Khalapur (dist Raigad), Kalyan (dist Thane), Ulhasnagar (dist Thane) 7 Each;

Gujarat Region: Khanvel (dist Dadara & Nagar Haveli) 24; Madhbun (dist Dadara & Nagar Haveli) 22; Silvassa (dist Dadara & Nagar Haveli) 19; Nanipalson (dist Valsad) 13; Vapi (dist Valsad), Umergam (dist Valsad), Kaprada (dist Valsad) 11 Each; Dharampur (dist Valsad), Ankleshwer (dist Bharuch), Bharuch (dist Bharuch), Dediapada (dist Narmada) 10 Each; Daman (dist Daman) 9; Pardi (dist Valsad), Valsad (dist Valsad), Umerpada (dist Surat) 8 Each; Hansot (dist Bharuch), Devgadh Baria (dist Dahod), Daman (dist Daman), Jhagadia (dist Bharuch), Daman (dist Daman) 7 Each;

Madhya Maharashtra: Ozharkheda - (dist Nashik) 19; Harsul - (dist Nashik) 14; Nandgaon (dist Nashik) 12; Lonavala (dist Pune), Trimbakshwar (dist Nashik) 10 Each; Peth (dist Nashik) 8; Igatpuri (dist Nashik) 7; Coastal Karnataka: Honavar (dist Uttara Kannada), Manki (dist Uttara Kannada), Shirali (dist Uttara Kannada), Gersoppa (dist Uttara Kannada) 12 Each; Kumta (dist Uttara Kannada) 10; Gokarna (dist Uttara Kannada) 9; Karwar (dist Uttara Kannada) 8; Ankola (dist Uttara Kannada) 7;

West Madhya Pradesh: Nasrullahganj (dist Sehore) 10;

South Interior Karnataka: Hunchadakatte (dist Shivamogga) 7

2.11 Deep Depression over Westcentral Bay of Bengal during 01st October-03rd October 2025

2.11.1 Life history

- An upper-air cyclonic circulation formed over the eastcentral Bay of Bengal (BoB) and neighbourhood in the afternoon (1430 hrs IST/0900 UTC) of 30th September 2025.
- Under its influence, a low-pressure area formed over westcentral BoB in the evening (1730 hrs IST/1200 UTC) of 30th September 2025.
- This system further intensified into a well-marked low pressure area over the same region in the morning (0530 hrs IST/0000 UTC) of 01st October 2025.
- It moved north-northwestwards and concentrated into a depression over westcentral BoB around noon (1130 hrs IST/0600 UTC) of 01st October 2025, subsequently intensified into a deep depression in the midnight (2330 hrs IST/ 1800 UTC) of 01st October 2025.
- Continuing to move north-northwestwards, it crossed Odisha coast close to Gopalpur as a deep depression with maximum sustained wind speed of 55-65 gusting to 75 kmph during (1530-1730 hrs IST/1000-1200 UTC) of 2nd October 2025.
- Thereafter, it moved further north-northwestwards and weakened into a depression over interior Odisha in the early morning (0530 hrs IST/0000 UTC) of 3rd October and into a well-marked low pressure area over North Chhattisgarh & adjoining areas of north interior Odisha & Jharkhand in the same evening (1730 hrs IST/1200UTC) of 3rd October 2025.

The observed track of the system is presented in **Fig.2.11.1**. The best track parameters are presented in **Table2.11.1.**

Fig. 2.11.1: Observed track of Deep Depression over westcentral Bay of Bengal during 01st October-03rd October 2025

Table2.11.1: Best track positions and other parameters of the Deep Depression over Westcentral Bay of Bengal during 01st October-03rd October 2025

.	Time (UTC)	Lat. (^{0}N)	Long. (^{0}E)	C.I. No.	ECP (hPa)	ΔP (hPa)	MSW (kt)	Category
01-10-2025	0600	15.8	86.5	1.5	998	3	25	D
	1200	16.3	86.3	1.5	997	4	25	D
	1800	16.8	86	2.0	996	5	30	DD
02-10-2025	0000	17.7	85.7	2.0	996	5	30	DD
	0300	18.0	85.6	2.0	995	6	30	DD
	0600	18.6	85.3	2.0	995	6	30	DD
	Crossed Odisha coast close to Gopalpur as a deep depression with maximum sustained wind speed of 55-65 gusting to 75 kmph during 1000-1200 UTC of 2nd October 2025.							
	1200	19.4	84.9	-	996	5	30	DD
	1800	19.8	84.4	-	997	5	30	DD
03-10-2025	0000	20.2	84.1	-	999	4	25	D
	0300	20.7	83.7	-	1000	4	25	D
	0600	21.2	83.6	-	1001	3	25	D
	Weakened into a well-marked low-pressure area over north Chhattisgarh & adjoining areas of north interior Odisha & Jharkhand							

KT: Knots (nautical mile per hour), 1 KT=1.85 kmph, D: Depression, DD: Deep Depression

2.11.2 Salient features:

- The life period of the system was 48 hours which is below normal for depressions over BoB during post monsoon season against the normal of 52 hrs.
- Climatologically about 28 cyclonic disturbances (CDs) formed over the westcentral BoB during the period of 1965-2024 in the month of October, out of which 19 were depressions/deep depression (D/DD), 5 intensified into cyclonic storms (CS) and 4 intensified further into severe cyclonic storms (SCS).
- There was only one cyclonic disturbance formed over westcentral BoB which crossed the Odisha coast in the month of October during 1965-2024.
- The depression developed simultaneously along with the Severe Cyclonic Storm Shakhti over the Arabian Sea during 1-7 October. However, the system over the AS intensified into a severe cyclonic storm and the system over BoB reached peak intensity of deep depression only.
- Last such activity was seen in 2024 with Cyclone Asna over AS (25 Aug-02 Sep) and depression over westcentral BoB (31 Aug-02 Sep).

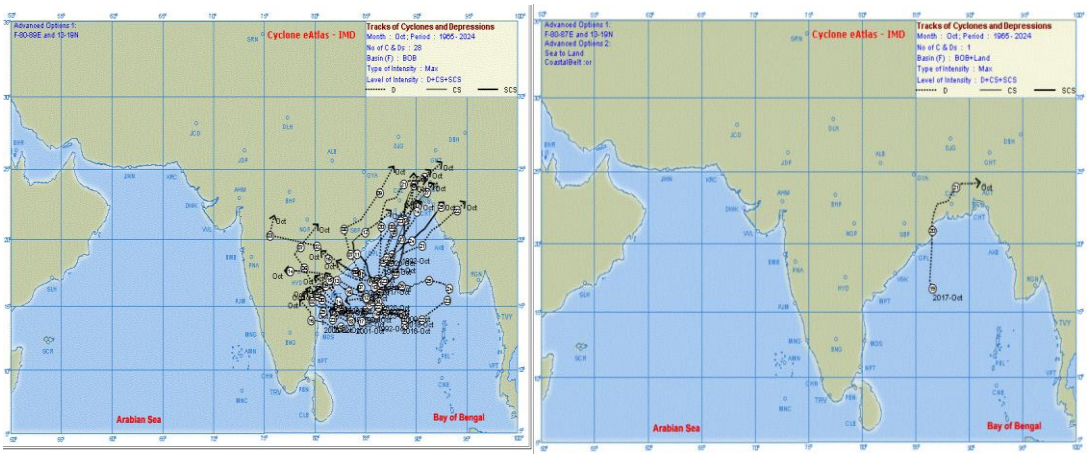


Fig.2.11.2(a) Tracks of Cyclonic disturbances over the westcentral BoB in the month of October (b) track of cyclonic disturbances crossed Odisha in the month of October during 1965-2024

2.11.3 Monitoring Deep Depression

India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean (NIO) and the system was monitored well in advance since 18th September about 13 days prior to formation of depression on 01st October. First information about the system was realized in the weekly extended range outlook issued by IMD on 18th May, indicating formation of depression over eastcentral and adjoining westcentral BoB during week 2 (26.09.2025-02.10.2025) with moderate probability (34-67%). The updated extended range outlook issued on 25th September, further reiterated the forecast and indicated formation of a depression over westcentral BoB with high confidence (68-100%). The depression formed over westcentral BoB on 01st October.

The system was monitored with the help of available satellite observations from INSAT 3DS, 3DR, SCAT SAT, ASCAT, microwave imageries, 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.

2.11.4 Brief life history – Genesis, intensification and movement

2.11.4.1 Genesis

An upper-air cyclonic circulation formed over the eastcentral BoB and neighbourhood in the afternoon (1430 hrs IST/0900 UTC) of 30th September. Under its influence, a low-pressure area formed over westcentral BoB in the evening (1730 hrs IST/1200 UTC) of 30th September. As per the satellite guidance at (1730 hrs IST/12 UTC) of 30th September, the low-level vorticity was about 100-150 x 10^{-6} s^{-1} around the system at 850 hPa, extending upto 500 hPa level. The low-level convergence was 10-15 x 10^{-6} s^{-1} around the system center. The upper-level divergence was about 20 x 10^{-6} s^{-1} around the system center. The south-southeasterlies prevailing in the middle to upper tropospheric levels were steering the system nearly north-northwestwards. The mid-level vertical wind shear (VWS) of horizontal wind was low to moderate (05-15 kts) near and to the southwest of the system center and was anticyclonic over the system area and along the predicted path, which were favorable

conditions for intensification of the system. Thus, system intensified into a well-marked low pressure area over the same region in the morning (0530 hrs IST/0000 UTC) of 01st October.

2.11.4.2 Intensification and movement

The Madden Julian Oscillation (MJO) index was in phase 2 with amplitude greater than 1 and remained in the same phase with amplitude greater than 1 for next 2 days. The NCICS based forecast of zonal winds indicated an extension of westerly wind anomaly (5-7 m/s) over south BoB along with Equatorial Rossby wave (ERW), MJO and Kelvin wave (KW) activity during next three days. Further, it indicated a strong easterly wind anomaly (5-7 m/s) to its north over northwest India. All these were favorable for intensification of the system.

As per satellite guidance at (0830 hrs IST/0300 UTC) of 01st October, the low-level vorticity increased to 150-160 x 10^{-6} s^{-1} around the system at 850 hPa, extended upto 500 hPa level. The low-level convergence increased to 30-40 X 10^{-6} s^{-1} to the southwest of system center. Upper-level divergence slightly increased and was about 20-30 X 10^{-6} s^{-1} to the southwest of system center. The mid-level vertical wind shear (VWS) of horizontal wind was low to moderate (05-15kts) near and to the southwest of the system center and was anticyclonic over the system area and along the predicted path, which were favorable conditions for maintenance and further intensification of the system. Additionally, as per guidance based on INSAT-3DR imagery at 0300 UTC of 01st October, Vortex over westcentral BoB & neighbourhood centered within half a degree of 15.5N/86.8E. Intensity of the system is T1.0. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over central & adjoining south Bay of Bengal, Coastal Andhra Pradesh, Andaman Sea, Arakan coast, Gulf of Martaban and Tenasserim coasts (Minimum cloud top temperature: -70°C to -90°C).

Thus, the system moved north-northwestwards and concentrated into a depression over westcentral BoB around noon (1130 hrs IST/0600 UTC) of 01st October 2025 near latitude 15.8°N & long. 86.6°E. As per satellite imagery, the intensity was T1.5. The depression showed sheared pattern with convective clouds steered to the northwest of the system centre. Subsequently it intensified into a deep depression at midnight (2330 hrs IST/ 1800 UTC) of 01st October 2025. These conditions were favorable for the maintenance of system intensity while moving north-northwestwards towards Odisha and adjoining north Andhra Pradesh coast.

As per satellite guidance at (0830 hrs IST/0300 UTC) of 02nd October, the low-level vorticity remained 150-160 x 10^{-6} s^{-1} around the system at 850 hPa extending up to 500 hPa level. The low-level convergence was slightly reduced to 10 x 10^{-6} s^{-1} to the southwest of system center. Upper-level divergence was about 20 x 10^{-6} s^{-1} to the southwest of system center. Southeasterlies prevailing in the middle-upper tropospheric levels were steering the system nearly north-northwestward. Mid-level VWS of horizontal wind was low to moderate (05-15kts) near the system center and to the southwest of the system center and was anticyclonic over the system area and along the predicted path.

Also, as per INSAT-3DR imagery at 0300 UTC of the 02nd October, Vortex lay over westcentral BoB centered near 17.8°N/85.7°E. Intensity of the system was T2.0. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over westcentral & North BoB, Telangana, Coastal Andhra Pradesh, Odisha and Gangetic West Bengal (Minimum cloud top temperature: -70°C to -90°C). These conditions were favorable for the maintenance of system intensity while moving north-northwestwards towards Odisha and adjoining north Andhra Pradesh coast. It crossed

Odisha coast close to Gopalpur as a deep depression with maximum sustained wind speed of 55-65 gusting to 75 kmph during 1000-1200 UTC of 2nd October 2025. The system maintained the intensity of Deep Depression till 1800 UTC of 2nd October 2025. Thereafter moving north-northwestwards it weakened gradually into a depression at 0000 UTC of 3rd October due to interaction with land surface.

As per satellite guidance at (0830 hrs IST/0300 UTC) of 03rd October, the low-level vorticity was reduced to 100 x 10^{-6} s^{-1} in the southern sector of the system at 850hpa extending upto 500 hpa level. The low-level convergence was also reduced to (5-10) x 10^{-6} s^{-1} west-southwest of the system center. The upper-level divergence was about 10 x 10^{-6} s^{-1} in the northeast sector. The mid-level VWS of horizontal wind was moderate (10-15 kts) near the system center. As per INSAT 3DR imagery at 0300 UTC of the 03rd October, the system was centered near 20.5°N/83.5°E. Associated scattered to broken low and medium clouds with embedded Intense to very intense convection lay over Odisha, Chhattisgarh, East Madhya Pradesh, Vidarbha, Telangana, Odisha, coastal Andhra Pradesh (Minimum cloud top temperature 60-80°C). Estimated central pressure of the system is 1000 hPa. Associated maximum sustained wind speed is 25 kts gusting to 35 kts. The system moved further north-northwestwards moving inland and under unfavorable environment conditions weakened into a well-marked low pressure area over North Chhattisgarh & adjoining areas of north interior Odisha & Jharkhand in the evening (1730 hrs IST/1200UTC) of 3rd October 2025.

Typical INSAT-3D visible/IR, enhanced colored imageries, brightness temperature and water vapor imageries are presented in Fig. 2.11. 3(a) to (d). During the entire life cycle, the clouds were organized in shear pattern.

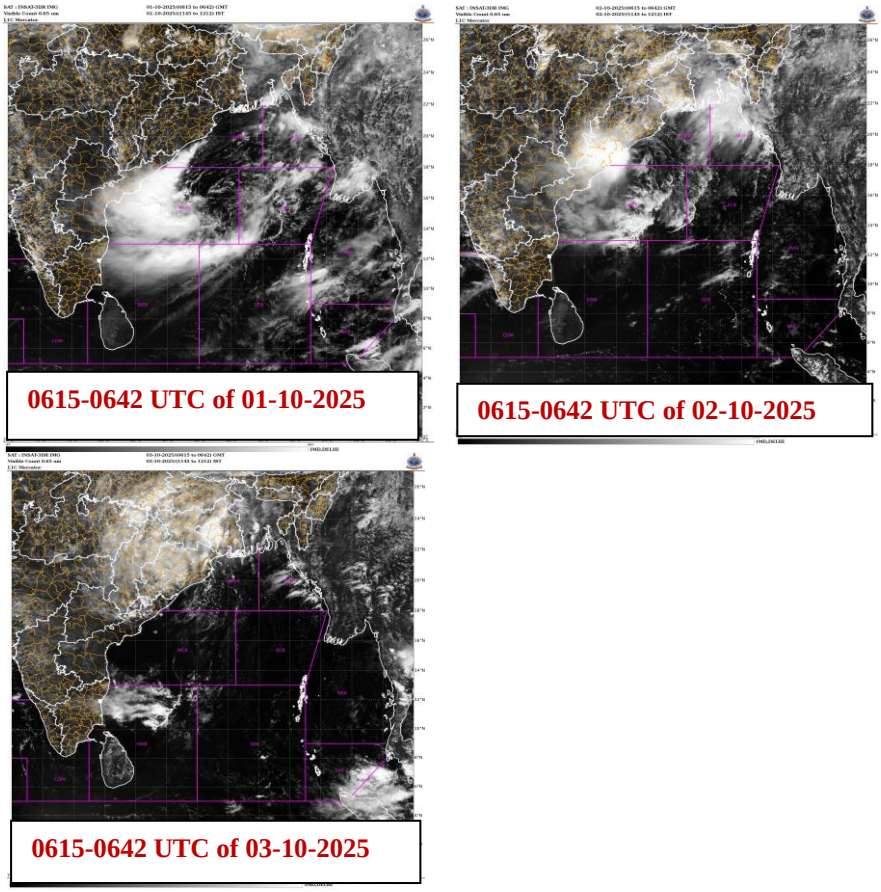


Fig.2.11.3(a) INSAT-3D Visible imagery during life cycle of Deep Depression over Westcentral Bay of Bengal during 1st October-3rd October 2025.

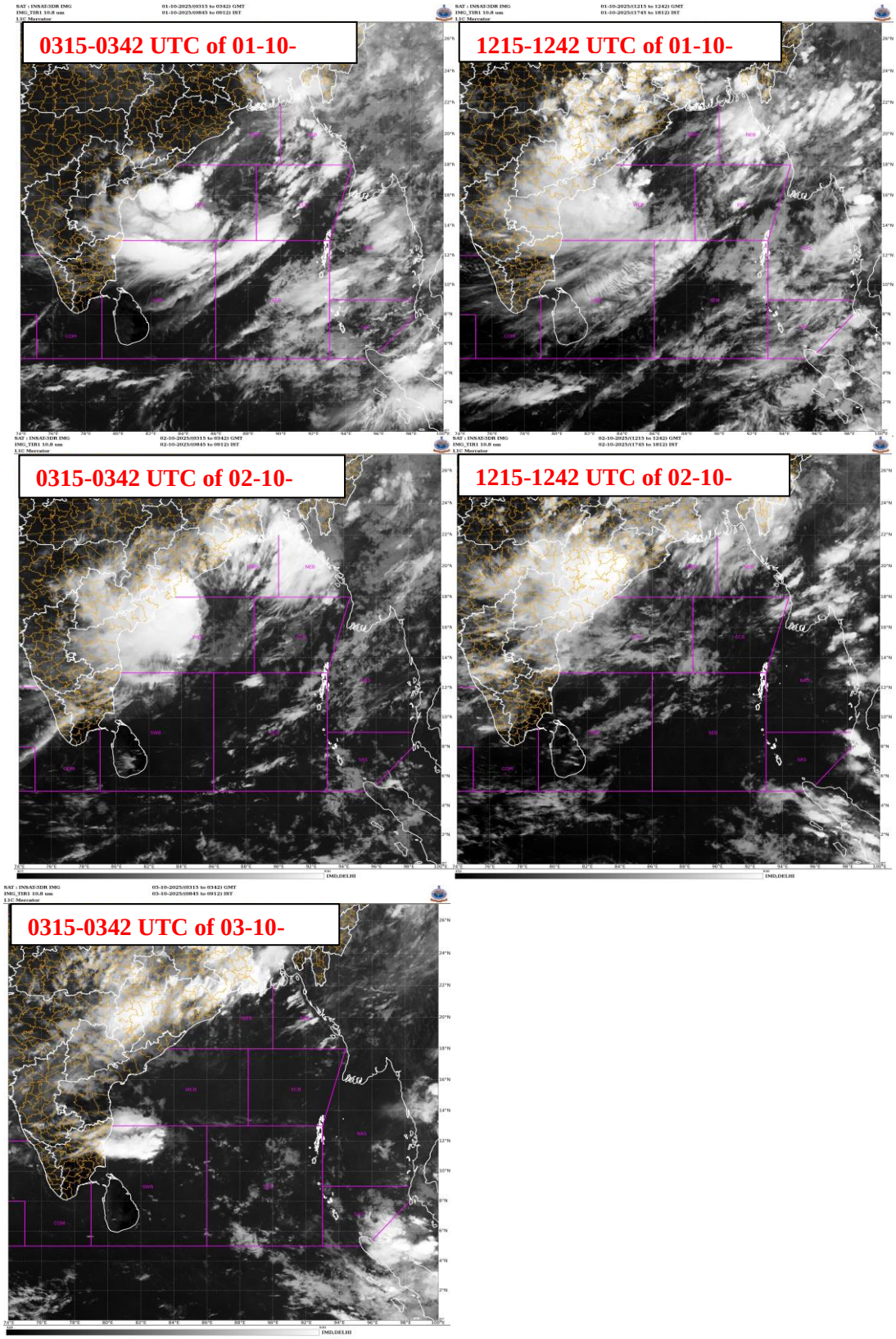


Fig.2.11.3(b) INSAT-3D IR imageries during life cycle of Deep Depression over Westcentral Bay of Bengal during 1st October-3rd October 2025

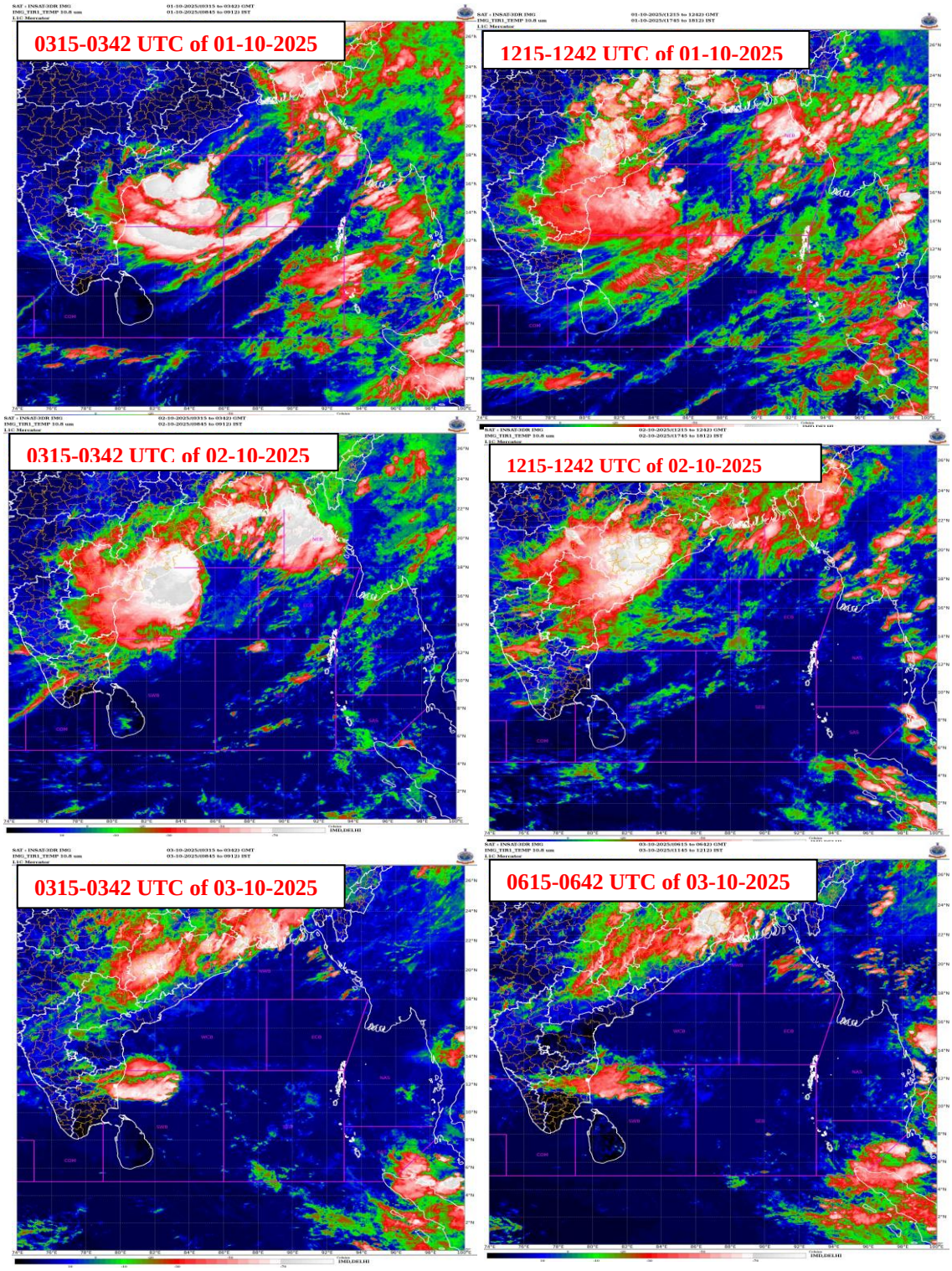


Fig.2.11.3(c) INSAT-3D enhanced colored imagery during life cycle of Deep Depression over westcentral BoB during 1st October-3rd October 2025

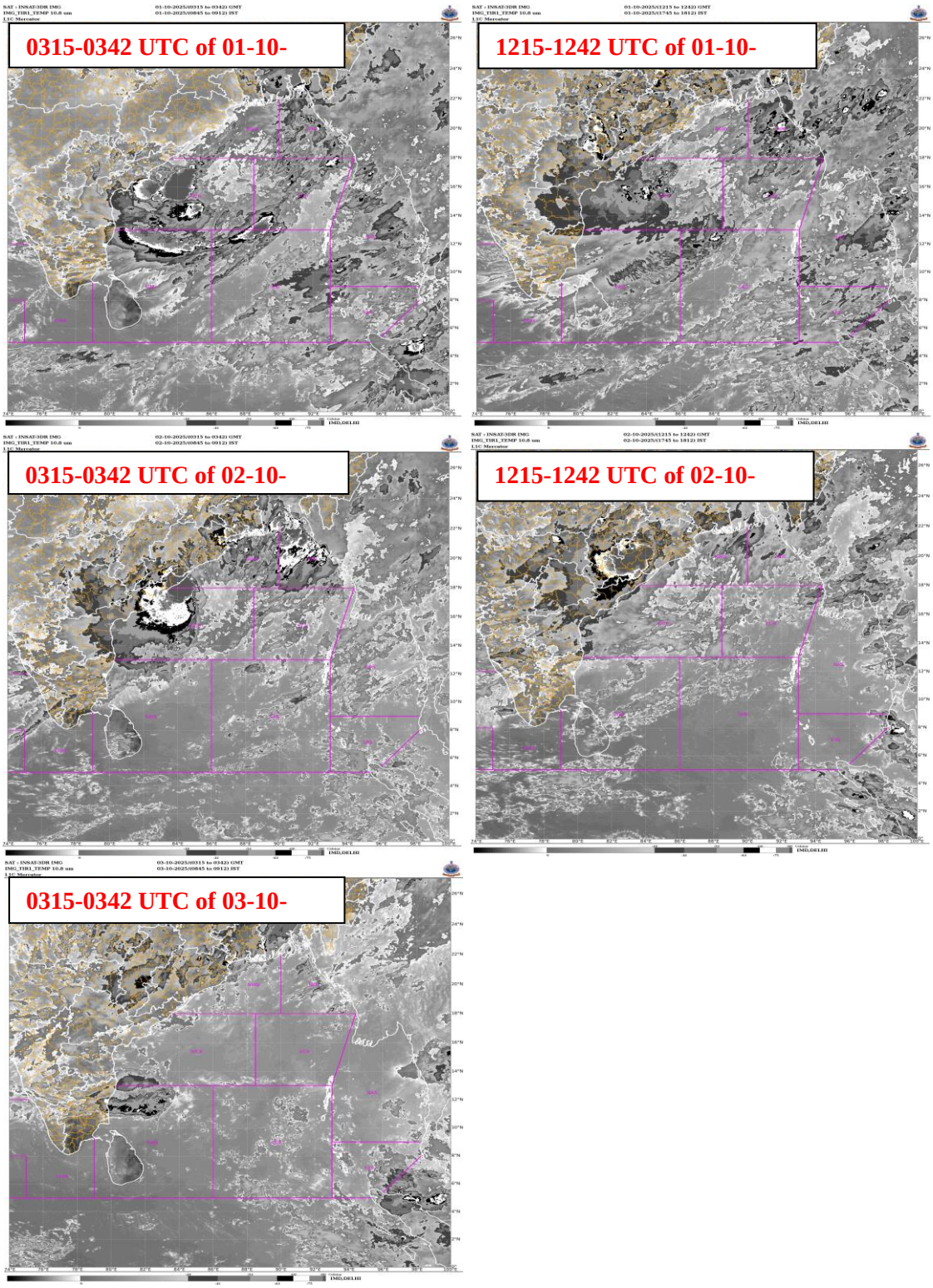


Fig.2.11.3(d) INSAT-3D BD imageries during life cycle of Deep Depression over westcentral BoB during 1st October-3rd October 2025.

ASCAT winds showed a depression over westcentral Bay of Bengal in Fig.2.11.4(a) at 1525 UTC of 01st October with the peak winds around 25kts and the deep depression over westcentral Bay of Bengal along the Odisha coast (b) at 0356 UTC of 02nd October with the peak intensity of 30kts (c) and the system crossed and weakened with peak wind along the Odisha coast were 20kts.

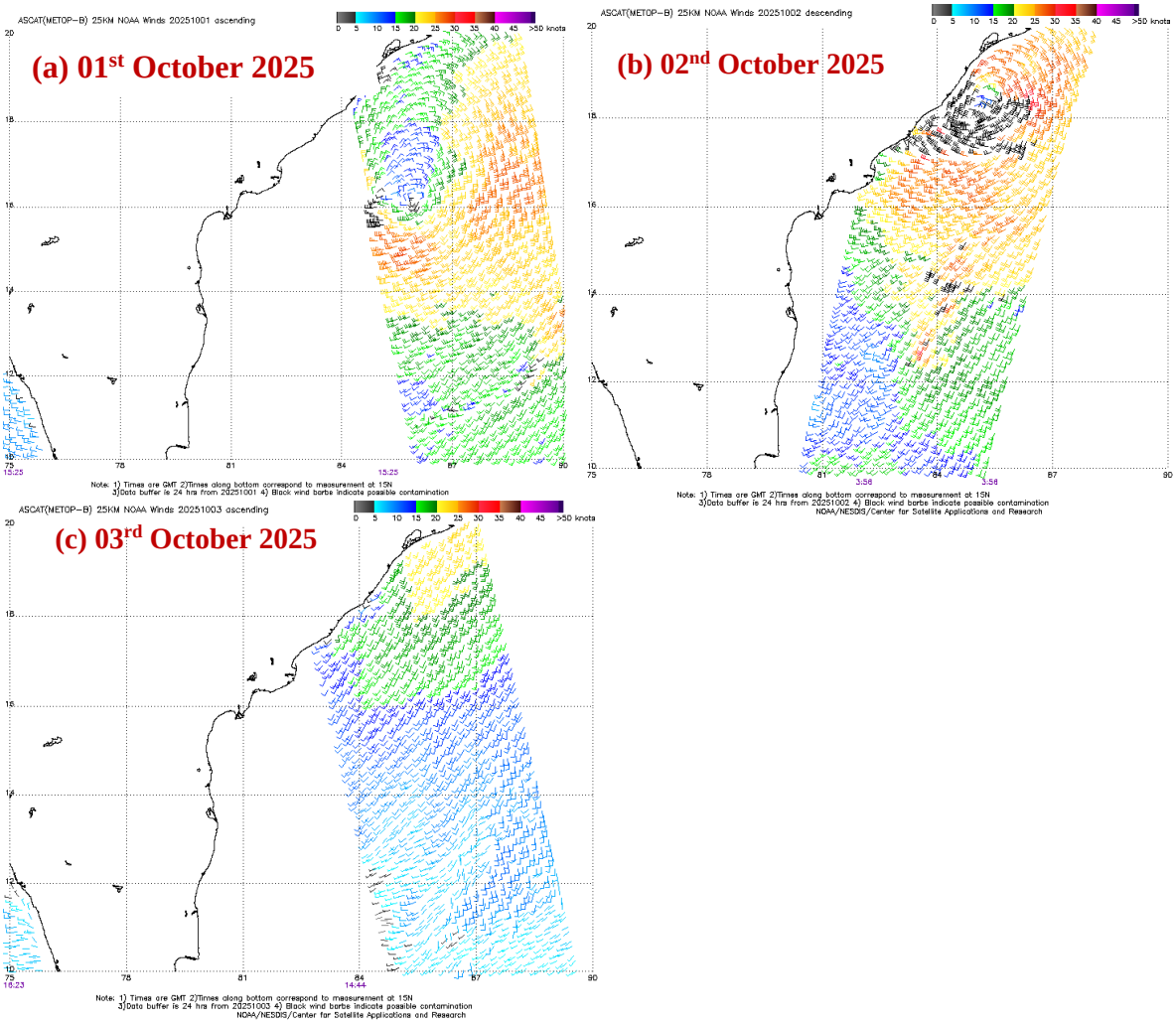


Fig.2.11.4 ASCAT based Sea Surface winds around (a) 1525UTC of 01st October (b) 0356 UTC of 02nd October (c) 1444 UTC of 03rd October during life cycle of Deep Depression over westcentral BoB.

2.11.5 Dynamical Features

IMD GFS (T1534) model daily analyses of mean sea level pressure (MSLP), and winds at 10m, 850hPa, 500hPa and 200hPa levels from 01st October to 3rd October are presented in **Fig. 2.11.5(a) to (c)** respectively.

The analysis of Fig. 2.11.5(a) indicated that a low pressure system over westcentral BoB with a single closed isobar and the associated upper air cyclonic circulation extended vertically upto 500 hPa tilting southwards with height at 0000 UTC of 01st October. Thus, GFS reasonably captured the initial conditions on 01st October. The model also captured Well Marked low pressure are over Saurashtra coast and adjoining Gulf of Kutch &

northeast Arabian Sea with the associated upper air cyclonic circulation extending vertically upto 500hPa tilting southwards with height.

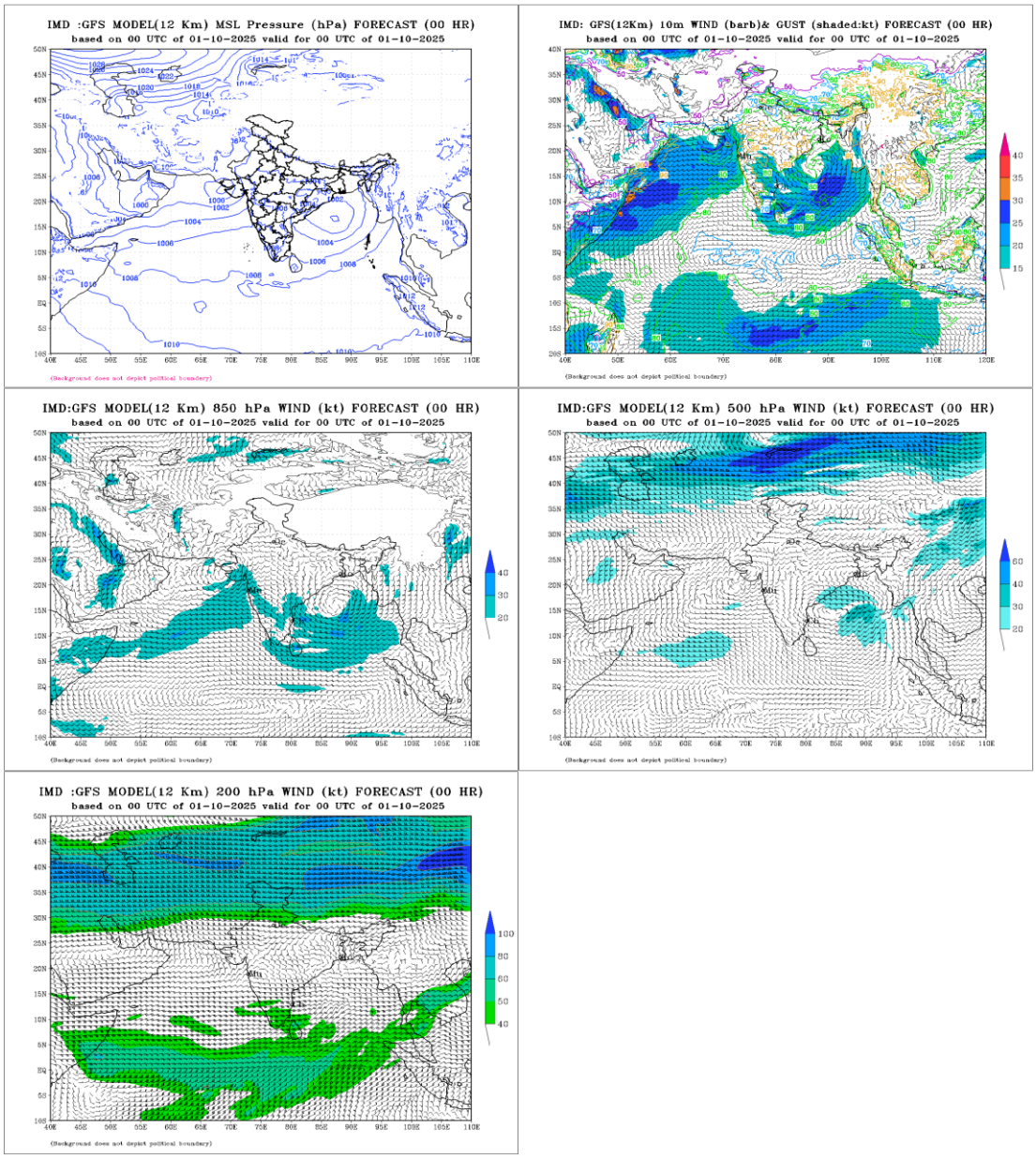


Fig.2.11.5(a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 01st October 2025.

The MSLP and upper air wind analysis at 0000 UTC of 02nd October indicated that the Bay of Bengal system intensified into a deep depression over south Odisha & north Andhra Pradesh coast adjoining westcentral Bay of Bengal with two closed isobars and the third north-south elongated isobar. The 10m wind indicates maximum winds speed of 30-35 kts along and off south Odisha & north Andhra Pradesh coast adjoining westcentral Bay of Bengal. The associated upper air cyclonic circulation extended vertically upto 500hPa tilting southwards with height. The Arabian Sea system further intensified into a depression over northeast Arabian Sea and the associated cyclonic circulation extending upto 500hPa tilting southwards with height.

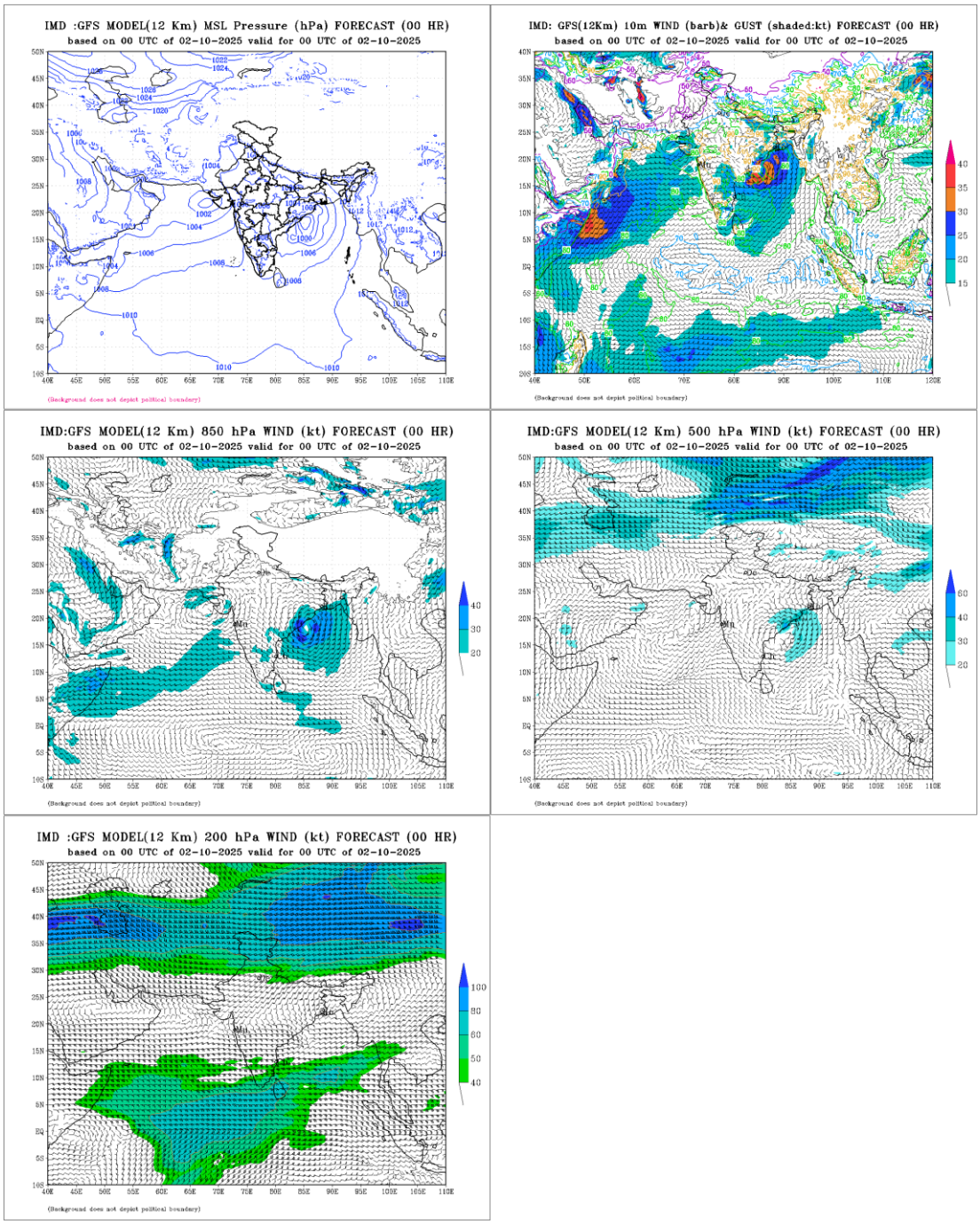


Fig.2.11.5(b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 02nd October 2025.

The analysis at 0000 UTC of 03rd October indicated that while moving north-northwestwards it weakened gradually into a depression as shown in MSLP charts over Interior Odisha and neighborhood due to interaction with land surface. The associated upper air cyclonic circulation extended vertically upto 500 hPa tilting southwards with height. At the same time the Arabian Sea system intensified further into a deep depression over northeast Arabian Sea. Due to mutual interaction and subsequently intensification of the system over northeast Arabian Sea the current system over Interior Odisha and neighborhood could not maintain its intensity and weakened into depression.

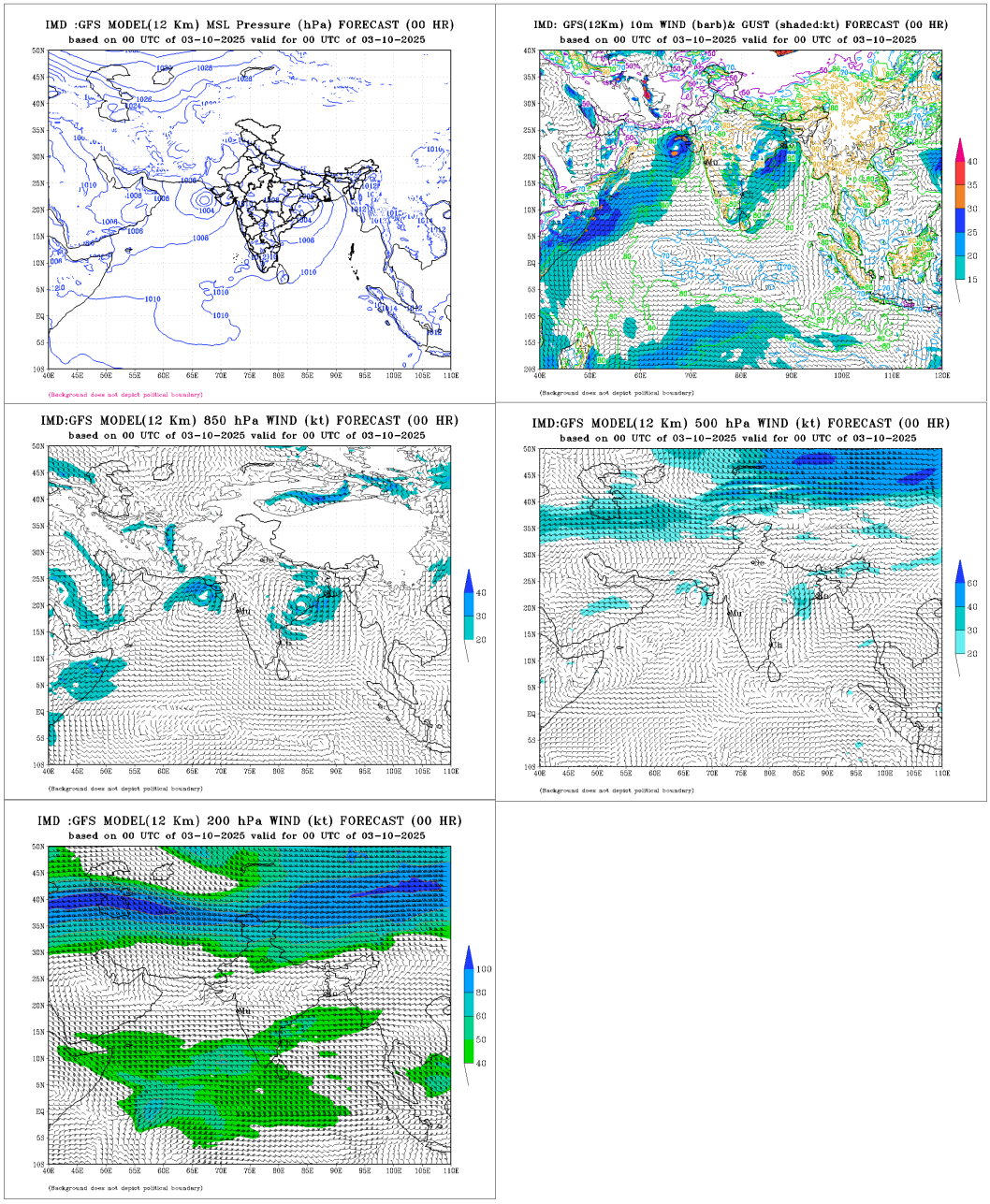


Fig.2.11.5(c): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 3rd October 2025

2.11.6 Realised Weather

2.11.6.1 Realised Rainfall

Rainfall associated with the deep depression based on IMD-NCMRWF satellite gauge merged data are depicted in Fig 2.11.6(a). It was seen that heavy to very heavy rainfall bands were noticed in the spatial distribution of rainfall which was mainly around the system center during 01st and 02nd October. The rainfall intensity was highest inner rainband close to center. There was also outer rainband far from the system center showed areas of heavy rainfall on both the days. The rainfall distribution pattern on 3rd October indicated a zone of heavy to very heavy rainfall over land (North coastal Andhra Pradesh and south

Interior Odisha) due to movement of system over land crossing the Odisha coast during forenoon of 2nd October. The rainfall distribution associated with outer band seizes to exist after depression entered into land. However, light to moderate rainfall at most places with isolated heavy rainfall occurred over Gangetic west Bengal and adjoining Bangladesh.

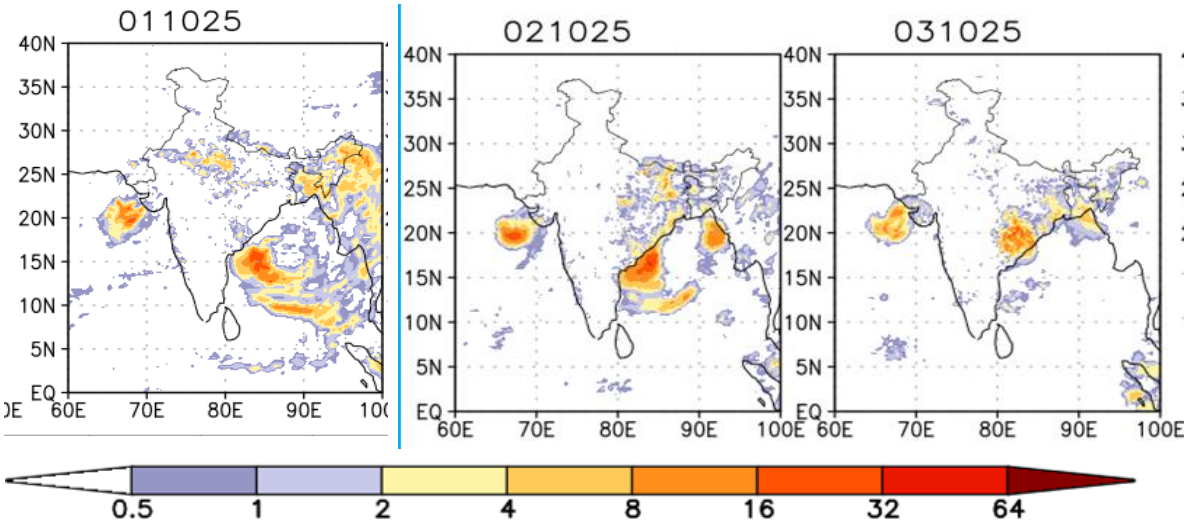


Fig.2.11.6(a): NCMRWF-IMD satellite gauge merged data plots of realized 24 hours accumulated rainfall from 01st to 03rd October 2025.

Realised Rainfall over IMD stations:

24 hours cumulative heavy rainfall (≥ 7cm) ending at 0830 hours IST of date is presented in the Fig. 2.11.6(b).

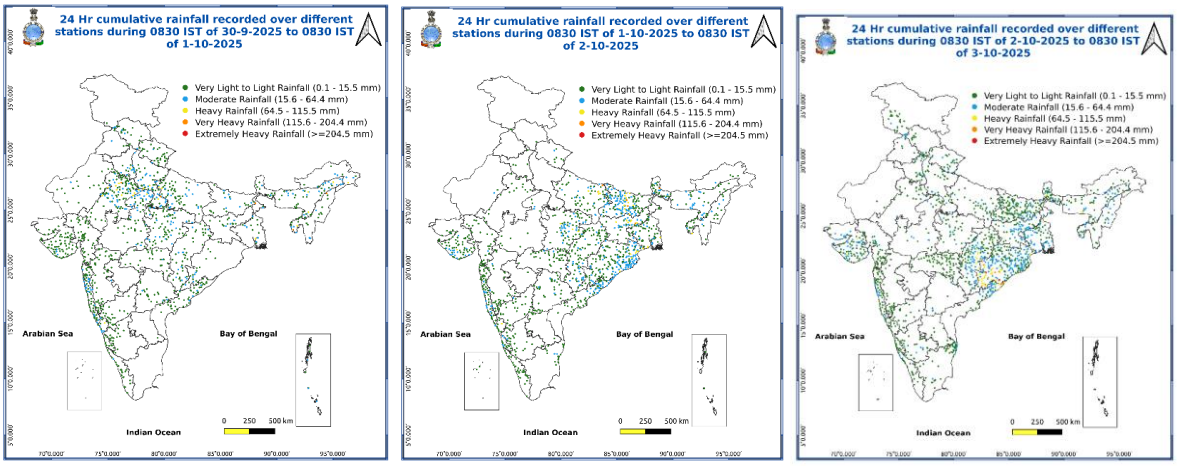


Fig.2.11.6(b) State-wise Point rainfall data plots of realized 24 hours accumulated rainfall from 01st October 2025 to 03rd October 2025.

Realised 24-hour heavy rainfall (≥ 7 cm) ending at 0300 UTC of dated:

02.10.2025/0830 hrs IST:

Odisha: Bahanga (dist Balasore) 11, Balasore (dist Balasore), Soro (dist Balasore), Nilgiri (dist Balasore) 9 each, Bhograi (dist Balasore), Krishnaprasad (dist Puri), Gobindpur (dist

Balasore) 8 each, Hatadihi (dist Keonjhargarh), Jajpur (dist Jajpur), Jajpur (dist Jajpur) 7 each,

Gangetic West Bengal: Digha (dist East Midnapore) 10, Sagar Island (dist South 24 Parganas) 9, Basirhat(pt) (dist North 24 Parganas), Contai (dist East Midnapore) 7 each,

Jharkhand: Rajdah dist dhanbhad) 21, Nandadih (dist Giridih), Karmatand (dist Jamtara) 14 each, Sikatia (dist Deoghar), Giridih (dist Giridih) 11 each, Narayanpur (dist Jamtara) 10, Chandwa (dist Latehar), Lohardaga (dist Lohardaga), Shilaichak (dist Chatra) 9 each, Zrs Dumka (dist Dumka), Barkisuriya(dist Giridih), Gobindpur (dist Dhanbad) 8 each, Jamtara (dist Jamtara), Dumri (dist Giridih), Jamtara Fmo (dist Jamtara), Palganj (dist Giridih) 7 each,

Sub-Himalayan West Bengal & Sikkim: Buxaduar (dist Alipurduar) 19, Chalouni (dist Jalpaiguri) 14, Rongo (dist Kalimpong) 13, Jhallong (dist Kalimpong) 11, (dist Jalpaiguri) 9, Zurrantee (dist Jalpaiguri), Gopalpur (dist Alipurduar) 8 each, Subhasini (dist Alipurduar), Hasimara (dist Alipurduar), Soongachi (dist Jalpaiguri), Patkapara (dist Alipurduar) 7 each,

East Uttar Pradesh: Nichlaul (dist Maharajganj) 12, Bansgaon (dist Gorakhpur) 11, Dhanghata (dist Sant Kabir Nagar) 10, Gorakhpur (dist Gorakhpur) 9,

East Madhya Pradesh: Nowrozabad (dist Umaria) 10, Budhar (dist Shahdol) 9, Pali (dist Umaria) 8, Raipura (dist Panna), Jabalpur (dist Jabalpur) 7 each.

03.10.2025/0830 hrs IST:

Odisha: Rampur 35; R. Udaigiri 29; Gumma, Junagarh 21 Each; Komna 20; Gosani, Nuagada 17 Each; Kotagarh, Nawapara, Mahendragarh 15 Each; Lamataput, Daringibadi, Narla 14 Each; Similiguda 13; Kashipur 12;

Nandahandi, NH5 Gobindpur, Lanjigarh, Madanpur Rampur, Kalampur, Kotpad 11 Each; Gunupur, Ambadola, Paralakhemundi, Rayagada, Rayagada PTO, Remuna, Gudvela, Raikia, Jeypore 10 Each;

Tentulikhunti, Betanati, Koraput, G Udayagiri, Kosagumda 9 Each; Patrapur, Muruda, Borigumma, Golamunda, Muniguda, Pottangi, Nandapur, Chandrapur, Turekela, Papadahandi, Balasore, Kolnara, R. Guda, Jaipatna, Phiringia 8 Each; Boden, Rasagovindapur, Jaleswar, Khariar, Jhorigam, Nawarangpur, Sorada 7 Each.

Coastal Andhra Pradesh: Palasa 17; Mandasa 16; Tekkali, Garividi 9 Each; Pathapatnam 8; Nellimarla, Kalingapatnam, Kurupam, Sompeta, Cheepurupalle 7 each.

Sub-Himalayan West Bengal: Leesh River Tea Garden 10; Jaybirpara Tea Estate 9; Sevoke, Mogulkata Tea Estate 8 Each.

Chhattisgarh: Baloda Bazar, Amlipadar 10 each; Mainpur, Mandir Hasoud 9 each; Pallari/Palari, Bilha, Kharora 8 each; Mahasamund, Arang, Gariabund, Bagbahara, Suhela 7 Each.

Jharkhand: Putki, Karmatand, Narayanpur 7 each.

Gangetic West Bengal: Jangipur 7.

04.10.2025/0830 hrs IST:

Bihar: Maharajganj 32; Jagdishpur 29; Goriakothi 28; Kessariah, Kalyanpur 25 Each; Pachrukhi, Piro, Raghunathpur 24 Each; Charpokhiri, Shahpur, Bihiyan 23 Each; Sasaram, Mairwa, Duraundha, Ziradei 22 Each; Tarari 21; Garhani 20; Nokha 19; Udwantnagar, Arrah , Nautan 18 Each; Hathwa, Gopalganj, Thawe, Bhagwanpur Hat 17 Each; Barauli, Agiaon, Kargahar, Andar 16 Each; Bhore, Hussainganj, Siswan, Kochas, Akorhi Gola, Rajpur, Basantpur, Barharia 15 Each; Guthani, Harsidhi, Tilouthu, Siwan Sadar, Darauli 14 Each; Indrapuri, Kataiya, Bikramganj, Pachdeuri, Bijaipur, Lakri Nabiganj, Hasanpura 13 Each;

Bhabhua, Jalalpur, Mahedi/Mehshi, Nawanagar, Sugauli, Kucchaikot, Bettiah 12 Each; Barahara, Chapra, Adhwara, Itarahi, Dinara, Raxual, Kesath, Phulwaria, Uchakagaon, Kotwa, Areraj, Sheosagar, Mohania 11 Each; Dehri, Tariyani, Rajpur, Barhampur, Chakki, Durgawati, Turkaulia, Banjaria, Sangrampur 10 Each; Lalbegiaghat, Chatia, Baitunthpur, Manghi, Chausha, Sanjhauli, Surajpura, Ishuapur, Kudra 9 Each; Marsrakh, Koilwar, Marhaura/Amnaur, Chand, Nautan, Chaugai, Bhagwanpur, Karakat, Panapur, Sahebganj 8 Each; Ramnagar, Chanpatia, Buxar, Dumri, Simri, Kaler, Purnahia, Dumraon, Taraiya 7 Each;

Odisha: Khordha PTO 10;

Gangetic West Bengal: Kandi 9; Bankura (CWC) 8; Rajnagar 7;

Chhattisgarh: Barsur 7;

East Uttar Pradesh: Varanasi BHU 19; Gaighat 17; Chunar 14; Chandauli 13; Sakaldeeha, Jaunpur Tehsil, Rajghat (Vns CWC) 12 Each; Turtipar, Mirzapur Tehsil 11 Each; Lalganj, Churk 10 Each; Ghazipur CWC, Jaunpur CWC, Mirzapur CWC 9 Each; Ballia, Chopan Fmo, Ghazipur, Mohammedabad (Y), Dudhi 8 Each; Azamgarh, Uska Bazar Fmo 7 each;

Jharkhand: Bhawnathpur 18; Dhurki 13;

East Madhya Pradesh: Churhat 13; Singrauli-aws 11; Sidhi, Chitrangi, Mada, Naigarhi 7 Each;

05.10.2025/0830 hrs IST:

Bihar: Saraigarh Bhaptiyahi 38; Sonbarsa 37; Chanpatia 36; Patahi 35; Narpatganj 32; Birpur 31; Sheohar 29; Bathnaha 28; Kessariah 26; Gaunaha, Rahghopur, Adapur 25 Each; Bairgania, Chhatapur, Bettiah 24 Each; Sugauli 23; Jhanjharpur, Saurbazar, Harsidhi 22 Each; Forbesganj, Motihari, Pipra, Kishanpur, Madhubani 21 Each; Ramnagar, Sursand, Kumarkhand, Raxual, Nanpur 20 Each; Dhengbridge, Bagaha, Udai Kishanganj, Thakrahan, Lauria Nandangarh, Kalyanpur, Runnisaidpur 19 Each; Murliganj, Baitunthpur, Pupari, Nautan, Areraj, Dumra, Pratapganj 18 Each; Chatia, Tribeniganj, Piprahi, Singheshwar, Sikta, Bokhara, Mejorganj 17 Each; Supaul, Belsand, Gopalganj, Dumri, Raniganj, Marauna, Turkaulia, Charaut, Nirmali 16 Each; Bhore, Phulparas, Kucchaikot, Ghailadh, Ghanharia, Kotwa, Bajpatti 15 Each;

Sub Himalayan West Bengal & Sikkim: Kurti T.e. 37; Ghatia. 35; Diana Tea Estate 34; Hilla, Jiti 33 Each; Gandrapara 32; Banarhat 31; Gajoldoba 30; Baradighi T.e. 29; Indong T.e. 27; Darjeeling, Ghughumari, Noweranuddi 26 Each; Moraghat 25; Neora 24; Anandpur, Baintgoorie., Good Hope Tea Estate, Palashbari, Saraswatipur, Soongachi 23 Each; Aibheel, Damdim, Zurrantee 22 Each; Chalouni, Gairkata, Kumlai, Lava, Jaybirpara 20 Each; Cooch Behar, Karballa, Washabari Tea Estate 19 Each; Ghish 18; Domohani, Nh31 Bridge, Jalpaiguri, Amfu Kalimpong, Batabari 17 Each; Kailashpur, Maynaguri College, Siliguri PTO, Dhupguri, Dalgaon 16 Each; Namthang, Barobhisha, Bijonbari, Gopalpur, Newlands Tea Garden 15 Each;

2.11.6.2 Reported Wind

<u>01.10.2025</u>

ASCAT winds showed a depression over westcentral Bay of Bengal in Fig. 2.11. 4 (a) at 1525 UTC of 01st October with the peak winds around 45-55 kmph .

02.10.2025

ASCAT winds showed a stronger wind in Fig. 2.11. 4 (b) at 0356 UTC of 02nd October with the peak increase wind speed intensity of 50-60kmph (c) and the system crossed and weakened with peak wind along the Odisha coast were 40-50 kmph.

2.11.7 Damage due to the system

The deep depression over Bay of Bengal triggers heavy rains in Odisha, Bengal which causes flooding in many areas as per the media report shown in Fig.2.11.7.

Fig.2.11.7 The deep depression affected Odisha and Bengal with flooding in many areas as per media reports. Photo Credit: HT 02 October.

2.12 Severe cyclonic storm "SHAKHTI" over Arabian Sea (01st – 07th) October, 2025

2.12.1 Life History of Shakhti

- The severe cyclonic storm "Shakhti" originated from the remnant of a depression that formed over northwest & adjoining westcentral Bay of Bengal on 26th September which moved across Odisha, Chhattisgarh and Vidarbha and weakened into a well marked low pressure area over west Vidarbha and adjoining north Madhya Maharashtra on 28th Sep. It moved across central India and emerged into Gulf of Cambay on 29th Sep. It then moved across Gujarat and emerged into northeast Arabian Sea (AS) in the morning (0300 UTC/0830 hrs IST) of 1st October as a well marked low pressure area.
- It intensified into a depression over northeast AS in the evening (1200 UTC/1730 hrs IST) of 1st Oct. and into a deep depression in the midnight (1800 UTC/ 2330 hrs IST) of 2nd Oct. Thereafter, it exhibited multiple recurvatures & changed its path about 7 times during its life period.
- It intensified into a Cyclonic Storm over northeast AS in the noon (1130 hrs IST/0600 UTC) of 3rd Oct. and into a severe cyclonic storm over northeast & adjoining northwest AS in the early morning (0530 hrs IST/0000 UTC) of 4th Oct. It reached its peak intensity of 60 kt in the early morning (0530 hrs IST/0000 UTC) of 5th October and maintained its intensity till noon (1130 hrs IST/0600 UTC) of 5th Oct.
- Thereafter, while moving south-southwestwards, it started weakening from evening (1730 hrs IST/1200 UTC) of 5th October onwards.
- Continuing to move south-southwestwards till evening of 6th October over northwest & westcentral BoB, it encountered unfavourable environmental conditions (decrease in vorticity, decrease in Coriolis force, decrease in low level convergence & upper level divergence, cold dry air incursion into the core from west and increased vertical wind shear) and subsequently weakened into a cyclonic storm in the early morning (0530 hrs IST/0000 UTC) of 6th Oct., into a deep depression in the midnight (2330 hrs IST/1800 UTC) of 6th Oct. It moved southeastwards from the midnight of 6th Oct. and weakened into a depression in the noon (1130 hrs IST/0600 UTC) of 7th Oct. and into a well marked low pressure area in the evening (1730 hrs IST/1200 UTC) of 7th Oct. over the westcentral AS.
- The observed track of the system is presented in Fig.2.12.1. The best track parameters of the severe cyclonic storm Shakhti are presented in **Table 2.12.1**.

Table.2.12.1: Best track positions and other parameters of the Severe Cyclonic Storm Shakhti over Arabian Sea during 01st – 07th October, 2025.

Date	Time (UTC)	Lat. (^{0}N)	Long. (^{0}E)	C.I. No.	ECP (hPa)	ΔP (hPa)	MSW (kt)	Category
01-10-2025	1200	22.0	68.3	1.5	1001	3	25	D
	1800	21.5	68.2	1.5	1001	3	25	D
02-10-2025	0000	21.0	68.0	1.5	1001	3	25	D
	0300	20.8	67.9	2.0	1001	3	25	D
	0600	20.8	67.9	2.0	1001	3	25	D

	1200	20.8	67.9	2.0	1001	3	25	D
	1800	20.8	67.7	2.0	1000	4	30	DD
03-10-2025	0000	21.3	67.2	2.0	1000	4	30	DD
	0300	21.5	67.0	2.0	999	5	30	DD
	0600	21.7	66.8	2.5	997	7	35	CS
	0900	21.8	66.6	2.5	997	7	35	CS
	1200	22.0	66.4	2.5	996	8	40	CS
	1500	22.1	66.2	3.0	996	8	40	CS
	1800	22.0	65.8	3.0	994	10	45	CS
	2100	22.0	65.6	3.0	994	10	45	CS
04-10-2025	0000	22.0	65.0	3.5	992	12	50	SCS
	0300	22.0	64.5	3.5	990	15	55	SCS
	0600	21.9	64.2	3.5	990	15	55	SCS
	0900	21.8	63.8	3.5	990	15	55	SCS
	1200	21.7	63.6	3.5	990	15	55	SCS
	1500	21.5	63.0	3.5	990	15	55	SCS
	1800	21.3	62.7	3.5	989	16	55	SCS
	2100	21.1	62.3	3.5	989	16	55	SCS
05-10-2025	0000	21.0	61.8	3.5	987	18	60	SCS
	0300	20.9	61.3	3.5	987	18	60	SCS
	0600	20.7	61.1	3.5	987	18	60	SCS
	0900	20.5	61.0	3.5	988	17	60	SCS
	1200	20.2	60.7	3.5	990	15	55	SCS
	1500	20.0	60.6	3.5	991	14	55	SCS
	1800	19.8	60.6	3.5	992	13	50	SCS

	2100	19.7	60.5	3.5	993	12	50	SCS
06-10-2025	0000	19.7	60.5	3.0	994	11	45	CS
	0300	19.7	60.4	3.0	994	11	45	CS
	0600	19.7	60.3	3.0	995	9	40	CS
	0900	19.6	60.3	3.0	996	8	40	CS
	1200	19.6	60.2	2.5	997	7	35	CS
	1500	19.6	60.1	2.5	998	6	35	CS
	1800	19.5	60.1	2.0	999	5	30	DD
07-10-2025	0000	19.2	60.3	2.0	999	5	30	DD
	0300	19.0	60.5	1.5	1001	4	25	D
	0600	18.9	60.7	1.5	1002	3	20	D
	1200	Weakened into a well marked low pressure area over westcentral Arabian Sea						

kt: Knots (nautical mile per hour), 1 kt=1.85 kmph, D: Depression,
DD: Deep Depression, CS: Cyclonic Storm, SCS: Severe Cyclonic Storm

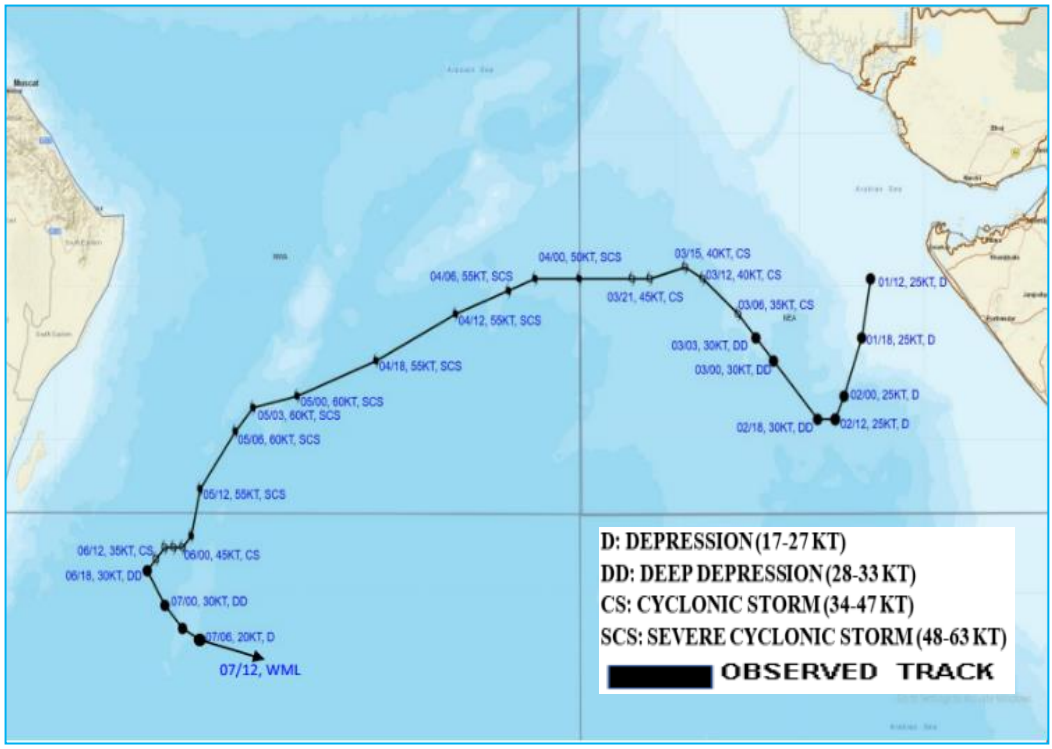


Fig2.12.1: Observed track of Severe Cyclonic Storm Shakhti over northeast Arabian Sea

2.12.2 Salient features:

- **No cyclone during January to September 2025**: It was the first cyclone of the year 2025. In the past, no cyclone formed during January to September over the North Indian Ocean (NIO) on 11 occasions, viz. 1938, 1949, 1980, 1983, 1984, 1986, 1988, 1993, 1995, 2011, 2012.
- **No damage due to Shakhti**: The system didn't cause any significant adverse weather over any of the countries bordering Arabian Sea including India, Pakistan, Iran, Oman and Yemen as it moved across various regions of north and westcentral AS except high sea conditions over north & westcentral AS. No ship was damaged due to early warnings by IMD.
- **Emergence from land to Sea**: Shakhti developed from the remnant low pressure area which emerged from land into sea. During recent years, last such activity was observed, in Sep. 2025 and Aug. 2024. A depression (06-11 Sept) formed over southwest Rajasthan on 6th Sept. midnight (2330 hrs IST/1800 UTC). It moved across southwest Rajasthan, North Gujarat & Pakistan and emerged into northeast AS on 10th early morning (0530 hrs IST/0000 UTC) and weakened into a well-marked low pressure area over northwest Arabian Sea in the early morning (0530 hrs IST/0000 UTC) of 11th Sep. It's track was quite similar to Shakhti. It also underwent multiple recurvatures (5 times) and moved like a sinusoidal wave. However, unlike Shakhti, it didn't intensify on emerging into AS (Fig.2.12. 2a). Similarly, cyclone ASNA (25 August-02 September, 2024) developed from a depression which formed over Northwest Madhya Pradesh on 25th early morning (0530 hrs IST/ 0000 UTC), moved across South Rajasthan & North Gujarat and emerged into northeast AS on 30th early morning (0530 hrs IST/0000 UTC), intensified into a cyclonic storm in the noon (1130 hrs IST/0600 UTC) of 30th Aug. It reached its peak intensity of 40 kt over northeast AS on 31st morning (0830 hrs IST/0300 UTC). It moved across northeast AS and then northwest AS and gradually weakened into a well-marked low pressure area over northwest & adjoining westcentral AS on 2nd Sept (**Fig.2.12.2b**).

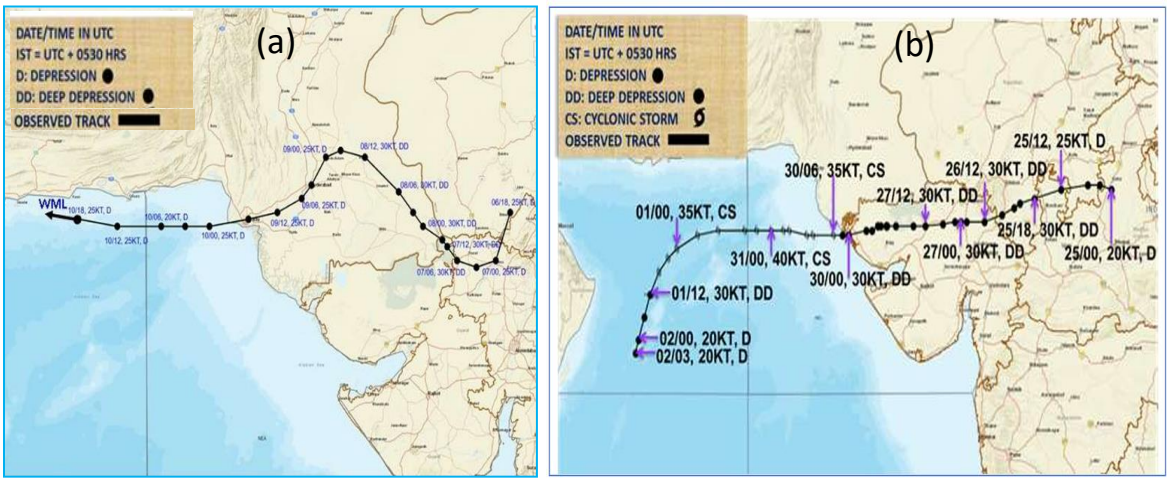


Fig.2.12.2: Track of (a) depression of southwest Rajasthan (6-11 Sept., 2025) and (b) Cyclonic storm (Asna) over northeast AS

- **Multiple recurvatures**: Shakhti exhibited multiple recurvatures and changed its track 5 times during its life cycle. It initially moved south-southwestwards under the influence of north-northeasterlies from the anticyclonic circulation prevailing to its northwest over

Oman & UAE region. It moved south-southwestwards till evening of 2nd Oct, (1730 hrs IST/ 1200 UTC). Thereafter, it gradually recurved northwestawards under the influence of ridge lying to its north. It continued to move northwestwards till night of 3rd Oct (2030 hrs IST/ 1500 UTC). Thereafter, it gradually recurved and moved westwards till early morning (0530 hrs IST/ 0000 UTC) of 4th October and then nearly southwestwards till midnight (2330 hrs IST/ 1800 UTC) of 6th Oct., under the influence of anticyclonic circulation to its northwest. Thereafter, it again recurved southeastwards under the influence of the anticyclone to its northwest and a deep trough in westerly while weakening over westcentral AS. The mean wind based on CIMSS supporting above features are shown in **Fig.2.12.3 (a & b)**.

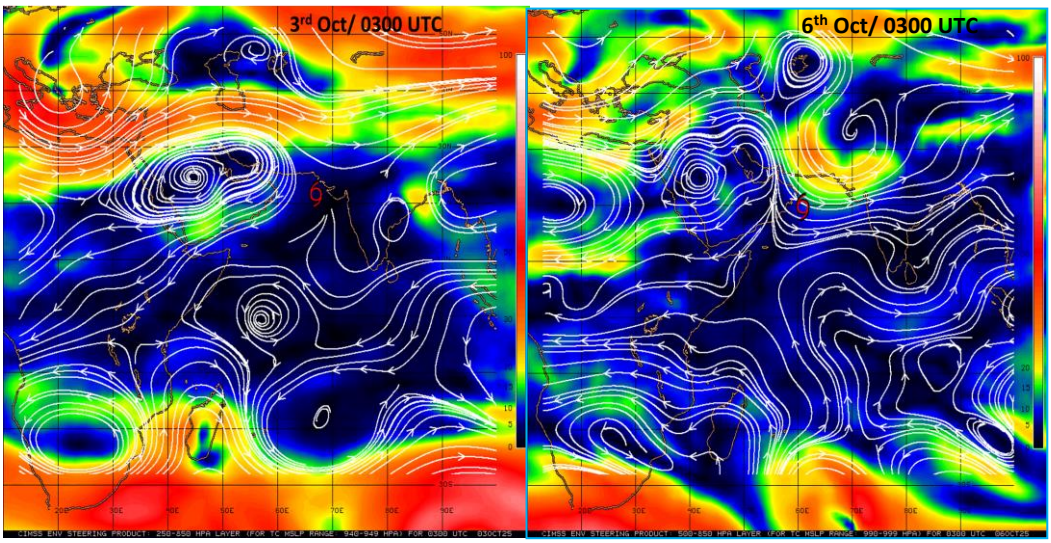


Fig.2.12.3: (a) Deep (200-850 hPa) layer mean steering winds at 0300 UTC of 3rd Oct and (b) mid (500-850 hPa) layer mean steering winds at 0300 UTC of 6th Oct

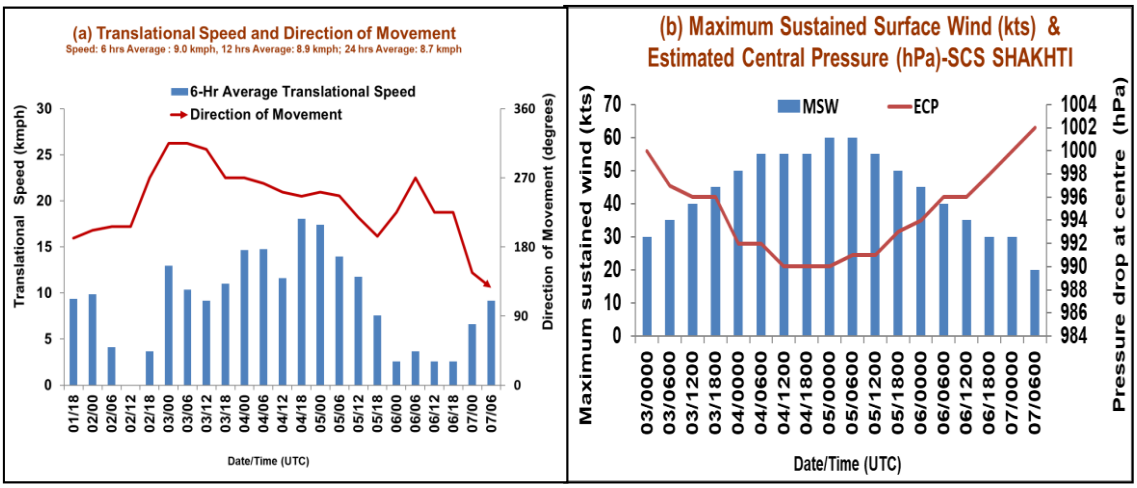


Fig.2.12.4: Six hourly (a) average translational speed & direction of movement and (b) maximum sustained surface wind speed & estimated central pressure during life period of cyclone Shakhti

- **Translational Speed**: Shakhti exhibited six hourly average translational speed of 9.0 kmph against normal of 16.7 kmph for severe cyclonic storms over the AS in the post-monsoon season based on data during 1990-2013 (**Fig.2.12.4a**). Thus, it was a slowing moving system.

- **Life period:** The average life period of the storm (depression to depression) was 6 days against the long period average (LPA) (1990-2013) of about 4 days and 05 hours for SCS category over the AS during post-monsoon season. Thus, Shakhti had a life period longer than the average life period of SCS over the AS during post-monsoon season.

- **Maximum sustained wind speed and estimated central pressure**: The system did not exhibit any rapid intensification/ weakening during its life cycle. The system reached its peak intensity of 60 knots in the early morning (0530 hrs IST/0000 UTC) of 5th Oct. The lowest estimated central pressure at this time was 987 hPa. The six hourly maximum sustained wind speed and estimated central pressure during the life cycle of Shakhti is presented in **Fig.2.12. 4b**.

- **Damage Potential and Power Dissipation Index**: The Accumulated Cyclone Energy (a measure of damage potential) and Power Dissipation Index (a measure of loss) in association with Shakhti were 3.40 X 10^4 knots^2 and 1.74 X10^6 knots^3 respectively against the normal of 1.88 X 10^4 knots^2 and 0.93 X10^6 knots^3 for SCS category during post-monsoon season over the AS based on the data during 1990-2020. **As it was a slow-moving cyclone with a longer life period, damage potential and losses due to Shakhti were higher than the long period average. However, no damage to marine community was observed due to this system due to timely genesis, track & intensity forecast and regular sea area bulletins and advisories under Global Maritime Distress Safety System, coastal weather bulletins, port warnings and fishermen warnings.**

2.12.3 Monitoring

India Meteorological Department (IMD) maintained round-the-clock watch over the north Indian Ocean, and the cyclone “Shakhti” was monitored since 25th Sep. The extended range outlook issued on 25th Sep. indicated emergence of remnant of depression over northwest & adjoining westcentral BoB into northeast AS and adjoining South Gujarat with moderate probability of its intensification into a depression around 30th Sep (**Fig.2.12.5**). Actually, it moved across central India and emerged into Gulf of Cambay on 29th Sep. It then moved across Gujarat and emerged into northeast AS on 1st Oct. morning as a well marked low pressure area. The system was monitored with the help of available satellite observations from INSAT 3DR & 3DS, SCATSAT, ASCAT, microwave imageries, and available ships, buoy observations, and coastal observations in the region. Various global models and dynamical-statistical models run by Ministry of Earth Sciences (MoES) institutions including IMD, NCMRWF, IITM & INCOIS, and guidance from models from various international agencies under bilateral arrangements were utilized to predict the genesis, track, and intensity of the cyclone, as well as associated severe weather. The forecasts were mainly based on a multi-model ensemble technique developed by IMD, further modulated by observations and forecaster intervention at IMD. An indigenously developed digitized forecasting system of IMD was utilized for analysis and comparison of

various observations and numerical weather prediction model guidance, decision-making processes, and warning product generation.

Monitoring by Satellites

The INSAT 3D visible, Infra-red 1, color composite and water vapor imageries are shown in the Figures 2.12.5(a-d) respectively. The images are sequentially arranged in the individual Figure according to their time during the life time of the cyclonic storm from 1st October to 6th October, 2025 and they can be identified by the date & time stamps on them.

As per INSAT 3D imageries at 1200 UTC of 01 October 2025, clouds with embedded intense to very intense convection lay over northeast and adjoining eastcentral Arabian Sea. Scattered low to medium clouds with embedded intense to very intense convection lay over Saurashtra, north and adjoining central Arabian Sea (minimum cloud top temperature 70–90°C), and moderate to intense convection lay over Gulf of Kutch & Gujarat region (minimum cloud top temperature 40–60°C), central and south Arabian Sea. Isolated weak to moderate convection was seen over Lakshadweep Islands, Maldives, and Comorin area. The convections were seen to start organising around the centre, but the clear banding structure was not very obvious surrounding the centre of low pressure system.

As per INSAT 3D visible imagery at 0600 UTC [Fig 2.12.5(a)], and IR1 & WV imageries at 1800 UTC [Fig.2.12. 5(b)-(d)] of 02 October 2025, clouds with embedded intense to very intense convection lay over the northeast and adjoining eastcentral Arabian Sea (minimum cloud top temperature 60–80°C). Scattered low to medium clouds with embedded moderate to intense convection lay over Gulf of Kutch, Saurashtra, Kutch, and Gulf of Cambay (minimum cloud top temperature 40–60°C). The scattered clouds with embedded intense to very intense convection gradually lay over the northeast and adjoining eastcentral Arabian Sea, Kutch region, and Gulf of Kutch (minimum cloud top temperature 70–90°C). In association, moderate to intense convections lay over southeast Pakistan, Kutch, Saurashtra, and the Gujarat region (minimum cloud top temperature 40–60°C). The central convections were seen to become enhanced along with a comma shape. The banding structure from the southern side of the depression was noticed to appear during this time, indicating the gradual intensification of the system. The WV imagery showed the abundance of moisture up to mid-tropospheric levels.

As per INSAT 3D visible, IR1 and WV imageries at 6000 UTC & 1200 UTC [Fig 2.12.5(a)-(d)] of 03 October 2025, the system centre was defined clearly for all times with intensity T2.5 and indicated the intensification of the deep depression into a cyclonic storm. Although the clouds were organised in a shear pattern, the outer banding structure became visible once the system further intensified. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over northeast and adjoining eastcentral Arabian Sea, Kutch region, Gulf of Kutch, and south Pakistan (minimum cloud top temperature 70–90°C). The WV imagery indicated an influx of moisture towards the centre of the storm; however, dry air was looming at the northwest sector of the storm. The multi-satellite-based wind product indicated stronger winds observed in the northern sector.

As per INSAT 3D visible imagery at 1200 UTC [Fig 2.12.5(a)] and IR1 and WV imageries at 0000 UTC & 1200 UTC [Fig 2.12.5(b)-(d)] of 04 October 2025, the clouds were organized in

a curved band pattern with defined centre at every time and the intensity was estimated asT3.5. The cloud top temperature at the central part of the system remained colder than the surroundings. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over north Arabian Sea (minimum cloud top temperature 70–90°C), and moderate to intense convection lay over south Pakistan (minimum cloud top temperature 40–60°C). As per multi-satellite-based winds, stronger winds were observed in the northern sector. The organization of clouds and the banding structure was portraying the intensification and both poleward and equatorward outflows were visible by the top-level cirrus clouds at this stage.

The INSAT 3D visible imageries at 0300 & 0600 UTC [Fig.2.12. 5(a)], IR1 and WV imageries at 0300 & 1200 UTC [5(b) to 5(d)] of 05 October 2025, the clouds were organized in a central dense overcast pattern. The system centre was defined with specific latitude and longitude at each time and estimated intensity was T3.5. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over northwest and adjoining westcentral Arabian Sea (minimum cloud top temperature 70–90°C). The band structure could not be seen and poleward outflow was also ceased to exist. The WV imagery showed that the dry air from northern sectors reduced the influx of moisture towards centre of the storm. However, as per multi-satellite-based winds, the stronger winds were observed in the northwest sector.

The visible imagery of INSAT 3D at 1200 UTC [Fig.2.12.5(a)] and IR1 & WV imageries at 0000 UTC of 06 October 2025 showed that the clouds had disorganized. Accordingly, the system weakened from the estimated intensity of T3.5 to T3.0 at 0000 UTC and further to T2.5 at 1200 UTC. Associated scattered to broken low and medium clouds with embedded moderate to intense convection lay over westcentral and adjoining northwest Arabian Sea between latitude 15.0–21.0°N and longitude 53.0–63.0°E, including Oman (minimum cloud top temperature –40 to 70°C). As per multi-satellite-based winds, stronger winds were observed in the northwest sector. Although, the cloud cluster gradually became disorganized, the equatorward outflow at the top was visible.

As per INSAT 3D imageries of 07 October 2025 [not included in the report], the clouds had disorganized further. The system centre was defined poorly with intensity of deep depression/depression T1.5/CI 2.0. Associated scattered to broken low and medium clouds with embedded moderate to intense convection lay over westcentral and adjoining northwest Arabian Sea between latitude 15.0–21.0°N and longitude 57.0–63.0°E (minimum cloud top temperature –60 to 80°C).

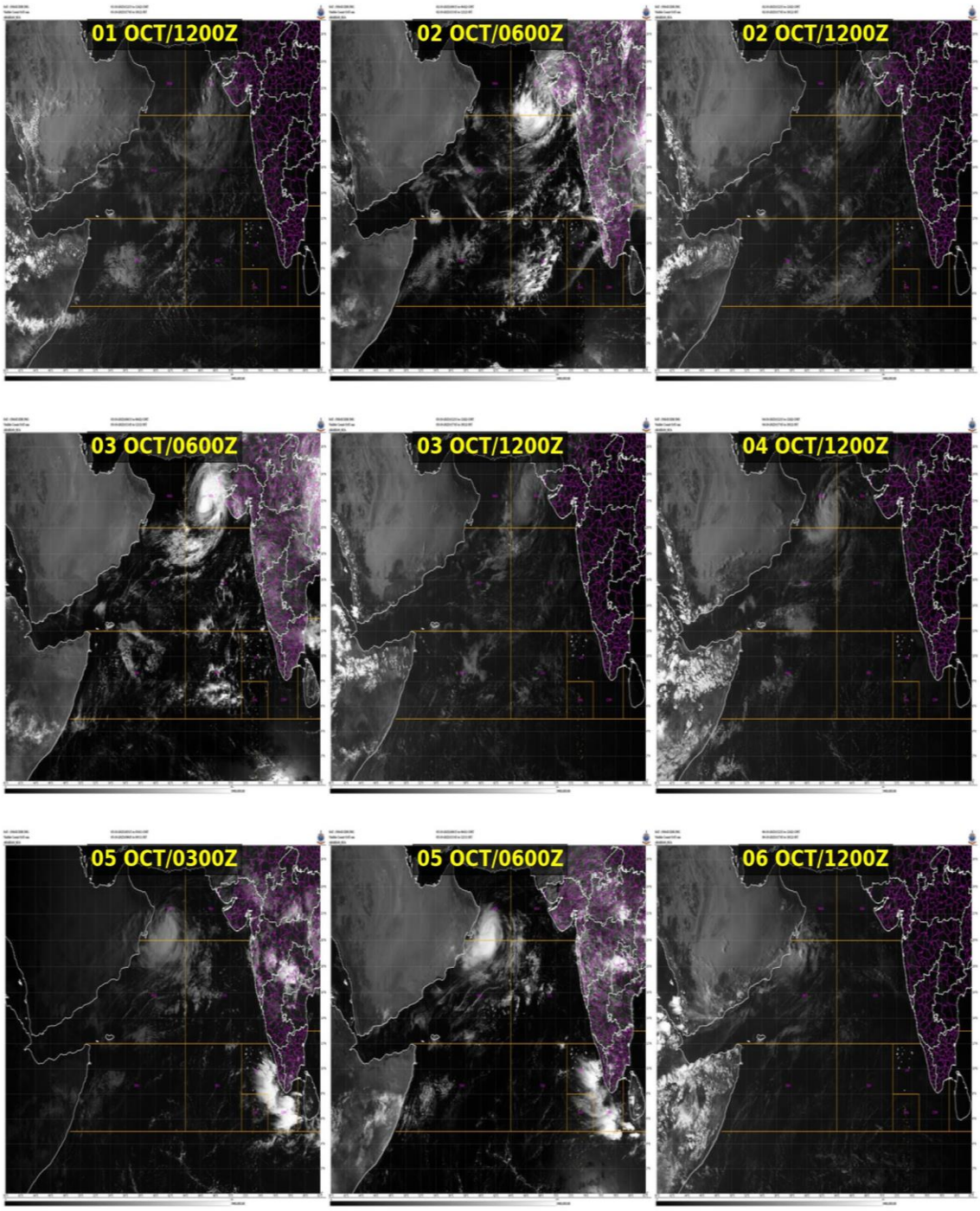


Fig.2.12.5(a): INSAT-3D visible imageries during life cycle of Severe Cyclonic Storm SHAKHTI over Arabian Sea (01st – 07th) October, 2025

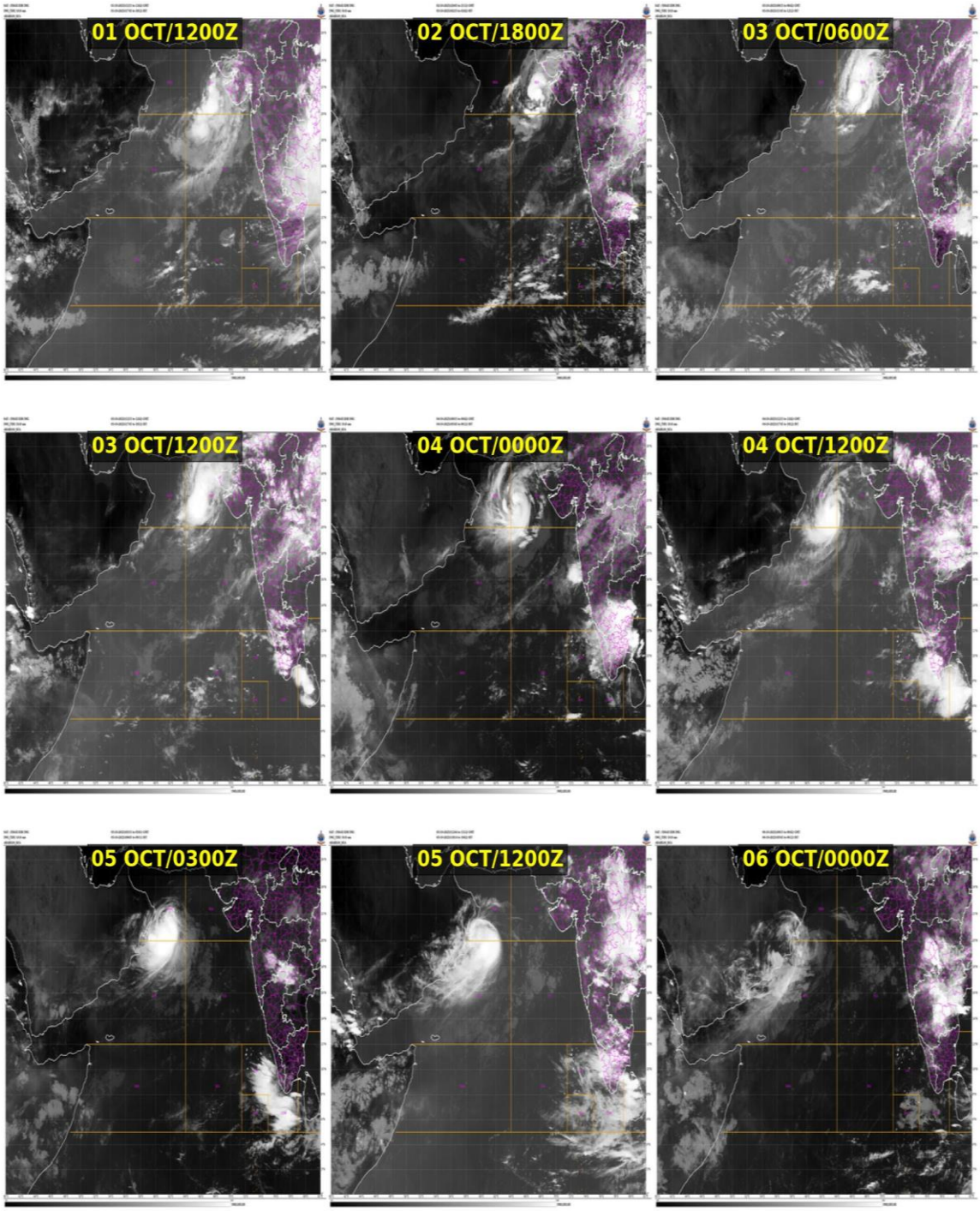


Fig.2.12.5(b): INSAT-3D IR1 imageries during life cycle of Severe Cyclonic Storm SHAKHTI over Arabian Sea (01st – 07th) October, 2025

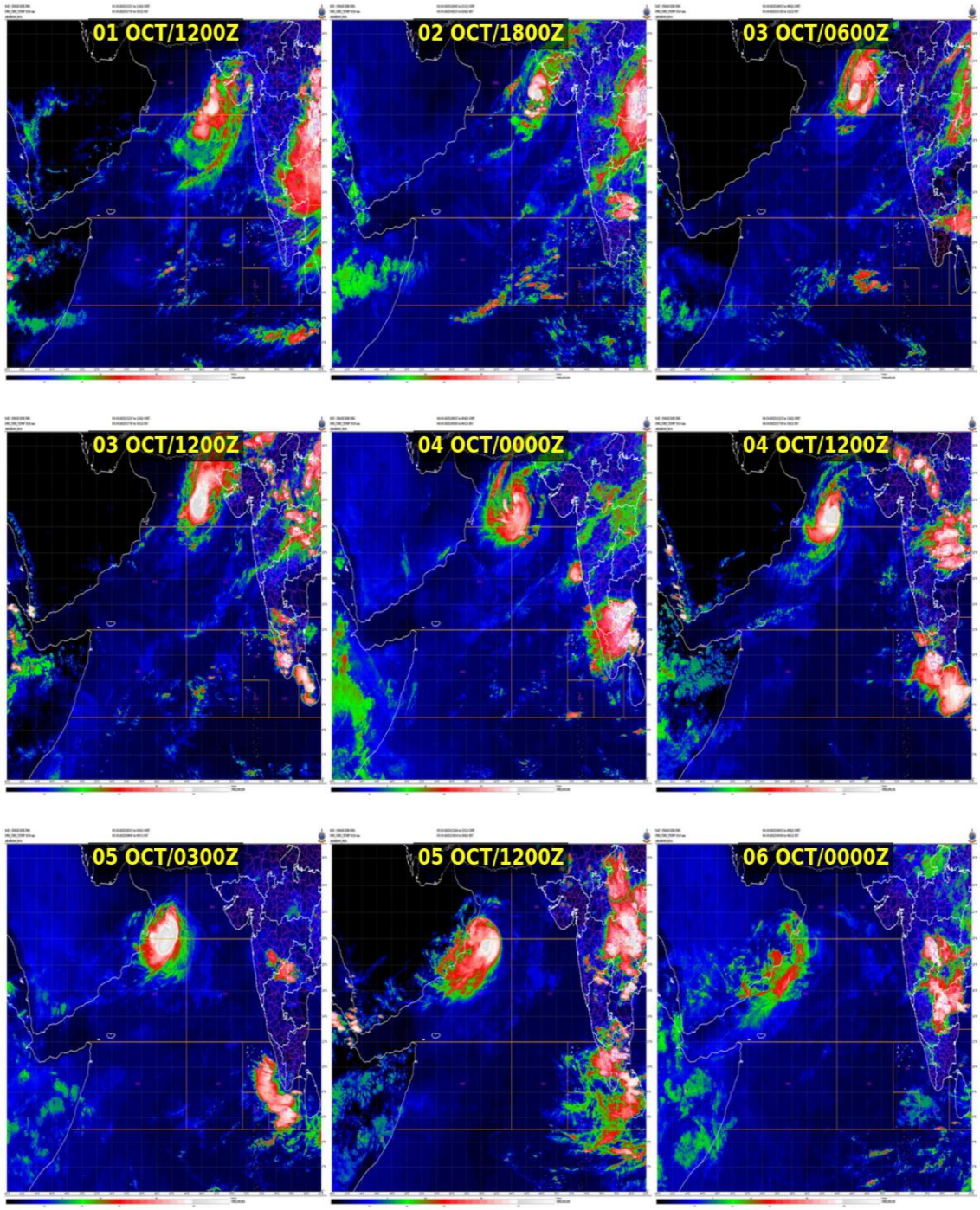


Fig.2.12.5(c): INSAT-3D IR1 imageries during life cycle of Severe Cyclonic Storm SHAKHTI over Arabian Sea (01st – 07th) October, 2025

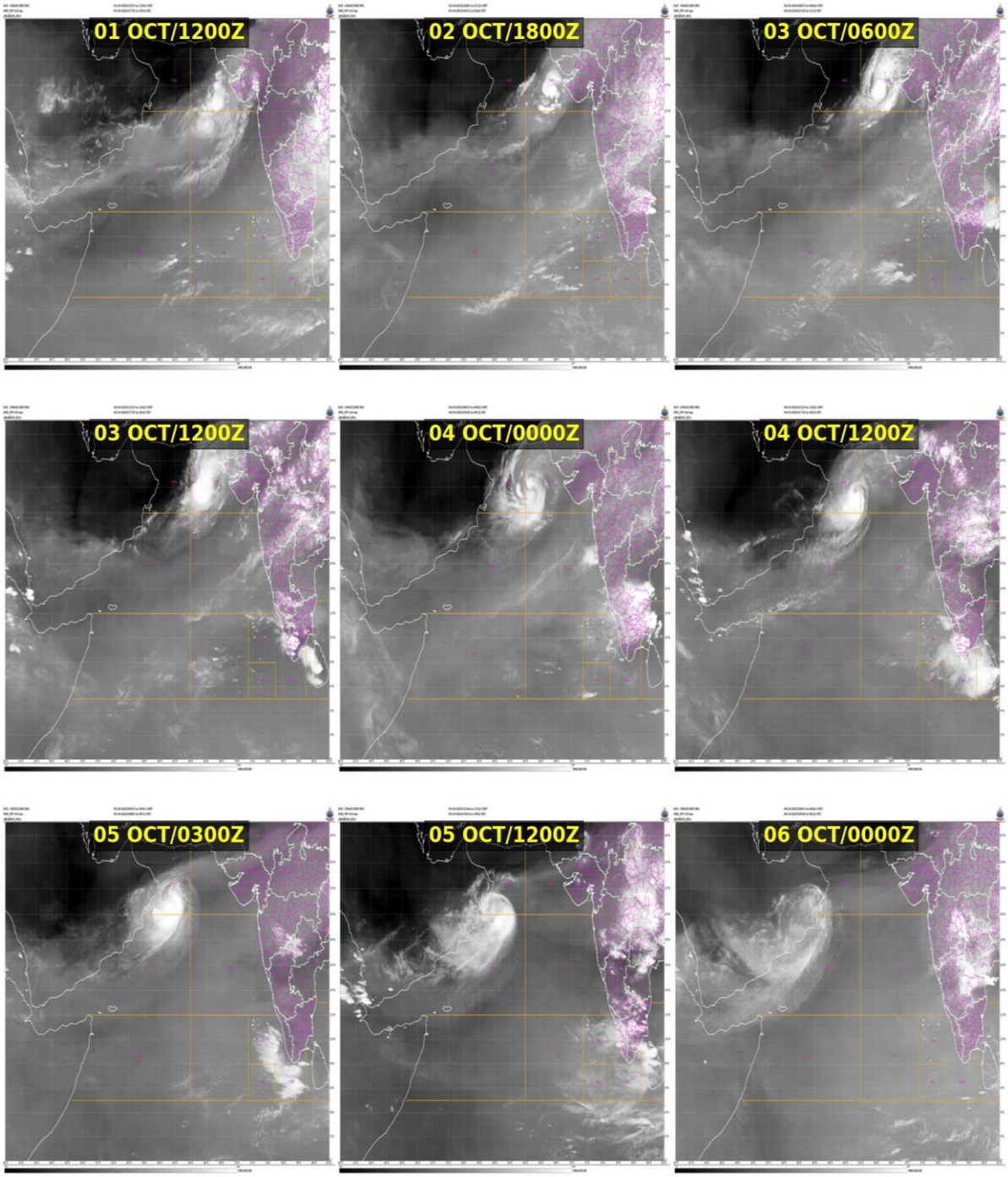


Fig.2.12.5(d): INSAT-3D BD imageries during life cycle of Severe Cyclonic Storm SHAKHTI over Arabian Sea (01st – 07th) October, 2025

The imagery from IR1 channel of the INSAT 3DR satellite at 14:00 UTC and corresponding available scatterometry surface wind product from ASCAT pass at 16:07 UTC, which were utilized for monitoring the system are presented in **Fig.2.12.6.**

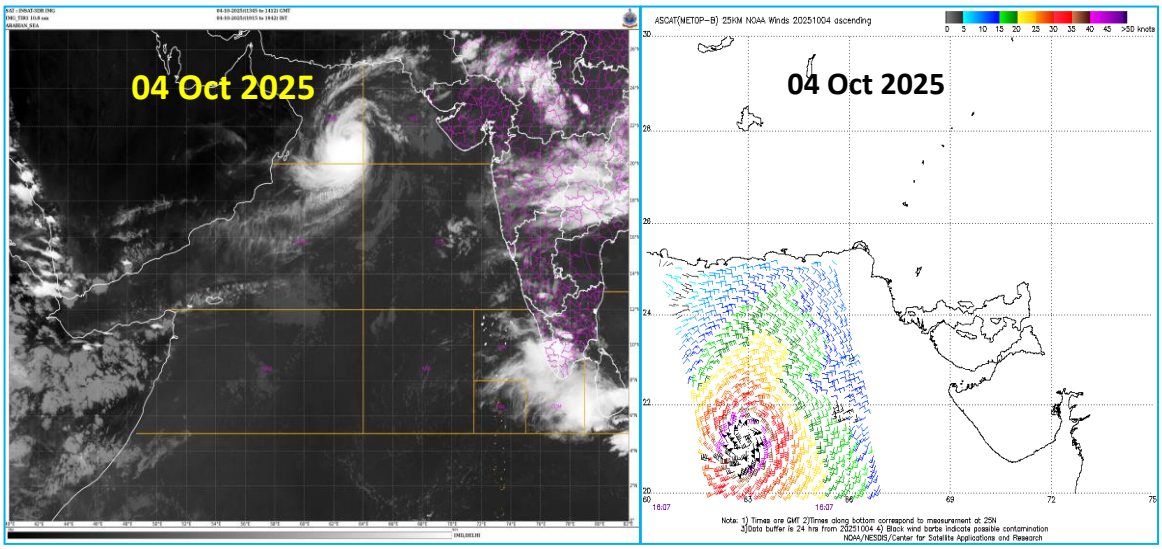


Fig.2.12.6: Typical satellite imageries used for monitoring SCS Shakhti

2.12.4 Dynamical Features

MD GFS (T1534) daily analyses of mean sea level pressure (MSLP) at 0000 UTC, winds at 10 m & 850, 500 and 200 hPa levels from 29th September to 07th October are presented in **Fig.2.12. 7(a) to 7(k)** respectively.

The MSLP analysis field at 0000 UTC of 29th September in Fig.2.12. 7(a) indicated that a remnant of the last depression of monsoon 2025, which developed over the northwest and adjoining westcentral Bay of Bengal off south Odisha-north Andhra Pradesh coasts and progressed across south Odisha, south Chhattisgarh and subsequently Vidarbha during 26th - 28th September reached over south Gujarat region and adjoining Maharashtra as a well-marked low pressure area. The surface wind distribution at 10m above ground was showing a cyclonic circulation with stronger wind in the southwest sector of the system over the northwest Arabian Sea (AS) due to the southwesterlies of the monsoon season over AS. Associated upper-level cyclonic circulation extending up to the 500 hPa pressure level. The upper-level wind at 200 hPa illustrated anticyclonic circulation above the system location embedded with a ridgeline along 22°N latitude.

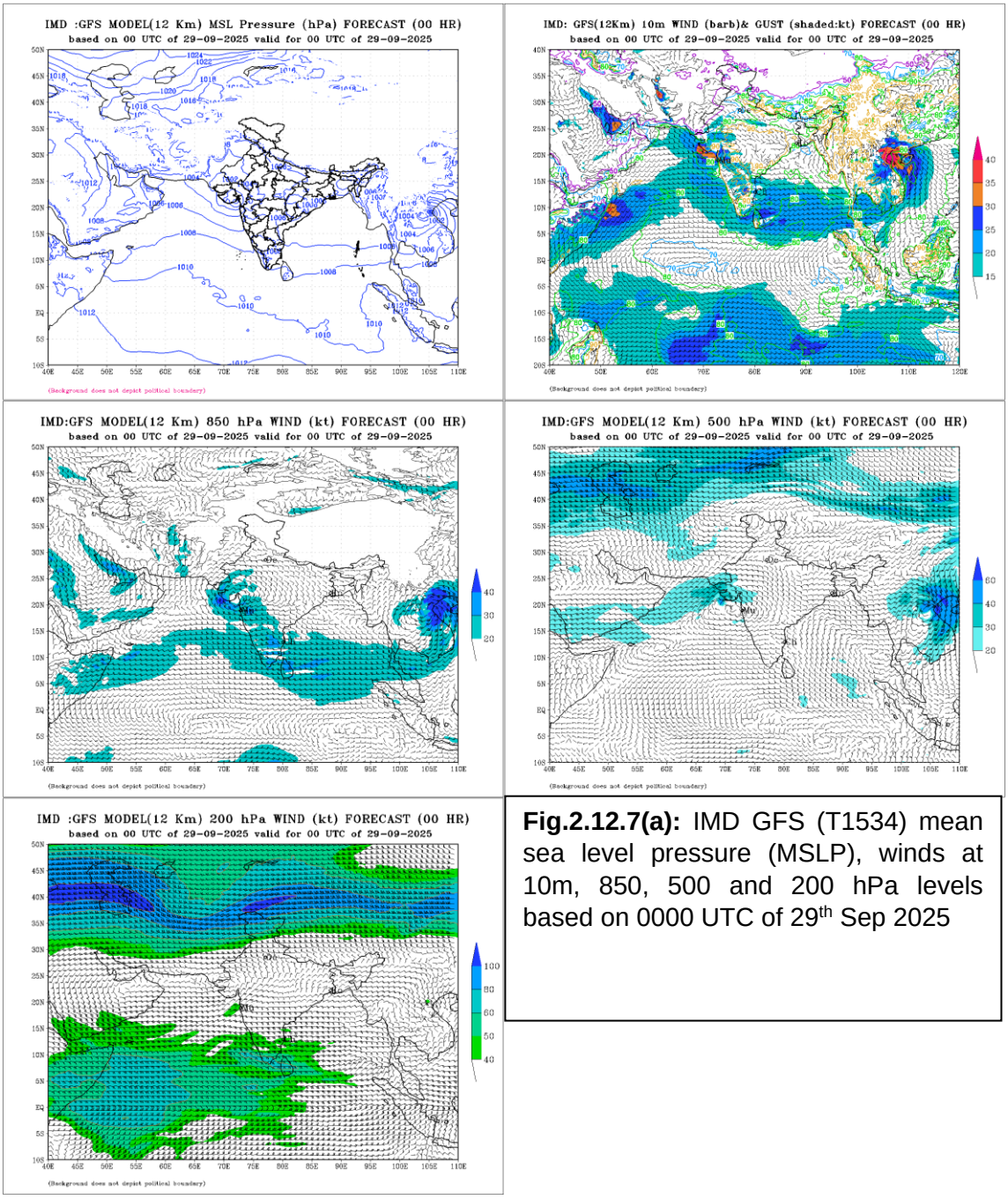


Fig.2.12.7(a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 29th Sep 2025

The Fig.2.12.7(b) illustrates the IMD GFS analyses of MSLP and winds at different level at 00 UTC of 30th September, 2025. The MSLP indicated that the remnant Well Marked Low Pressure area moved further westwards and reached over Saurashtra & Kutch and adjoining Gulf of Cambay. At the same time, the MSLP show formation of another Low Pressure area over West Central Bay of Bengal. The corresponding surface wind at 10 m above ground depicted a prominent cyclonic circulation over Saurashtra & Kutch with stronger winds in the southern sectors around the system due to the monsoonal southwesterly flow. Associated upper air cyclonic circulations extended up to 500 hPa tilting southwestwards with height. The circulation was elongated in a southwest & northeast direction. Other low pressure over Bay of Bengal also portrayed cyclonic circulation

extended upto 500 hPa. The 200 hPa wind indicated a ridge line along 23o N latitude due to which the system was likely to experience southwestwards steering.

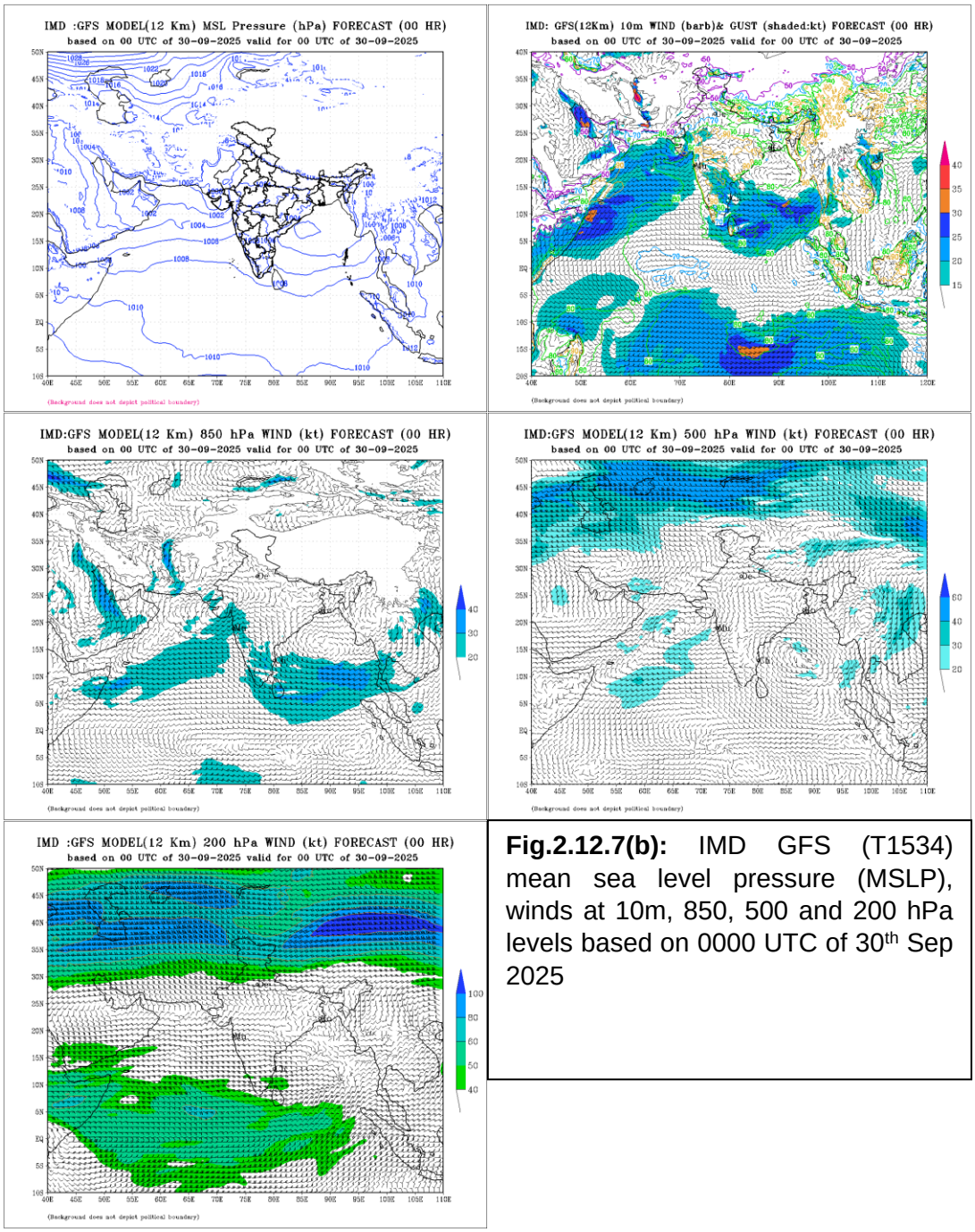


Fig.2.12.7(b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 30th Sep 2025

The MSLP pattern in the Fig.2.12.7(c) showing the model analyses at 00 UTC of 01st October, 2025, indicated the intensification of the Well Marked Low Pressure area and emergence over Gulf of Cambay as a depression. Accordingly, the surface wind distribution also shows strengthening of the cyclonic circulation at 10 m above ground. However, the stronger winds are persisting over southern sectors of the system as the southwesterly flow of monsoon across AS was feeding moisture to the system. The associated upper air cyclonic circulation extending upto 500 hPa with a similar feature as described in Fig.2.12. 7(b).

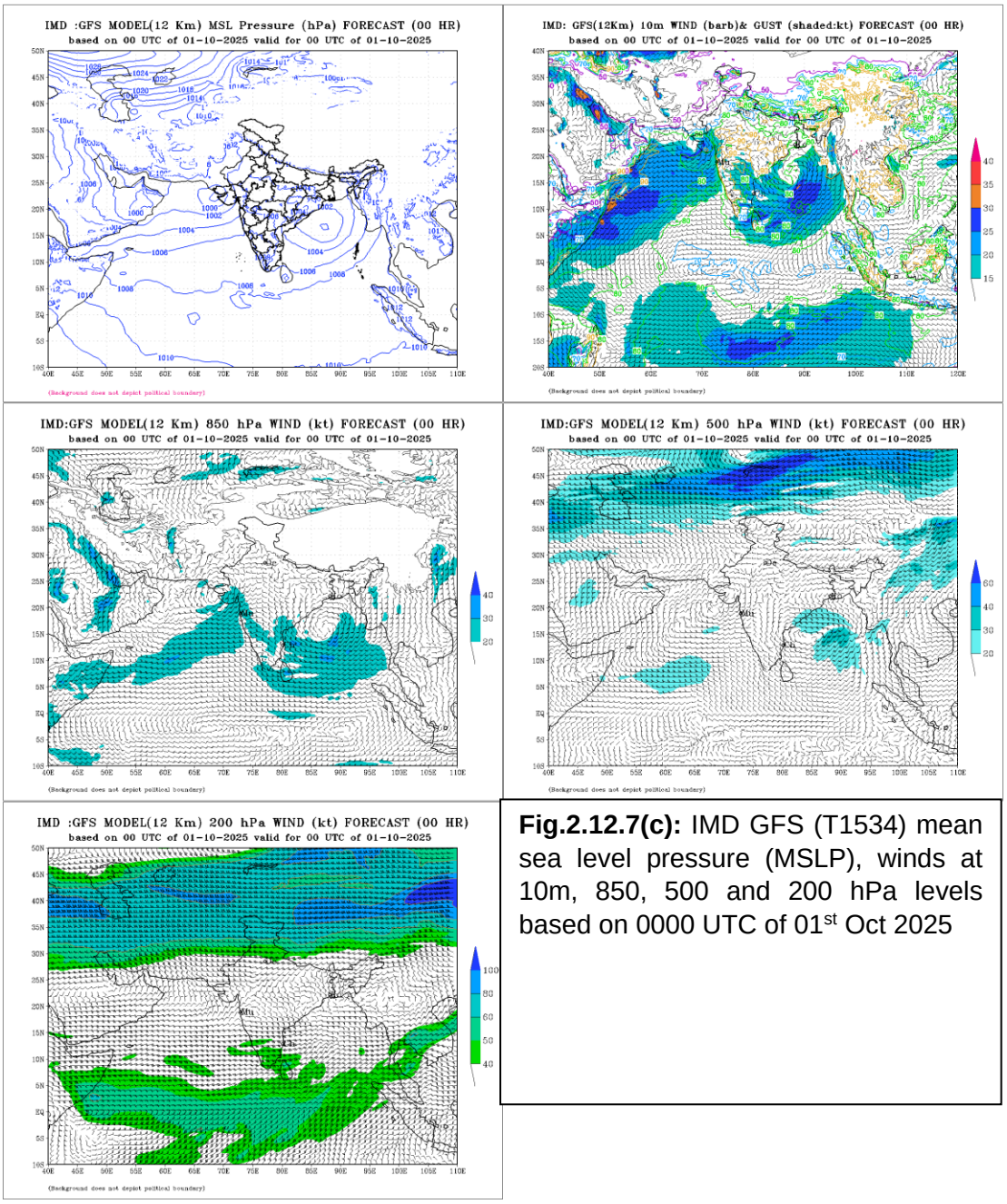


Fig.2.12.7(c): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 01st Oct 2025

The analyses of various parameters also indicated the intensification of low pressure area over westcentral Bay of Bengal. The wind circulations around the system over BoB was more symmetric as well as stronger compared to the system over Arabian Sea at this stage. The 200 hPa wind indicated the ridge line persisted along 23°N latitude resulting in continued southwestwards steering over the system. The model's analysis could bring out the emergence of Well Marked low Pressure area over northeast Arabian Sea.

The Fig.2.12.7(d) illustrated MSLP and wind analyses at different levels at 00 UTC of 02nd October, 2025. In the figure MSLP clearly brought out the depression over northeast

Arabian Sea off Saurashtra & Kutch coasts with slight southward movement. The isobaric analysis also indicated the intensification of the system into a deep depression over westcentral BoB off south Odisha coast. The surface wind distribution indicated stronger and more symmetric cyclonic circulation over Bay of Bengal system compared to the system over Arabian Sea. Consequently, associated upper air cyclonic circulations extending upto 500 hPa for both the systems represented similar characteristic differences as shown by the surface wind. The 200 hPa wind indicated the system was situated north of the ridge line (which was extended along 21o N latitude) and western side of the col region along the ridge. Due to this system started to experience southward steering.

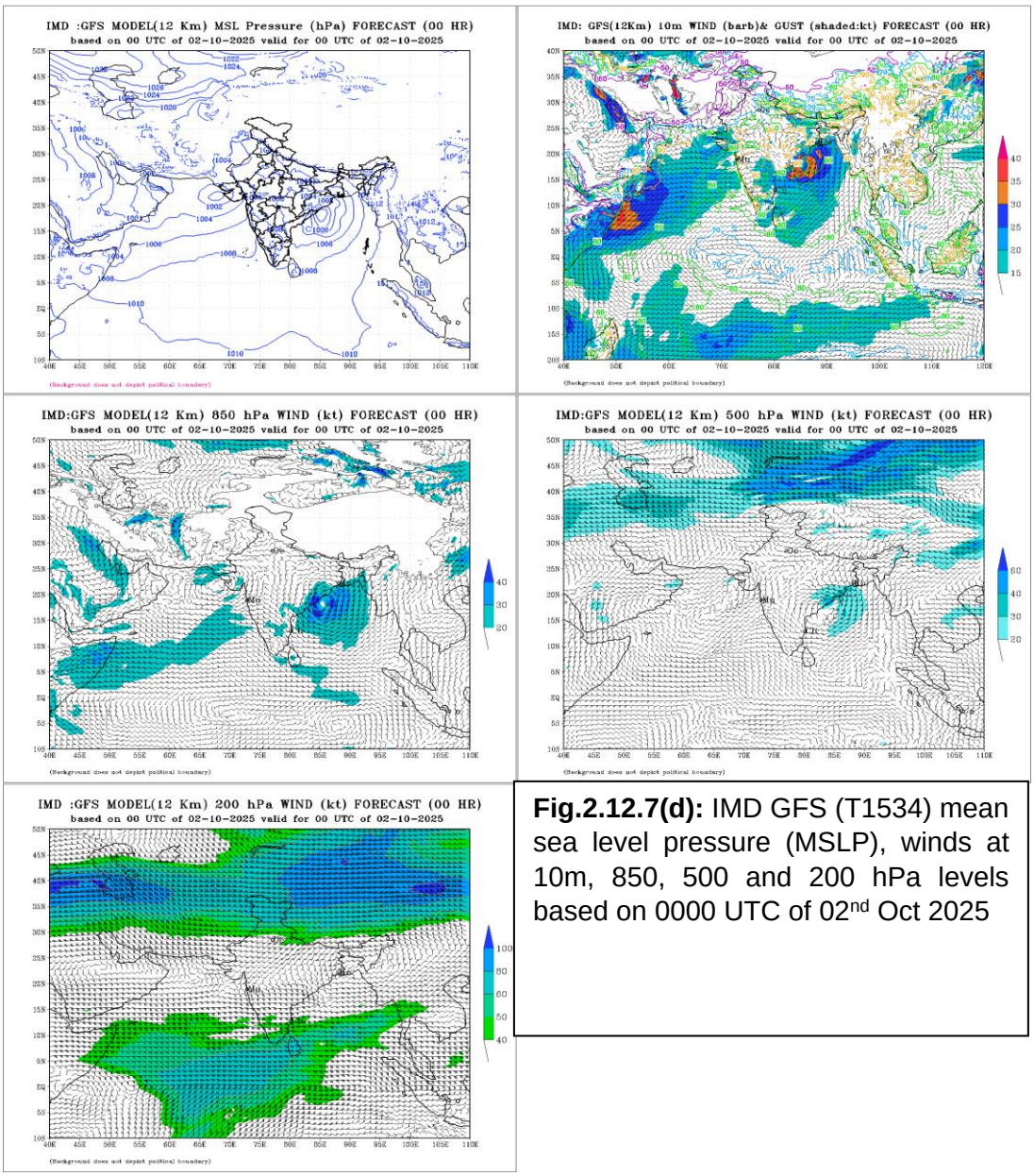


Fig.2.12.7(d): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 02nd Oct 2025

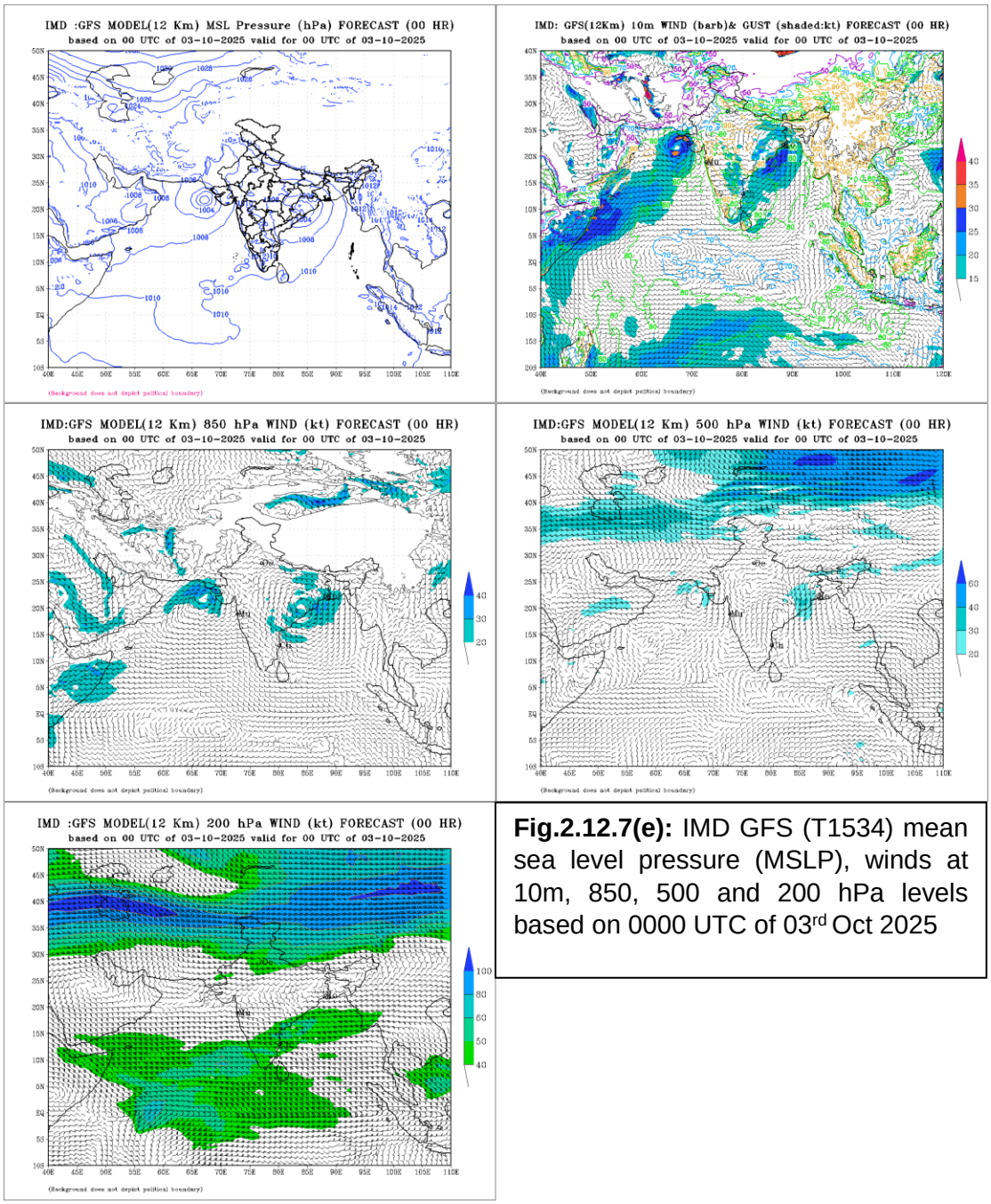


Fig.2.12.7(e): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 03rd Oct 2025

The model analyses of MSLP and winds at different heights valid at 0000 UTC of 3rd October, 2025 are shown in various panels Fig.2.12. 7(e). The isobaric pattern in the figure, depicted that the system intensified into a cyclonic storm with obvious 3 closed isobars within an area of 5□ span over northeast Arabian Sea off Saurashtra & Kutch coasts. Meanwhile, the other deep depression over westcentral BOB entered into land as it was shown by the MSLP and surface wind analyses. The cyclonic circulation in the surface wind analyses associated with the cyclonic storm became more symmetric with time, however there were two maxima in the southwest and northeast sectors of the storm. The strong southwesterly winds of monsoon over AS were directed towards the cyclonic storm and therefore the westerly flow leading towards the other deep depression over interior Odisha drastically weakened into a depression and subsequently into a well marked low pressure area over north Chhattisgarh and adjoining north Odisha & Jharkhand. Simultaneously,

along with the intensification of the storm, associated upper-air cyclonic circulation extended beyond mid-tropospheric levels (850 and 500 hPa winds) became stronger in all levels. The system at the surface was located near the upper-air ridgeline along 21°N as shown by the winds at 200 hPa. Therefore, the model analyses could capture the intensification of the cyclone.

The isobaric patterns in the MSLP analysis in Fig.2.12. 7(f) for 00 UTC of 04th

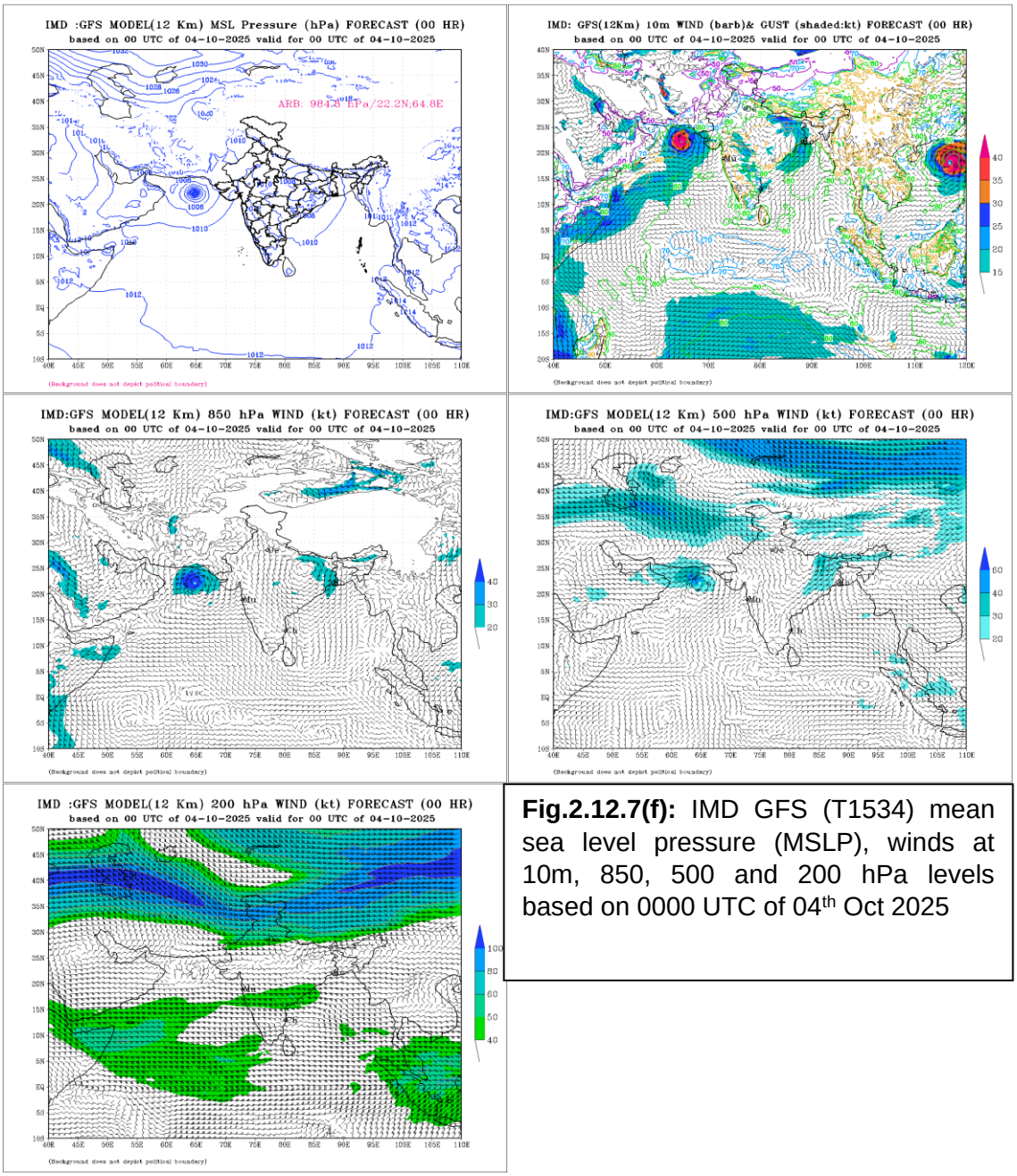


Fig.2.12.7(f): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 04th Oct 2025

October, 2025. Described that the Cyclonic Storm moved northwestward and increasing number of closed isobars was indicating intensification of the storm into a Severe Cyclonic Storm over northeast Arabian Sea. The surface wind indicated a very symmetric core of the cyclone with wind speed more than 40 Kts. Associated upper air cyclonic circulation at 850 hPa depicted similar kind of wind structure of the storm. The system was vertically extending

upto mid-tropospheric level (500 hPa) but system was showing a certain asymmetry with stronger winds at the northwest sector. At this time the system center was located south of the ridge line (along 23°N) at 200 hPa. Accordingly, the system was steered by the upper level easterly winds

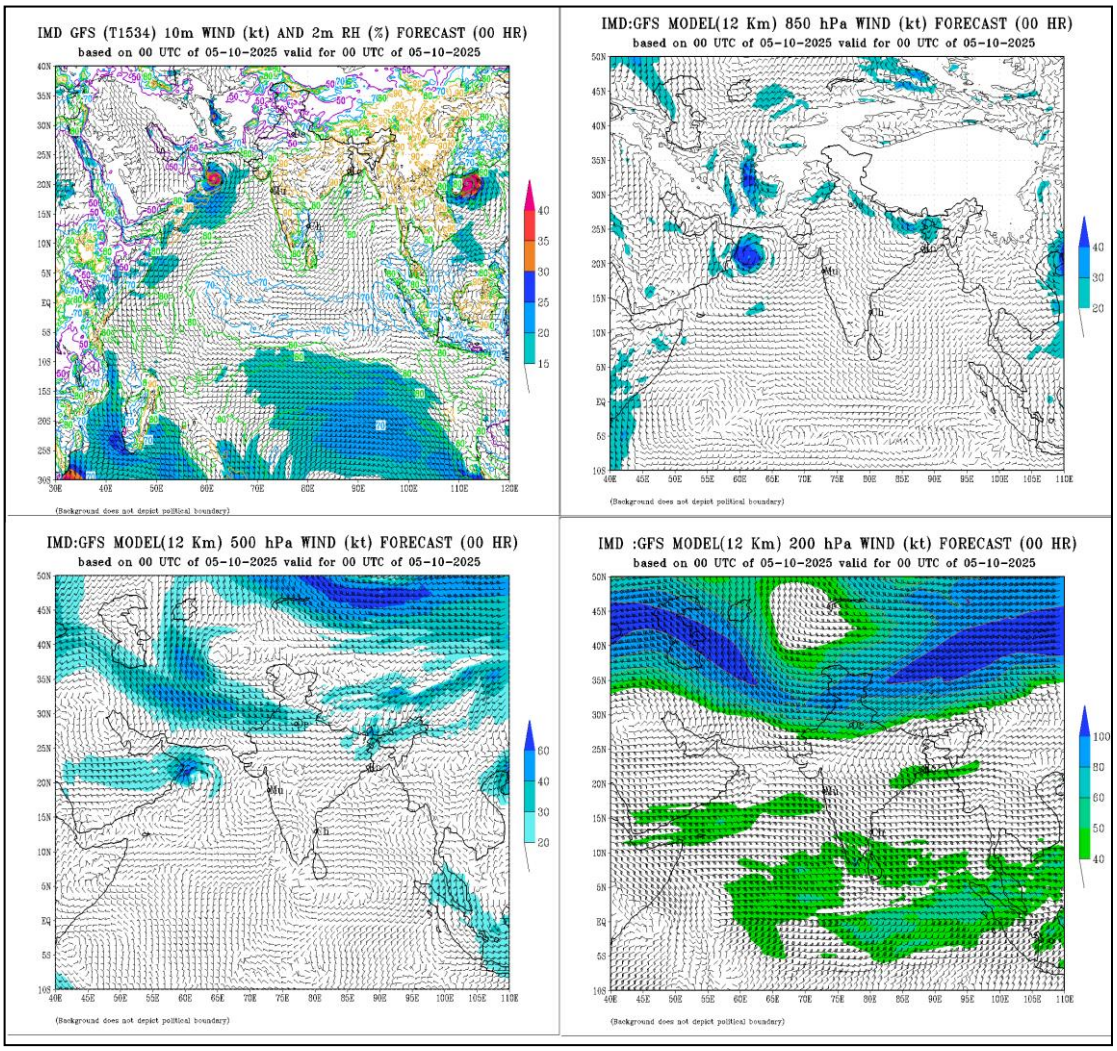


Fig.2.12.7(g): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 05th Oct 2025

The model analysis at 00 UTC of 05th & 06th October, 2025 are plotted in Fig.2.12. 7(g) & Fig.2.12. 7(h) respectively. The surface analysis of MSLP and wind indicated the system initially moved westwards and then gradually west-southwestwards reached upto northwest Arabian sea near to Oman coast on 06th October maintaining its intensity. The core of the storm with MSW crossing 40 Kts was maintained throughout this period. It reduced slightly on 06th October. Associated upper air cyclonic circulations at 850 hPa was more intact and symmetric compared to the cyclonic circulations at 500 hPa on 05th & 06th October. It was noticed that the cyclonic circulations at 500 hPa weakened slightly losing its symmetry. However, the stronger winds were found at the northwest sector of the storm at this level. The 200 hPa winds indicated that as the system moved further away from the ridge line (along 23□N) on 05th October. It was gradually steered more by the upper level

southwesterly winds. The wind pattern at 200 hPa altered slightly due to strengthening of the anti-cyclone over Arabian Peninsula making steering flow more southwards on 06th October. The model analysis could bring out the fact that while moving west-southwestwards the system would maintain its intensity of a Severe Cyclonic Storm.

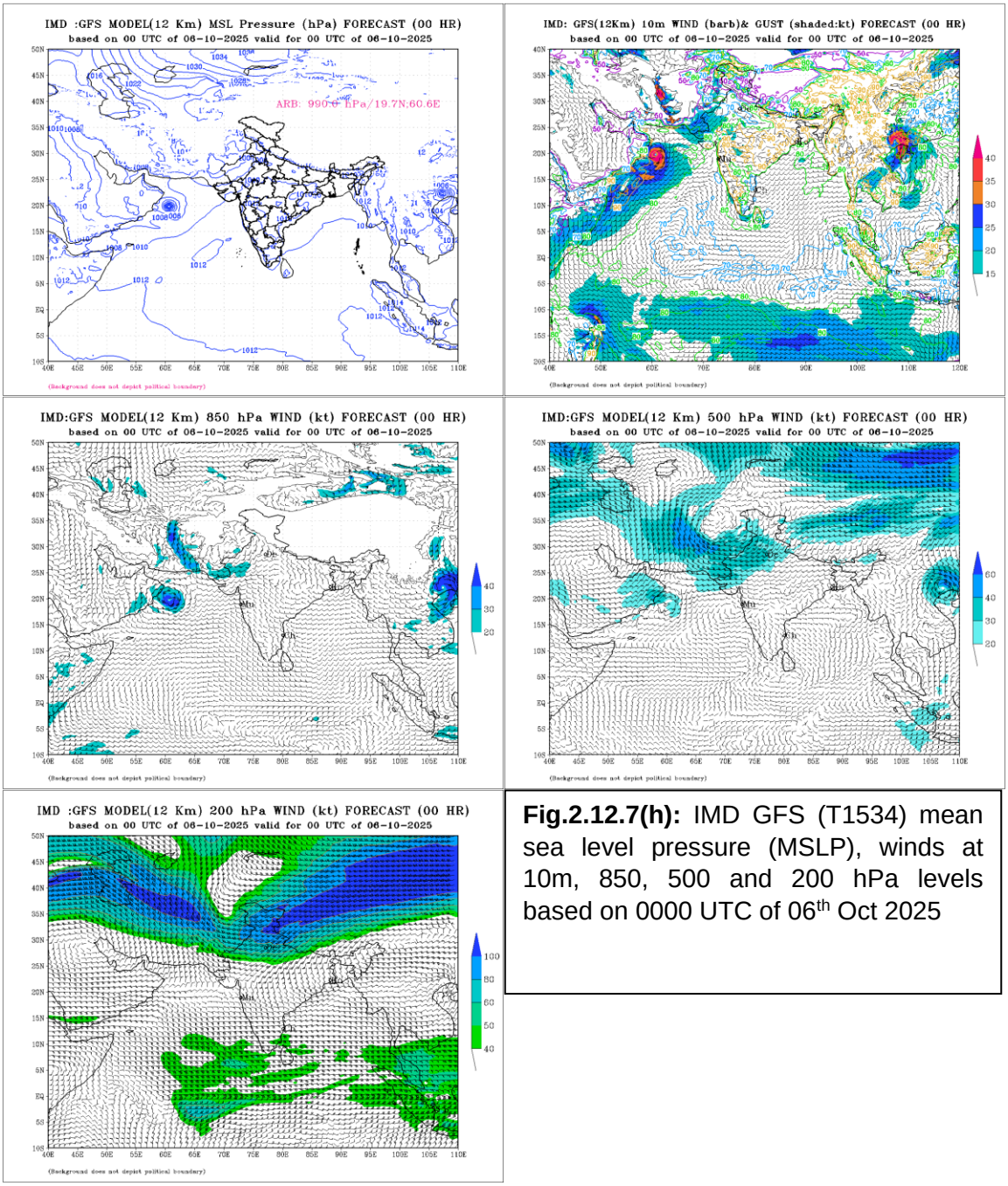


Fig.2.12.7(h): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 06th Oct 2025

The MSLP analysis of the model at 00 UTC of 07th October, 2025 and corresponding surface wind at 10 m above ground as shown in Fig.2.12. 7(i), indicated weakening of the system into a Deep Depression over northwest & adjoining westcentral Arabian Sea. Although isobaric analysis displayed only 2 closed isobars. The surface winds indicated MSW exceeding 30 Kts prevailed over the southern side of the cyclone.

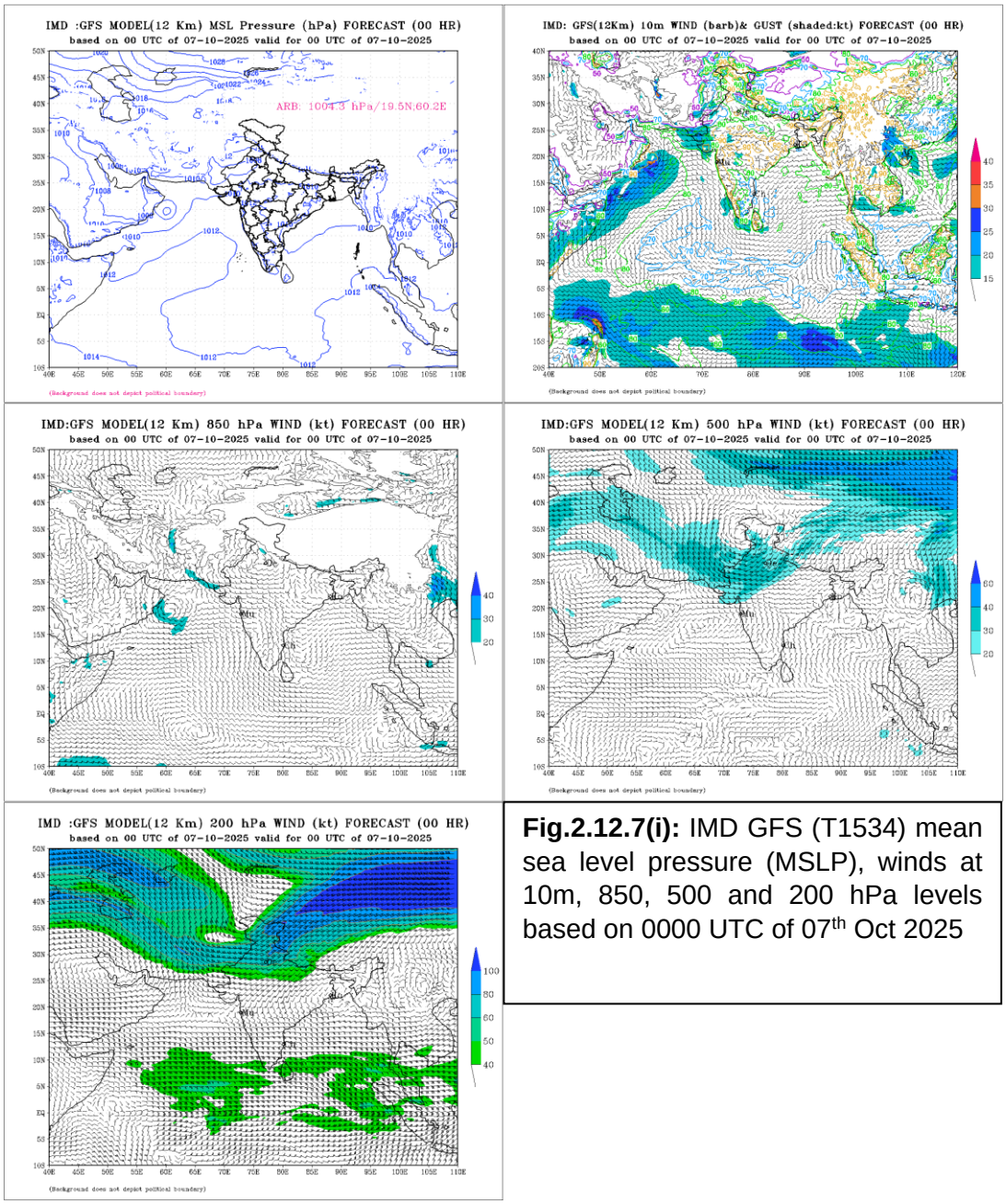


Fig.2.12.7(i): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 07th Oct 2025

The associated upper air cyclonic circulations were extending up to mid-tropospheric levels. But the wind pattern at 500 hPa indicated only a feeble cyclonic circulation associated with the system embedded inside a southwest-northwest trough along the coastal areas of Oman & Yemen. The upper-level ridge line at 200 hPa was oriented along 19°N latitude, and the location of the system centre was south of the system with northerly wind at the periphery of the anticyclone over the Arabian Peninsula. Therefore, there was a northerly mean wind of the mid and upper-tropospheric layers which steered the storm more southward. Due to increasing vertical shear, as well as dry air incursion from Arabian Peninsula on the northwest sector of the storm in the mid & upper tropospheric levels, the system weakened into a deep depression and further quickly into a depression within 12 hours. The model analyses captured the weakening into a deep depression on 7th early morning.

2.13 Depression over Southeast Arabian Sea (22nd October – 1st November 2025)

2.13.1 Introduction

- An upper air cyclonic circulation lay over southeast Arabian Sea & adjoining Lakshadweep in the morning (0830 hrs IST/ 0300 UTC) of 15th October. It persisted over the same region till early morning (0530 hrs IST/ 0000 UTC) of 18th October.
- Under its influence, a low-pressure area (LPA) formed over southeast Arabian Sea (AS) & Lakshadweep area off Kerala-Karnataka coasts in the early morning (0530 hrs IST/0000 UTC) of 18th October.
- It became a well-marked low pressure area (WML) over the same region in the same morning (0830 hrs IST/0300 UTC). It moved nearly westwards and lay over southeast AS in the morning (0830 hrs IST/0300 UTC) of 20th October 2025.
- It concentrated into a Depression at 0000 UTC of 22nd October over southeast AS.
- The Depression over southeast AS moved slowly north-northeastwards and lay over Southeast & adjoining Eastcentral AS in the midnight (2330 hrs IST/1800 UTC) of 23rd October.
- Thereafter, it moved nearly northwards till midnight (2330 hrs IST/1800 UTC) of 24th October over eastcentral AS.
- It then gradually recurved and moved nearly westwards till early morning (0530 hrs IST/ 0000 UTC) of 26th Oct. & south-southwestwards till evening (1730 hrs IST/ 1200 UTC) of 26th Oct. Thereafter, it looped and moved east-northeastwards till 29th early morning (0530 hrs IST/ 0000 UTC) and nearly westwards till 30th noon (1130 hrs IST/ 0600 UTC) over eastcentral AS.
- It again recurved and moved northwards till midnight (2330 hrs IST/ 1800 UTC) of 30th October & northeastwards thereafter till midnight (2330 hrs IST/ 1800 UTC) of 31st October over eastcentral AS and weakened into a WML over eastcentral & adjoining northeast AS in the early morning (0530 hrs IST/0000 UTC) of 1st November.
- The observed track of the system is presented in **Fig.2.13.1**. The best track parameters of the system are presented in **Table 2.13.1**.

Table 2.13.1: Best track positions and other parameters of the Depression over Southeast Arabian Sea during 22nd October– 1st November, 2025.

Date	Time (UTC)	Lat. (0N)	Long. (0E)	C.I. No.	ECP (hPa)	ΔP (hPa)	MSW (kt)	Category
22.10.25	0000	8.6	67.6	1.5	1002	3	20	D
	0600	9.0	67.0	1.5	1002	3	20	D
	1200	9.3	67.4	1.5	1002	3	20	D
	1800	9.5	67.6	1.5	1002	3	20	D
23.10.25	0000	9.6	67.7	1.5	1001	3	20	D
	0600	10.1	68.0	1.5	1001	3	20	D

	1200	11.0	69.4	1.5	1001	3	20	D
	1800	12.0	70.0	1.5	1001	3	20	D
24.10.25	0000	13.3	70.5	1.5	1001	3	20	D
	0600	14.4	70.7	1.5	1001	3	20	D
	1200	15.2	70.7	1.5	1001	3	20	D
	1800	16.1	70.7	1.5	1001	3	20	D
25.10.25	0000	16.4	70.4	1.5	1001	3	20	D
	0600	16.6	69.2	1.5	1001	3	20	D
	1200	16.6	68.0	1.5	1001	3	20	D
	1800	16.6	67.2	1.5	1001	3	20	D
26.10.25	0000	16.5	66.8	1.5	1001	3	20	D
	0600	15.5	66.4	1.5	1001	3	20	D
	1200	15.1	66.4	1.5	1001	3	20	D
	1800	15.1	66.5	1.5	1001	3	20	D
27.10.25	0000	16.1	66.8	1.5	1000	4	25	D
	0600	16.6	67.2	1.5	1000	4	25	D
	1200	16.7	67.3	1.5	1000	4	25	D
	1800	16.7	67.3	1.5	1000	4	25	D
28.10.25	0000	17.0	67.8	1.5	1000	4	25	D
	0600	17.2	68.0	1.5	1000	4	25	D
	1200	17.4	68.5	1.5	1000	4	25	D
	1800	17.7	69.0	1.5	1000	4	25	D
29.10.25	0000	17.9	69.2	1.5	1000	4	25	D
	0600	18.0	69.1	1.5	1000	4	25	D
	1200	17.9	69.0	1.5	1000	4	25	D

	1800	17.9	68.8	1.5	1000	4	25	D
30.10.25	0000	17.9	68.2	1.5	1000	4	25	D
	0600	17.9	68.2	1.5	1000	4	25	D
	1200	18.1	68.2	1.5	1000	4	25	D
	1800	18.3	68.2	1.5	1000	4	25	D
31.10.25	0000	18.6	68.4	1.5	1000	4	25	D
	0600	18.9	68.5	1.5	1000	4	25	D
	1200	19.2	69.0	1.5	1000	4	25	D
	1800	19.4	69.6	1.5	1001	3	20	D
01.11.25	0000	Weakened into a well marked low pressure area over the eastcentral and adjoining northeast Arabian Sea						

KT: Knots (nautical mile per hour), 1 KT=1.85 kmph, D: Depression.

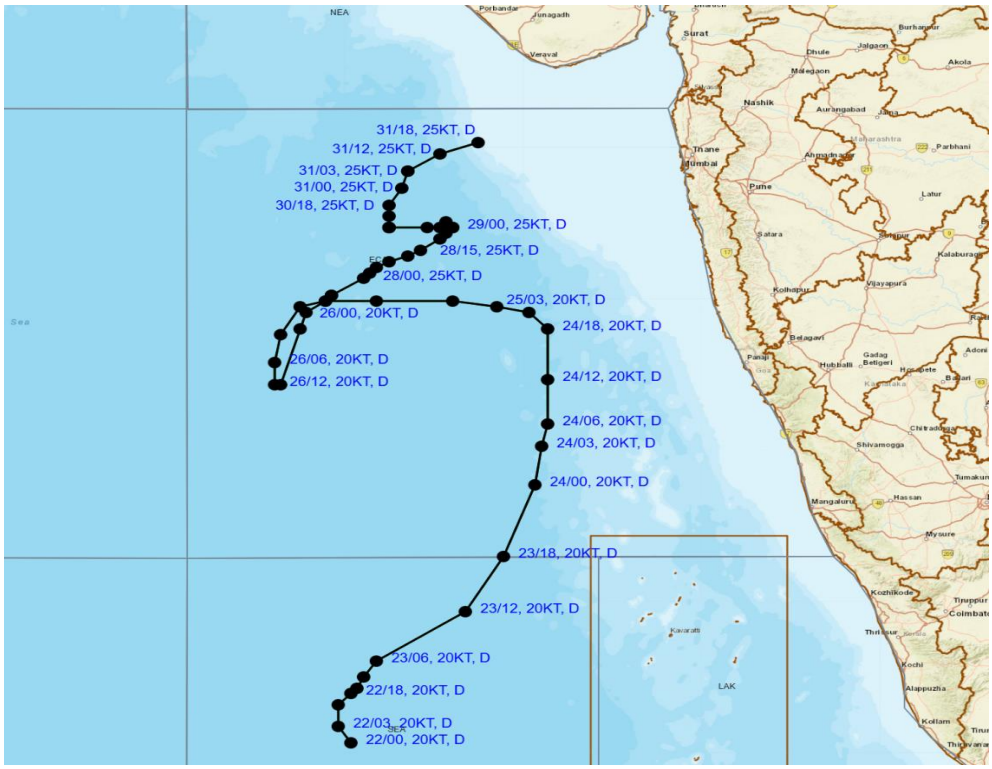


Fig.2.13.1: Observed track of Depression over Southeast Arabian Sea during 22nd – 31st October 2025 (depression to depression)

2.13.2 Salient features of the system

- It had one of the longest life period over the AS (around 10 days) against normal of normal of 2 days & 16 hours for depressions over AS in post-monsoon season based on data during 1990-2013.
- It experienced multiple recurvatures while moving across southeast & eastcentral AS during 22nd October-01st November.
- There has been development of 39 depressions in the post-monsoon season during 1965-2024 (**Fig.2.13.2a**). Out of these, 16 developed in October (**Fig.2.13.2b**). No such long lived depression formed over AS during this period.

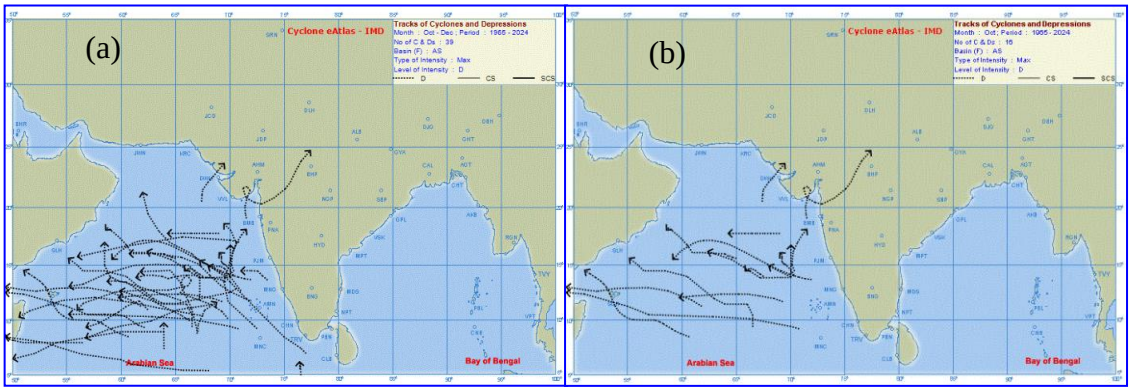


Fig.2.13.2: Tracks of depressions over AS in (a) post-monsoon season (October to December) and (b) October during 1965-2024

- **Long life period**: In recent years, there has been long lived cyclones viz. extremely severe cyclonic storm Biparjoy (June, 2023) had a life period of 13 days & 13 hours and super cyclone Kyarr (October, 2019) had a life period of 9 days & 15 hours.
- **Simultaneous occurrence**: During this depression, severe cyclonic storm Montha occurred simultaneously over the Bay of Bengal (BoB) during 25th-29th October. Such simultaneous occurrence was last observed in 2018 with cyclone Luban (06-15 October) over AS & Titli (08-13 October) over BoB and cyclones Gati (21-24 November) over AS & Nivar (22-27 November) in 2020.

2.13.3 Genesis, intensification and movement

At 0300 UTC of 16th Oct, the Madden Julian Oscillation (MJO) index was expected to move in phases 2 & 3 during 16th to 20th October and in phase 4 during 20th to 28th October with amplitude remaining close to 1, supporting enhancement of convective activity and cyclogenesis over the AS during 16th to 20th and over the BoB during 18th to 26th Oct. Guidance from NCICS model indicated enhanced cross equatorial flow from 17th Oct. onwards leading to westerly wind burst over southern parts of AS and BoB and adjoining equatorial Indian Ocean (EIO) during 20th to 25th Oct. The Model indicated prevalence of equatorial Rossby wave (ERW), Kelvin wave (KW), MJO, Low frequency Background wave (LW), enhanced westerly wind Anomaly (>9mps) over the region during 17th to 25th Oct. The mode also indicated setting in of easterly wind over the BoB and AS from 17th onwards with enhanced wind anomaly (5-7 mps) over central and adjoining and south BoB during 20th to 25th October and weak easterly wind anomaly (1-3 mps) over southeast Arabian Sea during 16th - 19th October. These features indicated a favourable environment for cyclogenesis

(formation of Depression) over AS during 19th to 22nd and over the BoB during 20th to 26th Oct. Actually, depression formed over the AS on 22nd Oct and over the BoB on 25th Oct. As discussed above, the MJO and equatorial waves continued to prevail over the AS till 1st Nov. and over the BoB till 29th Oct.

At 0000 UTC of 22nd Oct, MJO lay in phase 4 with amplitude more than 1. Guidance from NCICS model indicated enhanced cross equatorial flow on 22nd October onwards leading to westerly wind burst over southern parts of AS and BoB and adjoining equatorial Indian Ocean (EIO) during 22nd to 26th October. The Model indicated prevalence of equatorial Rossby wave (ERW) Kelvin wave (KW), MJO, Low frequency Background wave (LW), enhanced westerly wind anomaly (>9mps) over the region during 22nd to 26th October. The model also indicated setting in of easterly winds anomaly (5-7 mps) over central and adjoining south BoB during 21st to 26th October and over central parts of south & east AS during 22nd – 23rd October. These features provided a favourable environment for enhanced convective activity & cyclogenesis (formation of Depression) over AS during 22nd –23rd and over the BoB during 22nd – 25th October. The guidance from Cooperative Institute for Meteorological Satellites (CIMSS) indicated, multiple positive low level vorticity at 850 hPa centres viz. an east-west oriented zone with about 50 X 10^{-6} s^{-1} to the southwest and another over southeast & east of system area off Kerala coast. Vertically they were extending upto 500 hPa level. The upper level divergence was around 20 X 10^{-6} s^{-1} to the west and another 20 X 10^{-6} s^{-1} to the southeast of system area. Low level convergence was about 10 X 10^{-6} s^{-1} to the west of system area and another zone of 30 X 10^{-6} s^{-1} to the east of system area. Mid-level vertical wind shear (VWS) of horizontal wind was anticyclonic & low (05-10 kt) over the system area and over central parts of south and eastcentral AS along the predicted path. Upper tropospheric ridge ran along 17°N over the AS. Under these favourable features, a depression formed over southeast AS at 0000 UTC of 22nd Oct.

At 0300 UTC of 23rd Oct., the MJO and equatorial waves continued to provide a favourable environment. The guidance from CIMSS indicated, a zone of positive low level vorticity at 850 hPa of about 50 X 10^{-6} s^{-1} extending upto eastcentral Arabian Sea. Multiple vorticity centres were seen over the southeast and eastcentral AS. Vertically positive vorticity zones were extending upto 500 hPa level. The upper-level divergence was around 20 X 10^{-6} s^{-1} to the northeast and another 10 X 10^{-6} s^{-1} to the southwest of system area. Low level convergence was about 20 X 10^{-6} s^{-1} to the east of system area along the west coast of India and another zone of 15 X 10^{-6} s^{-1} to the west of system area. Mid-level vertical wind shear (VWS) of horizontal wind was anticyclonic & low (05-10 kt) over the system area and over central parts of south and eastcentral AS along the predicted path. Upper tropospheric ridge ran along 17˚N over the AS. Under these favourable thermodynamic features, the system maintained its intensity.

At 0300 UTC of 24th Oct., the MJO lay in phase 4. The westerly wind burst till 27th Oct and slight decreasing trend thereafter till 2nd November alongwith prevalence of ERW, MJO, LW over the southeast AS during 24th -30th October. Easterly wind anomaly (5-7 mps) was likely to prevail over eastcentral AS during 24th to 27th October. Thus, equatorial waves were likely to support the depression to maintain its intensity over southeast & eastcentral AS during 24th to 27th October. The low level vorticity at 850 hPa was the same about 50-60 X 10^{-6} s^{-1} extending up to 500 hPa level. The upper-level divergence decreased and was around 10-20 X 10^{-6} s^{-1} over the system area and was extending to the west of the system. Low level convergence increased and was about 15-20 X 10^{-6} s^{-1} to the west of system area. Mid-level vertical wind shear (VWS)

of horizontal wind was anticyclonic & low (10-15 kt) over the system area and over eastcentral Arabian Sea. Upper tropospheric ridge ran along 18˚N over the AS.

At 0300 UTC of 25th Oct., similar thermodynamical features prevailed which helped system to maintain its intensity of depression.

On 26th Oct., MJO and equatorial waves remained the same. The dynamic features indicated increase in low level vorticity at 850 hPa to 100 X 10^{-6} s^{-1} to the southwest of system area with vertical extension upto 500 hPa level. It was southwest-northeast oriented and was extending upto west coast of India. Two positive zones of upper-level divergence were seen to the west (10 X 10^{-6} s^{-1}) and another zone of (30 X 10^{-6} s^{-1}) to the east of system area along the west coast of India. Two positive zones of low-level convergence were seen with about 10X 10^{-6} s^{-1} to the southwest and another zone of 20X 10^{-6} s^{-1} to the northeast of system area. Mid-level vertical wind shear (VWS) of horizontal wind is anticyclonic & low to moderate (5 – 10 kt) over the central parts of Arabian Sea. Upper tropospheric ridge ran along 16.5˚N over the eastcentral AS off Maharashtra coast. Though all features were supportive, presence of multiple vorticity centres prevented further intensification of system.

At 0300 UTC of 27th Oct., MJO lay in phase 5. The equatorial waves continued to provide favourable environment with prevalence of ERW, MJO, LW over southeast AS till 30th October. The model guidance also indicated prevalence of easterly wind anomaly (5-7 mps) over southwest & adjoining westcentral AS on 27th October. Thus, equatorial waves were supporting the convective activity associated with the cyclonic disturbances over eastcentral AS.

The dynamical features indicated, low level vorticity at 850 hPa was about 100 × 10^{-6} s^{-1} to the northeast sector of system area, extending upto 700 hPa level. It is southwest-northeast oriented and is extending upto west coast of India. Three positive zones of upper-level divergence were seen around the centre (30 × 10^{-6} s^{-1}), another zone of (20 × 10^{-6} s^{-1}) to the northeast of system area and another zone of (30 × 10^{-6} s^{-1}) to the southeast of system area along the west coast of India. Positive zone of low-level convergence about 20 × 10^{-6} s^{-1} to the northeast of system area along the west coast of India. Mid-level vertical wind shear (VWS) of horizontal wind was anticyclonic & low to moderate (5 – 10 kt) over the central parts of Arabian Sea. Upper tropospheric ridge ran along 17˚N over the eastcentral AS in association with anticyclonic circulation over Maharashtra coast.

At 0300 UTC of 28th Oct., the MJO lay in phase 5. The equatorial waves continued to provide favourable environment with prevalence of westerly wind burst, ERW & LW over southeast AS and easterly wind anomaly over eastcentral AS. The low level vorticity at 850 hPa was about 100 × 10^{-6} s^{-1} to the south of system area, extending up to 700 hPa level. It is southwest-northeast oriented and is extending upto west coast of India. Two positive zones of upper-level divergence were seen to southwest of the system centre (10 × 10^{-6} s^{-1}) and another zone of (10 × 10^{-6} s^{-1}) to the northeast of system area. Positive zone of low-level convergence was about 15 × 10^{-6} s^{-1} to the northeast of system area. Mid-level vertical wind shear (VWS) of horizontal wind was anticyclonic & low to moderate (5 – 10 kt) over the eastcentral parts of Arabian Sea. Upper tropospheric ridge ran along 18˚N over the eastcentral AS in association with anticyclonic circulation over Maharashtra coast.

Similar, features prevailed on 29th and 30th as well. From 31st October onwards, weakening of dynamical features was observed. However, most of the features remained favourable. The low level vorticity at 850 hPa decreased and was about 80-100×10^{-6} s^{-1} around system area, extending towards Northeast Arabian Sea and upto 700 hPa level. Upper-level divergence was around 20 × 10^{-6} s^{-1} to the northeast of the system centre over North Maharashtra. Low-level convergence was about 15 × 10^{-6} s^{-1} to the northeast of system area over North Maharashtra. Mid-level vertical wind shear (VWS) of horizontal wind was anticyclonic & low to moderate (10 – 20 kt) over the system area. Upper tropospheric ridge ran along 20°N over the eastcentral AS in association with anticyclonic circulation off North Maharashtra coast. Under these conditions, the system maintained its intensity of depression on 30th and 31st Oct. and weakened into a well marked low pressure area over the eastcentral and adjoining northeast Arabian Sea in the early morning (0530 hrs IST/ 0000 UTC) of 1st November.

With respect to movement, the system exhibited multiple recurvatures. It was steered mainly by the combined effects of the ridge prevailing near 17^0N passing across anticyclonic circulation over Oman to the anticyclonic circulation over central Myanmar. Simultaneously, there was also cyclonic circulation over south & adjoining central AS and another anticyclonic circulation over Southeast AS and adjoining Equatorial Indian Ocean.

Thus, during the entire life period of the system, westerly wind burst over the south AS, prevalence of ERW, LW, MJO wave over the southeast AS and easterly wind anomaly over the eastcentral AS, low to moderate & anticyclonic vertical wind shear, positive low level vorticiy, low level convergence and upper level divergence, supported cyclogenesis and maintenance of intensity of the system for almost 9 days. However, presence of multiple vorticity centres and also the development of cyclone Montha over the BoB prevented further intensification of the system.

2.13.4 Monitoring through satellite

India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean (NIO) and the system was monitored well in advance since 9th October. The system was monitored with the help of available 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.

Satellite monitoring of the system was mainly done by using half hourly INSAT-3DR and 3DS 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.2.13.3. (a) to (e)**.

During the entire life cycle, the clouds were organized in shear pattern. From 25th October onwards, the clouds were steered to the northeast. The detailed features from the satellite pictures are discussed in this section.

At 0300 UTC of 22nd Oct., the intensity of the system was T1.5. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over south & adjoining central AS lay between latitude 5.0°N to 15.0° N and longitude 57.0° E to 71.0° E. The minimum cloud top temperature was minus 70 to 90 degree Celsius.

At 0300 of 23rd Oct., the vortex lay over southeast AS & neighbourhood with intensity characterised as T1.5. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over south & adjoining central AS between latitude 7.0°N to 18.0° N and longitude 54.0° E to 74.0° E. The minimum cloud top temperature was minus 70 to 90 degree Celsius.

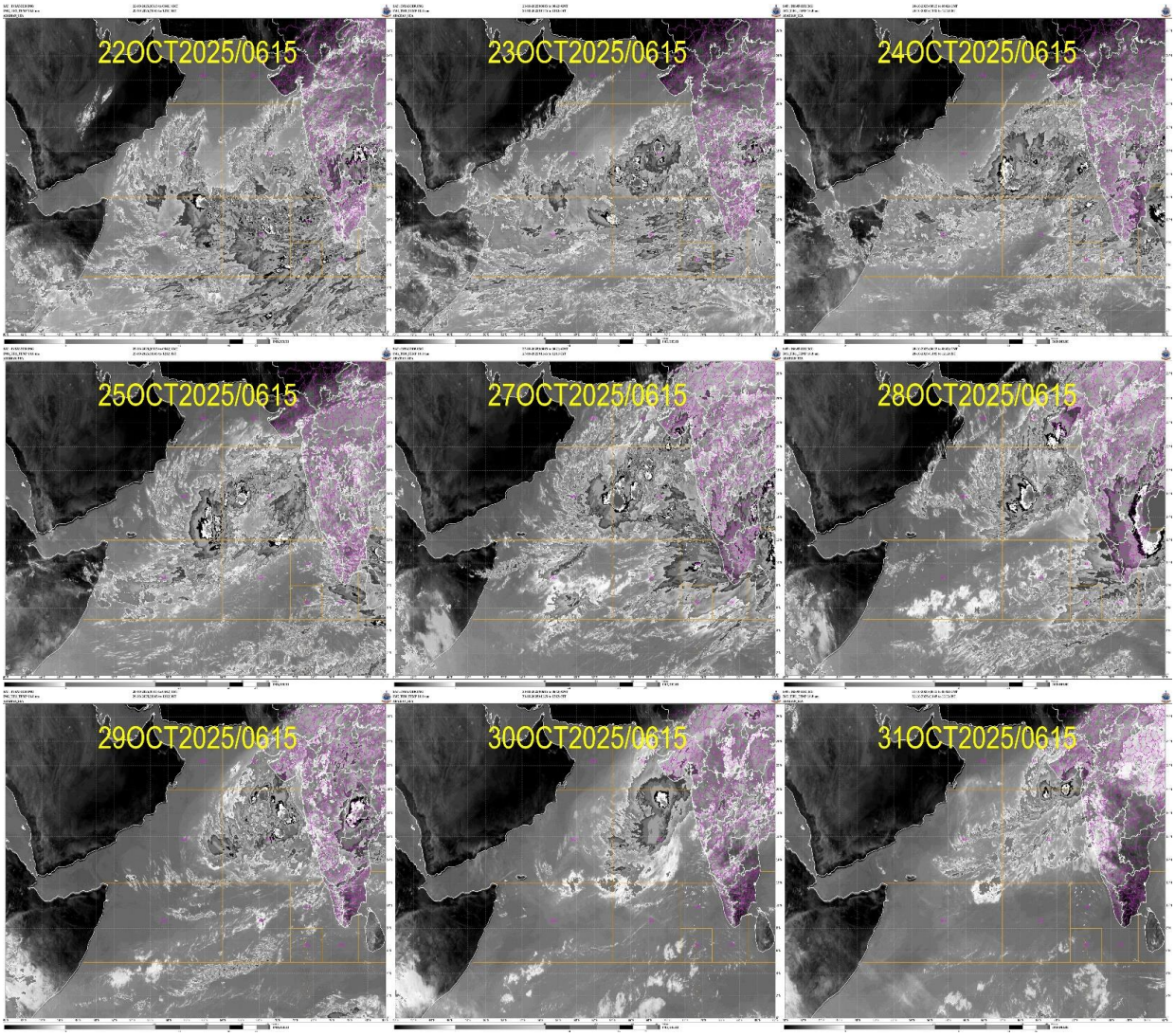


Fig.2.13.3(a): INSAT-3D BD imageries during life cycle of Depression over Southeast Arabian Sea during 22nd – 31st October 2025.

At 0300 of 24th Oct., the vortex lay over eastcentral AS & neighbourhood with intensity characterised as T1.5. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over eastcentral and adjoining southeast

AS and Lakshadweep Islands area. The minimum cloud top temperature was minus 70 to 90 degree Celsius.

At 0300 of 25th Oct., the vortex lay over eastcentral Arabian Sea & neighbourhood with Intensity T1.5. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over central & south AS, Lakshadweep Islands, Maldives and Comorin area (minimum cloud top temperature was minus 70 to 90 degree Celsius).

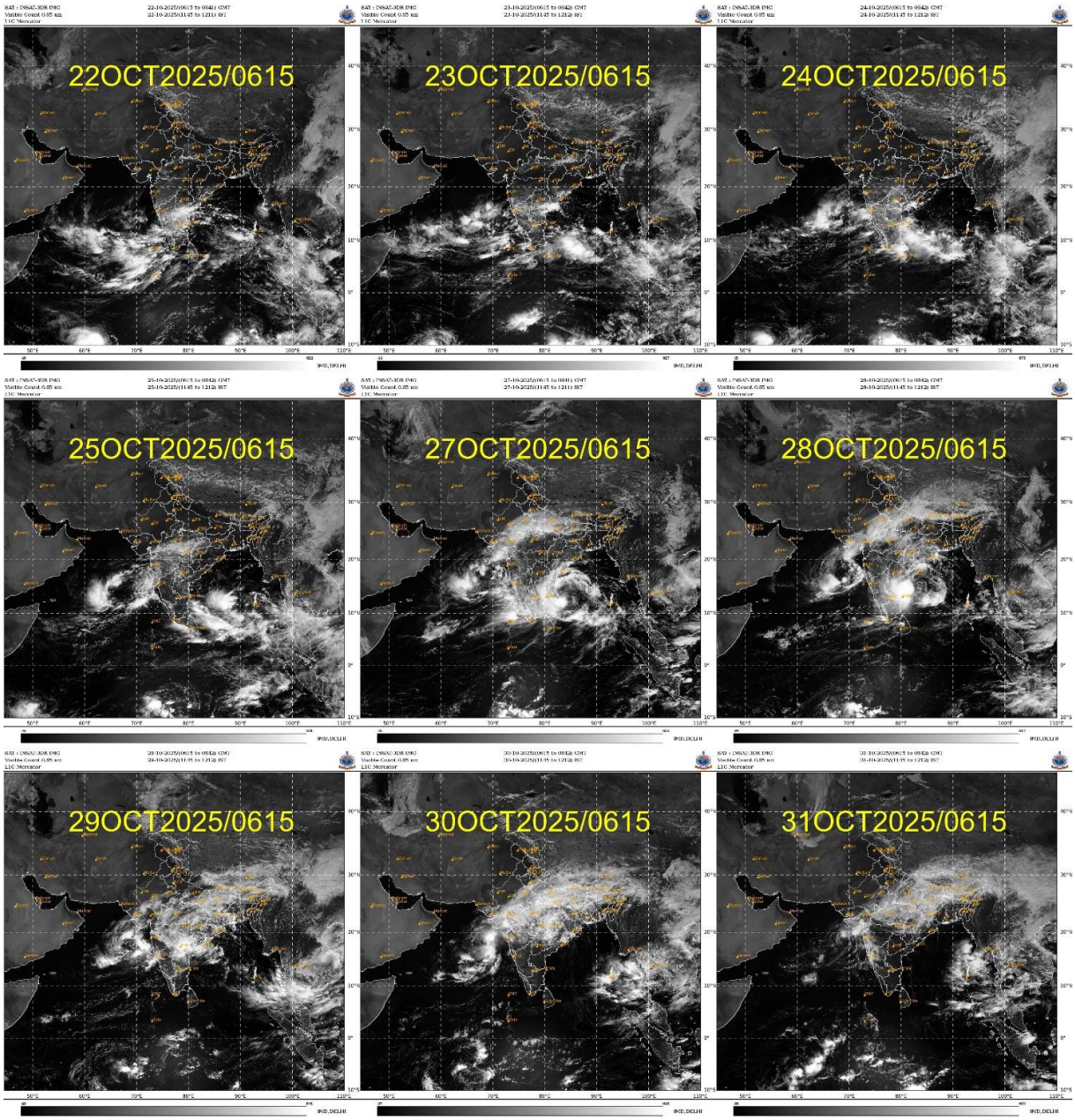


Fig.2.13.3(b): INSAT-3D Visible imageries during life cycle of Depression over Southeast Arabian Sea during 22nd – 31st October 2025.

At 0300 of 26th Oct., the vortex lay over eastcentral AS & neighbourhood with Intensity T1.5. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over central & adjoining south Arabian Sea, between latitude 10.0 N to 20.0 N, longitude 57.0 E to 73.0 E (minimum cloud top temperature was minus 70 to 90 degree Celsius).

At 0300 of 27th Oct., the vortex lay over eastcentral Arabian Sea & neighbourhood with intensity as T1.5. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over central & adjoining south Arabian Sea, between latitude 8.0 N to 20.0 N, longitude 60.0 E to 73.0 E and adjoining Gujarat. (Minimum cloud top temperature was minus 70 to 90 degree Celsius). Moderate to intense convection was also seen over Maharashtra with minimum cloud top temperature as minus 40 to 70 degree Celsius).

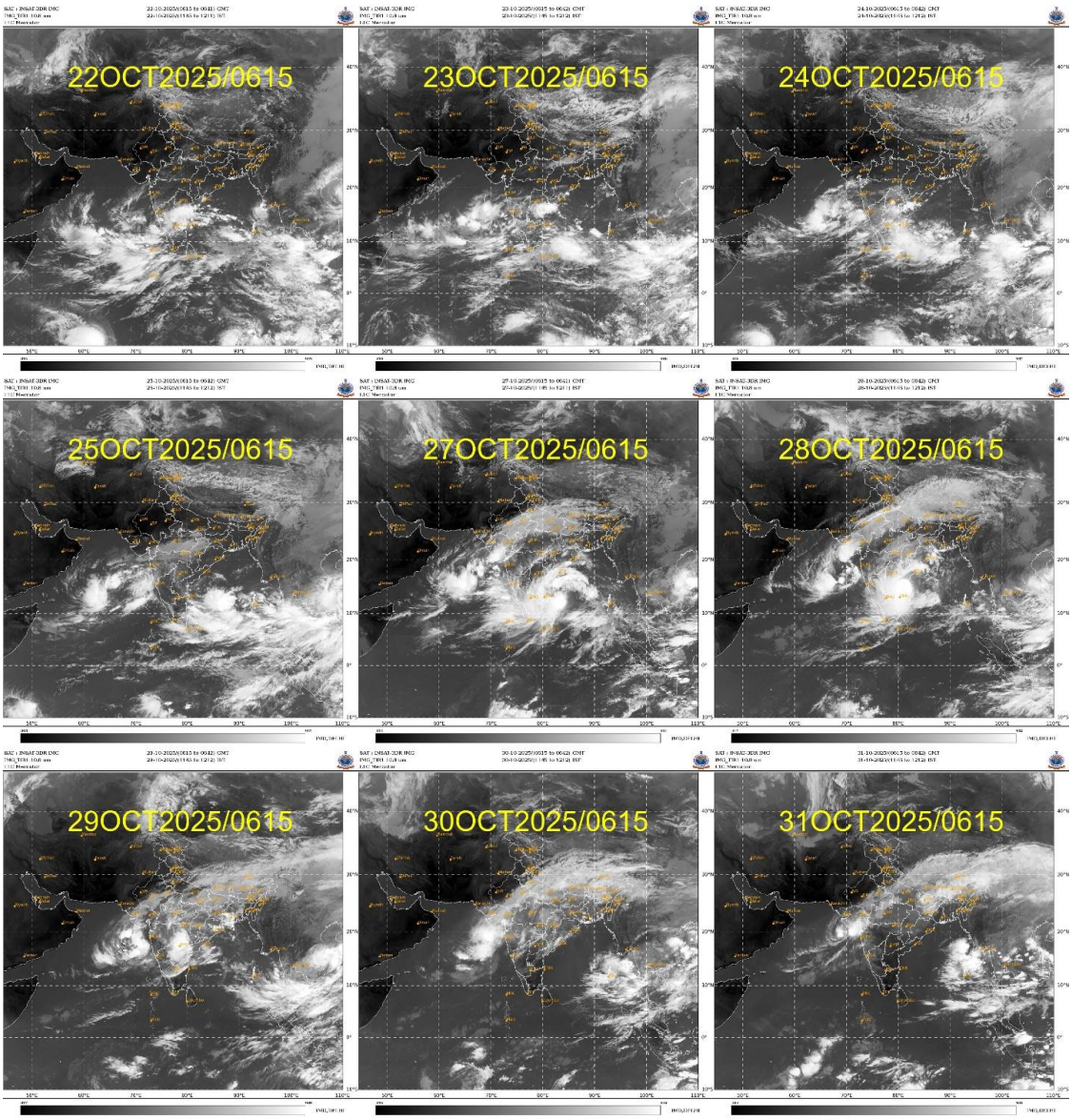


Fig.2.13.3(c): INSAT-3D IR imageries during life cycle of Depression over Southeast Arabian Sea during 22nd – 31st October 2025.

At 0300 of 28th Oct-2025, the vortex lay over eastcentral Arabian Sea & neighbourhood centered within half a degree of latitude 17.0°N & longitude 67.8°E with intensity characterised as T1.5. Scattered to broken, low and medium clouds with embedded intense to very intense convection lay over central & northeast AS and Gulf of Cambay Gujarat & Gulf of Kutch with minimum cloud top temperature as minus 70 to 90 degree Celsius.

At 0300 of 29th Oct., the intensity of the system was T1.5. Associated scattered to broken, low and medium clouds with embedded intense to very intense convection lay over central & northeast AS and minimum cloud top temperature was minus 70 to 90 degree Celsius and moderate to intense convection lay over Gujarat, Gulf of Cambay, Gujarat & Gulf of Kutch with minimum cloud top temperature as minus 40 to 60 degree Celsius.

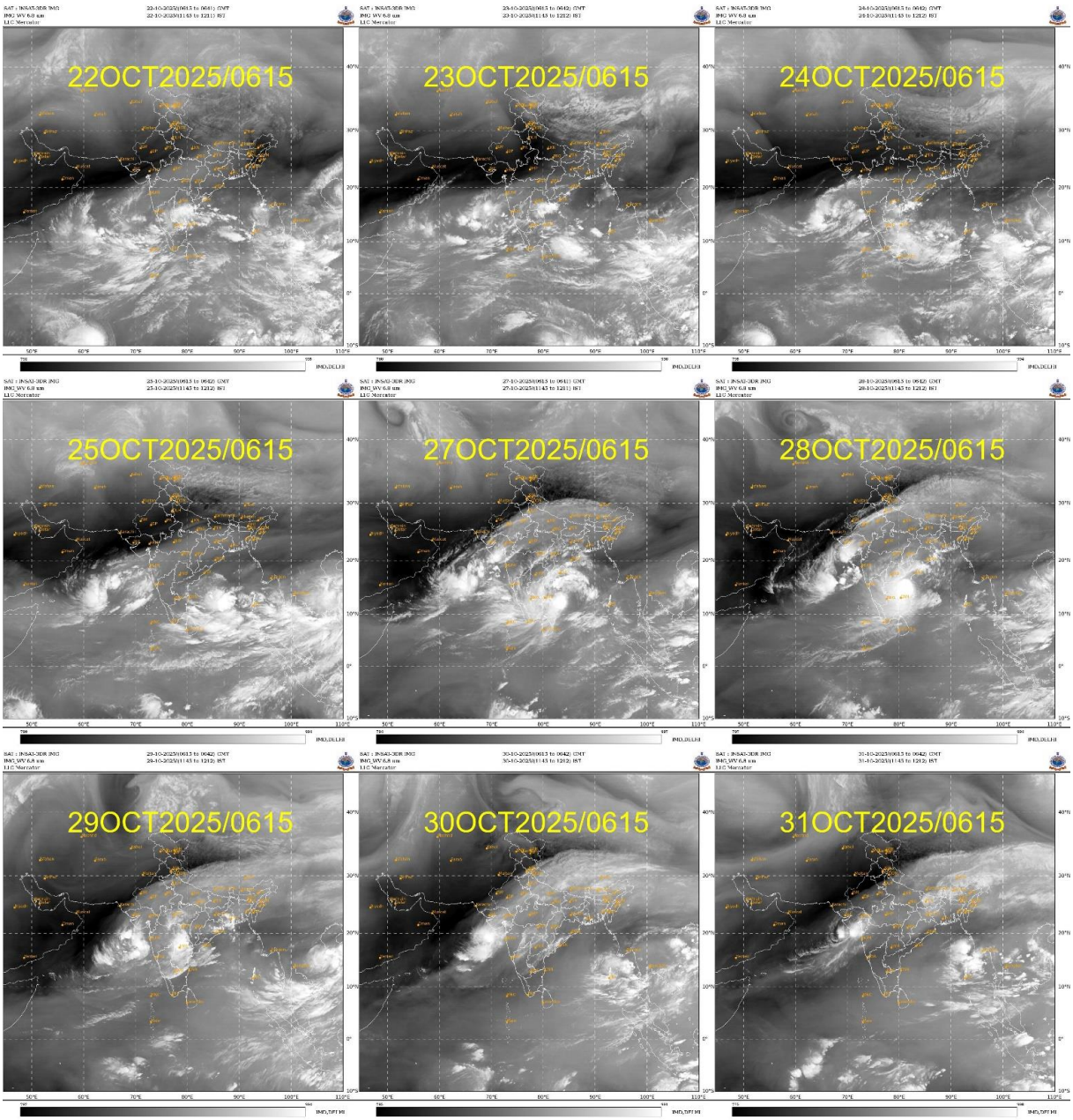


Fig.2.13.3(d): INSAT-3D WV imageries during life cycle of Depression over Southeast Arabian Sea during 22nd – 31st October 2025.

At 0300 of 30th Oct., the intensity of the system was T1.5. Associated scattered to broken, low and medium clouds with embedded intense to very intense convection lay over eastcentral & adjoining northeast AS, Gujarat, Gulf of Cambay & Gujarat and Gulf of Kutch (Minimum cloud top temperature was minus 70 to 90 degree Celsius).

At 0300 of 31st Oct, the intensity was characterised as T 1.5. Associated scattered to broken low/medium clouds with embedded intense to very intense convection lay over eastcentral and adjoining northeast AS, Gujarat, Gulf of Cambay & Gulf of Kutch (minimum cloud top temperature was minus 70 to 90 degree Celsius).

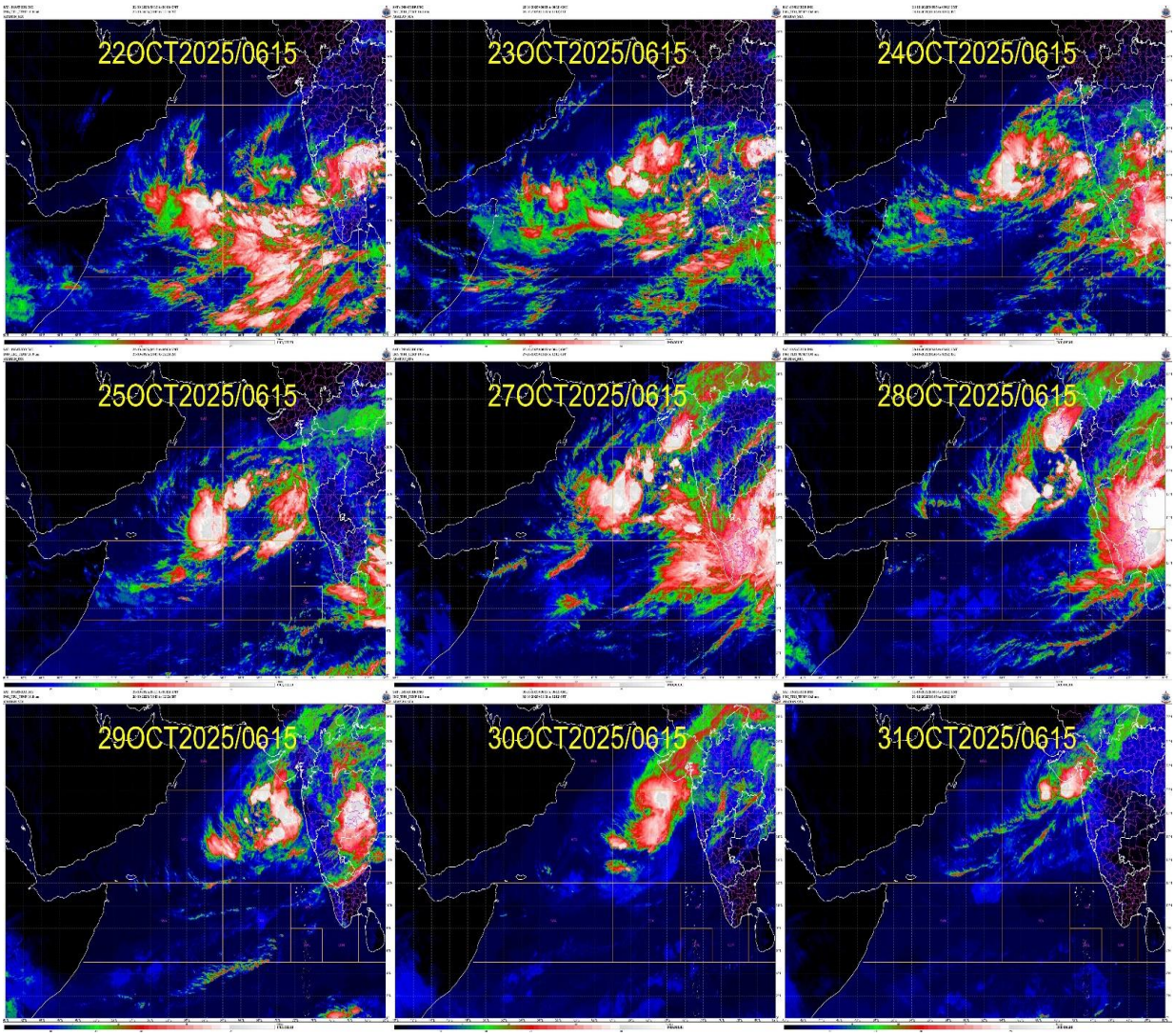


Fig.2.13.3(e): INSAT-3D enhanced colored imageries during life cycle of Depression over Southeast Arabian Sea during 22nd – 31st October 2025.

2.13.5 Dynamical Features

IMD GFS (T1534) daily analyses based on 0000 UTC of mean sea level pressure (MSLP), 10m winds and winds at 850, 500, 200 hPa pressure levels from 22nd – 31st October are presented in **Fig.2.13.4**. IMD GFS analysis field at 0000 UTC of 22nd October

indicated a WML over southeast AS near 7.2 ^{0}N/ 70.2 ^{0}E. The associated cyclonic circulation extended upto 500 hPa tilting south-westwards with height. Upper tropospheric ridge was seen near 18°N. However, at that time, the system lay as a depression over southeast AS near 8.6 ^{0}N/ 67.6 ^{0}E.

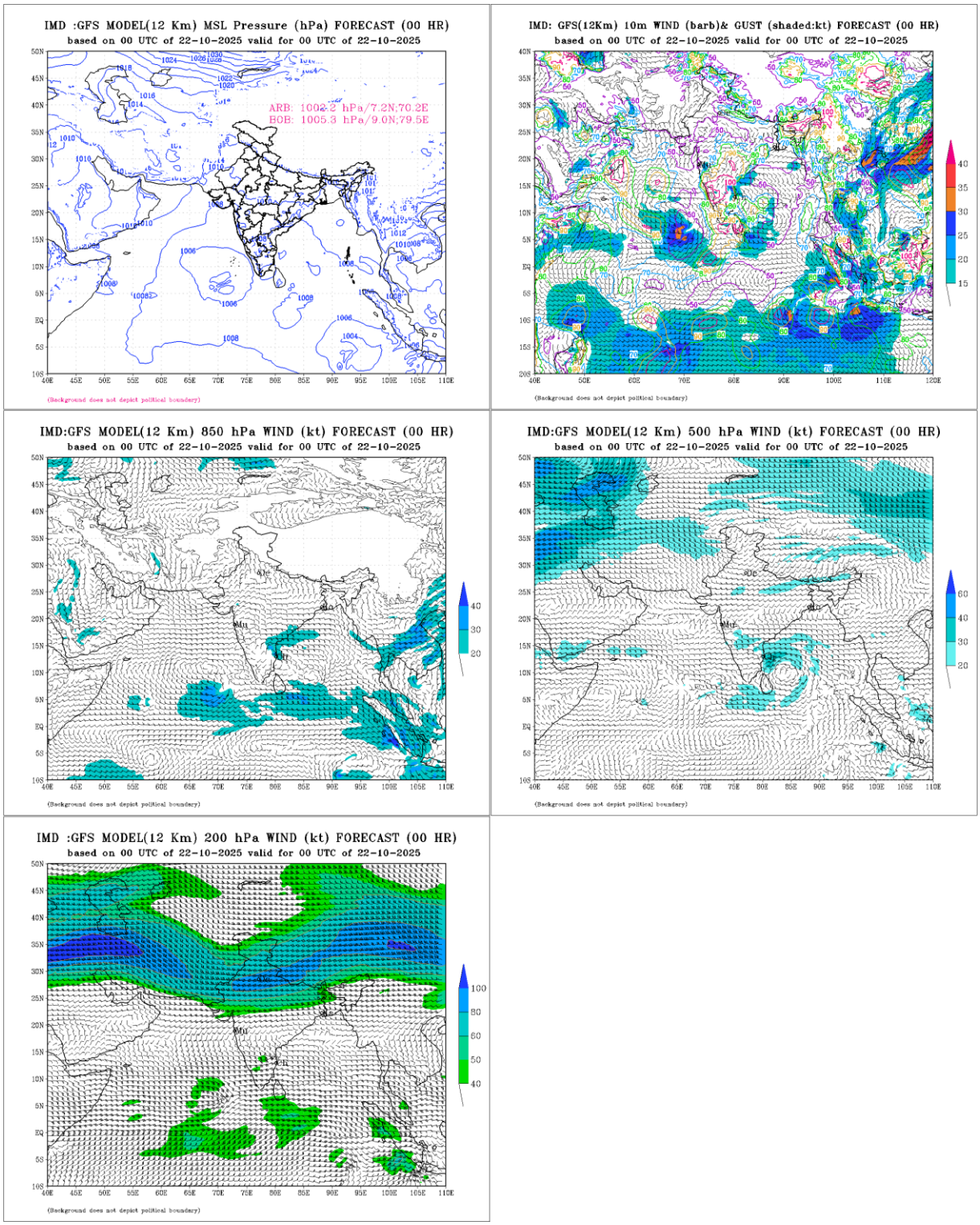


Fig.2.13.4(a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 22nd Oct 2025

IMD GFS analysis field at 0000 UTC of 23rd October indicated a WML over southeast AS near 10.2 ^{0}N/ 70 ^{0}E. The associated cyclonic circulation extended upto 500 hPa tilting south-westwards with height. Upper tropospheric ridge was seen near 18°N. However, at that time the system lay as a depression over southeast AS near 9.6 ^{0}N/ 67.7 ^{0}E.

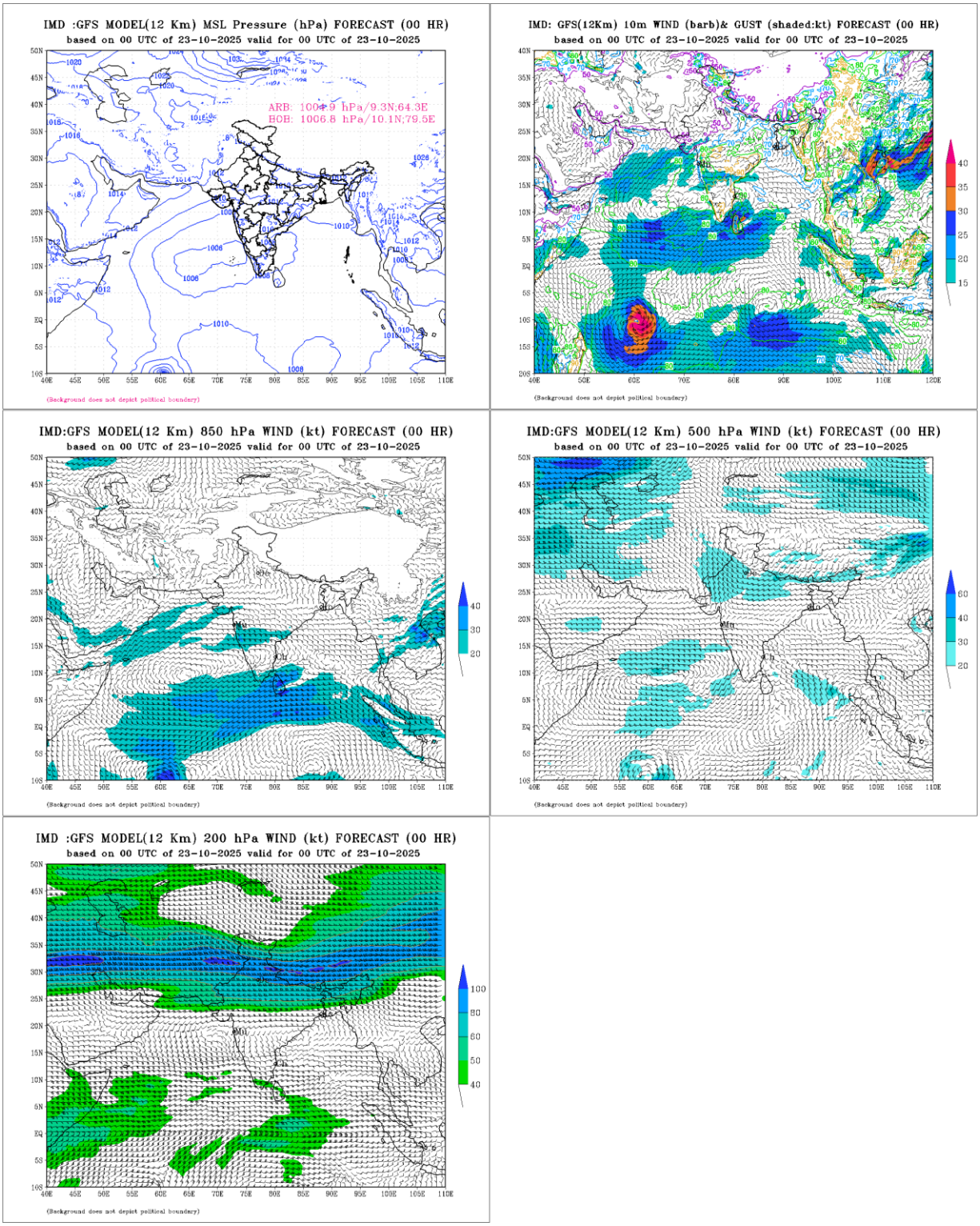


Fig.2.13.4(b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 23rd Oct 2025

IMD GFS analysis field at 0000 UTC of 24th October indicated a WML over eastcentral AS near 12.8 ^{0}N/ 69.7^{0}E. The associated cyclonic circulation extended upto 500 hPa tilting south-westwards with height. Upper tropospheric ridge was seen near 18°N. However at that time, system lay as a depression over eastcentral AS near 13.3^{0}N/ 70.5 ^{0}E.

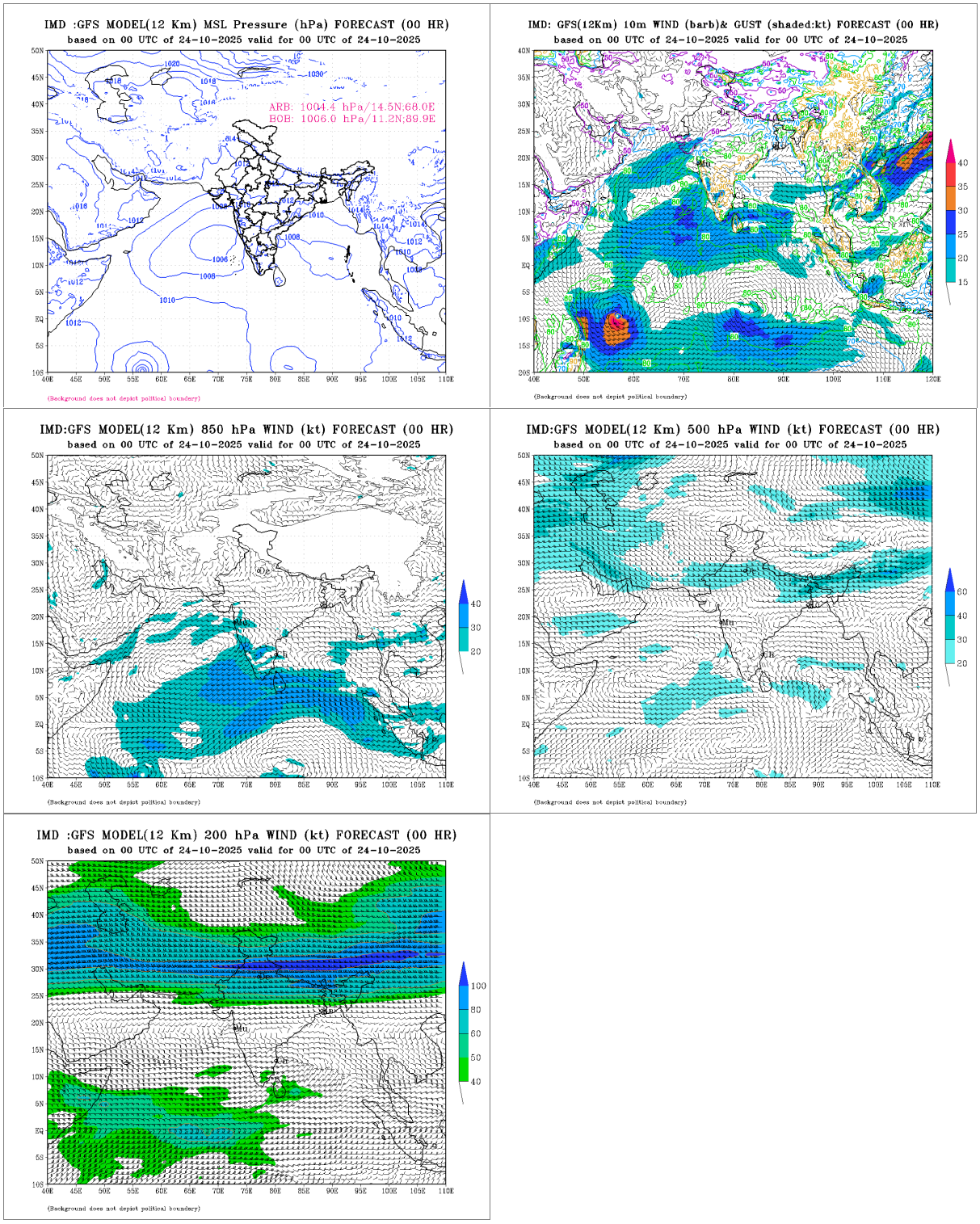


Fig.2.13.4(c): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 24th Oct 2025

IMD GFS analysis field at 0000 UTC of 25th October indicated a cyclonic storm over central parts of AS near 15.8 ^{0}N/ 65.2^{0}E. The associated cyclonic circulation extended upto 500 hPa tilting south-westwards with height. Upper tropospheric ridge was seen near 18°N, however at that time, system lay as a depression over eastcentral AS near 16.4^{0}N/ 70.4 ^{0}E. Thus, the model could not capture the location correctly and also overestimated the intensity of system. At the same time, it did not capture the depression over Bay of Bengal on 25th October.

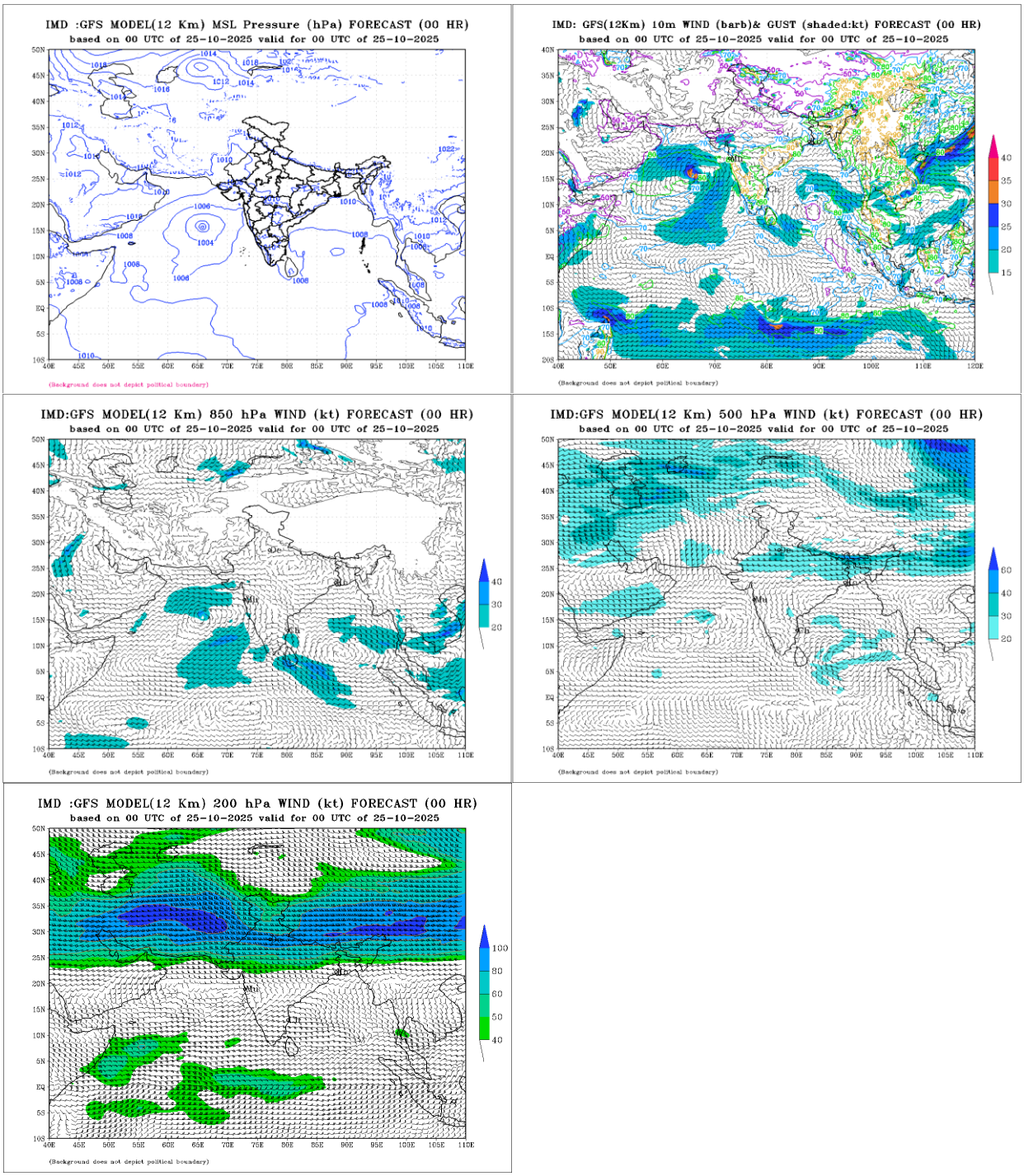


Fig.2.13.4(d): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 25th Oct 2025

IMD GFS analysis field at 0000 UTC of 26th October indicated weakening of the system over AS into a deep depression at 25/1200 UTC. The associated cyclonic circulation extended upto 500 hPa tilting south-westwards with height. Upper tropospheric ridge was seen near 17^{0}N. The model indicated the depression over southeast Bay of Bengal on 25/1200 UTC. Actually, the system lay as depression over eastcentral AS near 16.5^{0}N/ 66.8^{0}E. The model could capture location correctly but the intensity was overestimated.

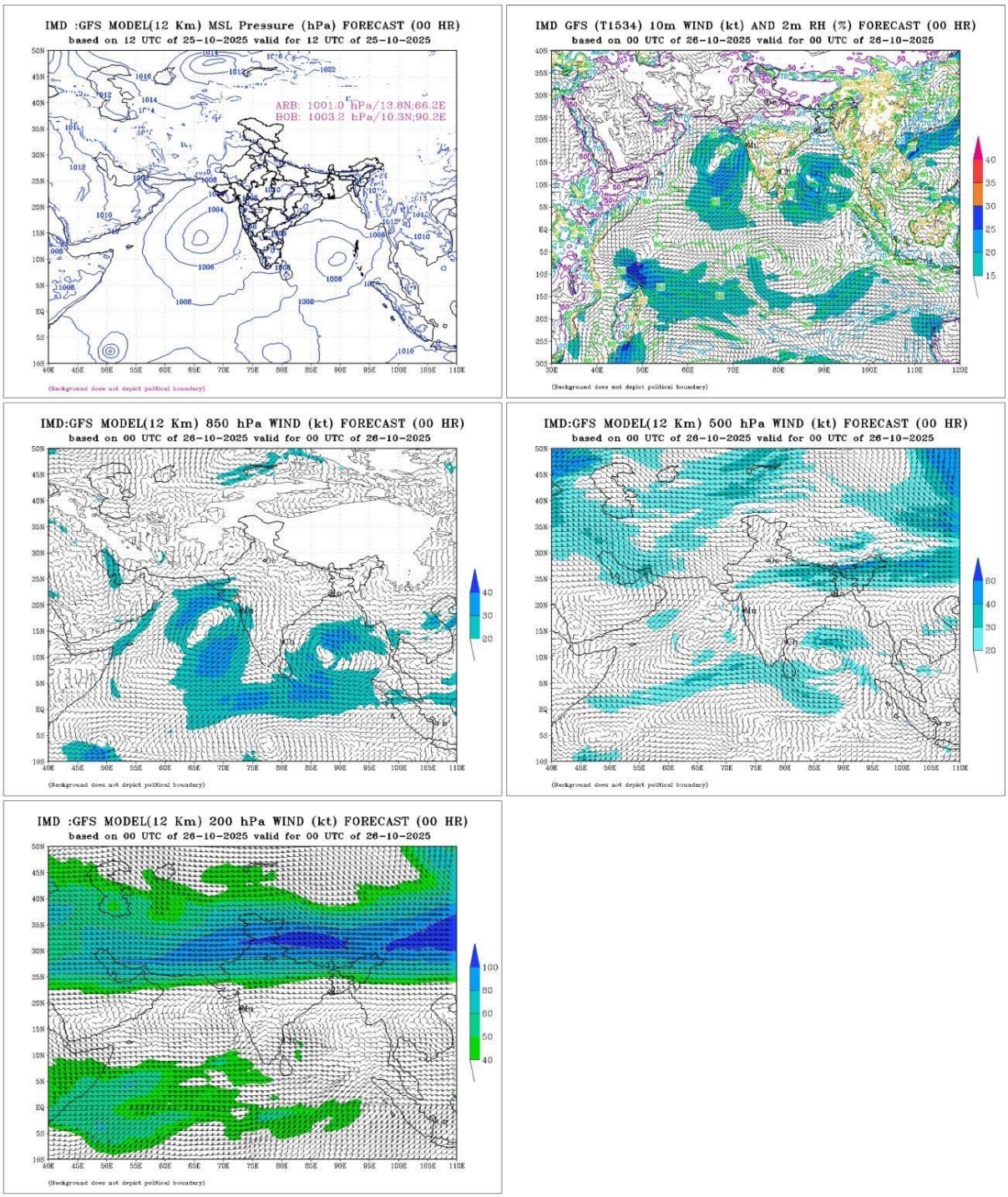


Fig.2.13.4(e): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 26th Oct 2025

IMD GFS analysis field at 0000 UTC of 27th October indicated a deep depression over eastcentral AS near 17.5^{0}N/. The associated cyclonic circulation extended upto 500 hPa tilting south-westwards with height. Upper tropospheric ridge was seen near 17^{0}N. The model indicated the cyclonic storm over westcentral Bay of Bengal on 27/0000 UTC. Actually, the system lay as depression over 16.1^{0}N/ 66.8^{0}E. The model could not capture location and intensity correctly.

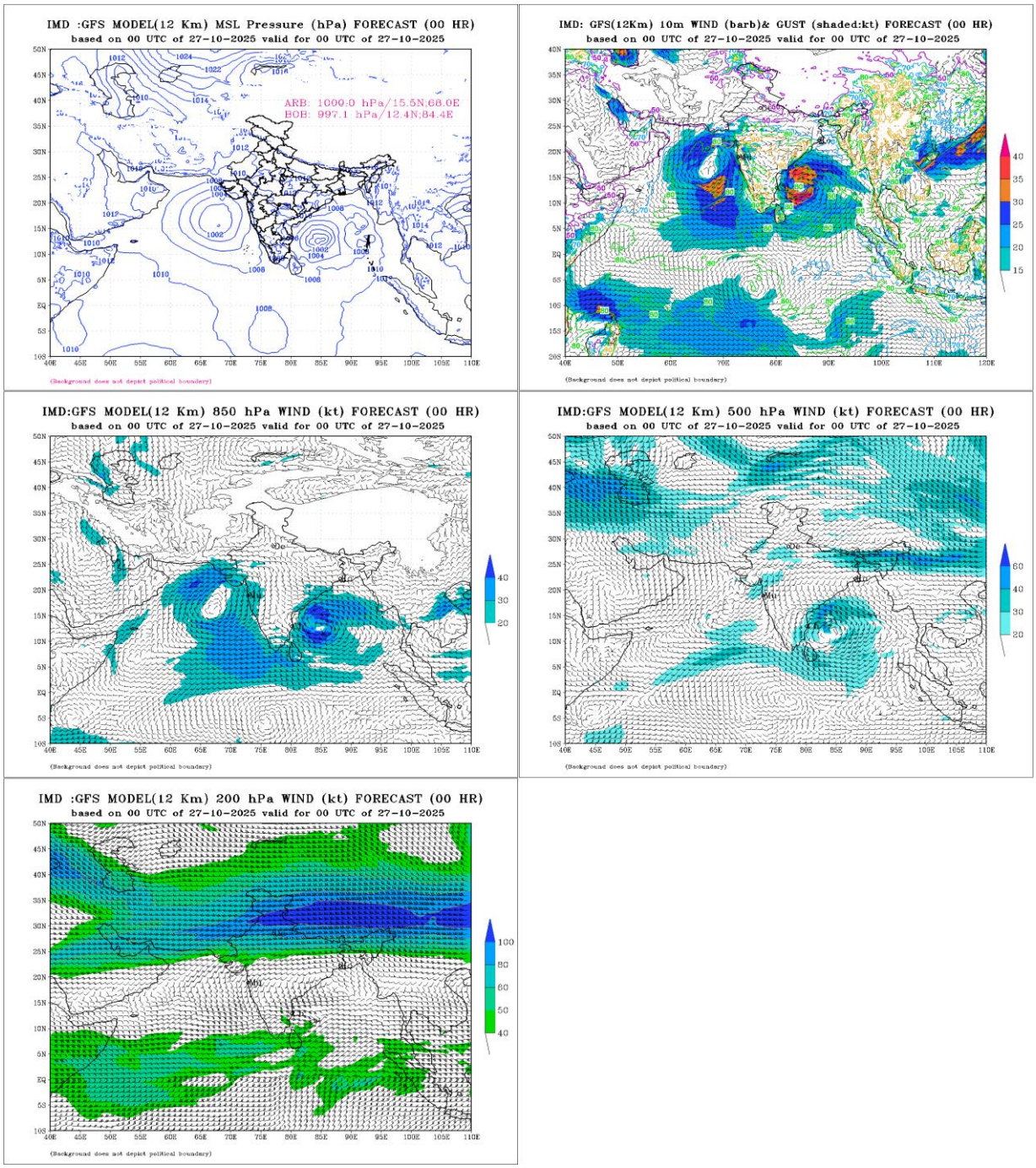


Fig.2.13.4(f): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 27th Oct 2025

IMD GFS analysis field at 0000 UTC of 28th October indicated a deep depression over eastcentral AS near 19^{0}N/68^{0}E. The associated cyclonic circulation extended upto 500 hPa tilting south-westwards with height. Upper tropospheric ridge was seen near 17^{0}N. The model indicated the severe cyclonic storm over westcentral Bay of Bengal off Andhra Coasts on 28th/0000 UTC. Actually, system lay as depression over westcentral AS near 17.0N/67.8E. The model could not capture location and intensity correctly.

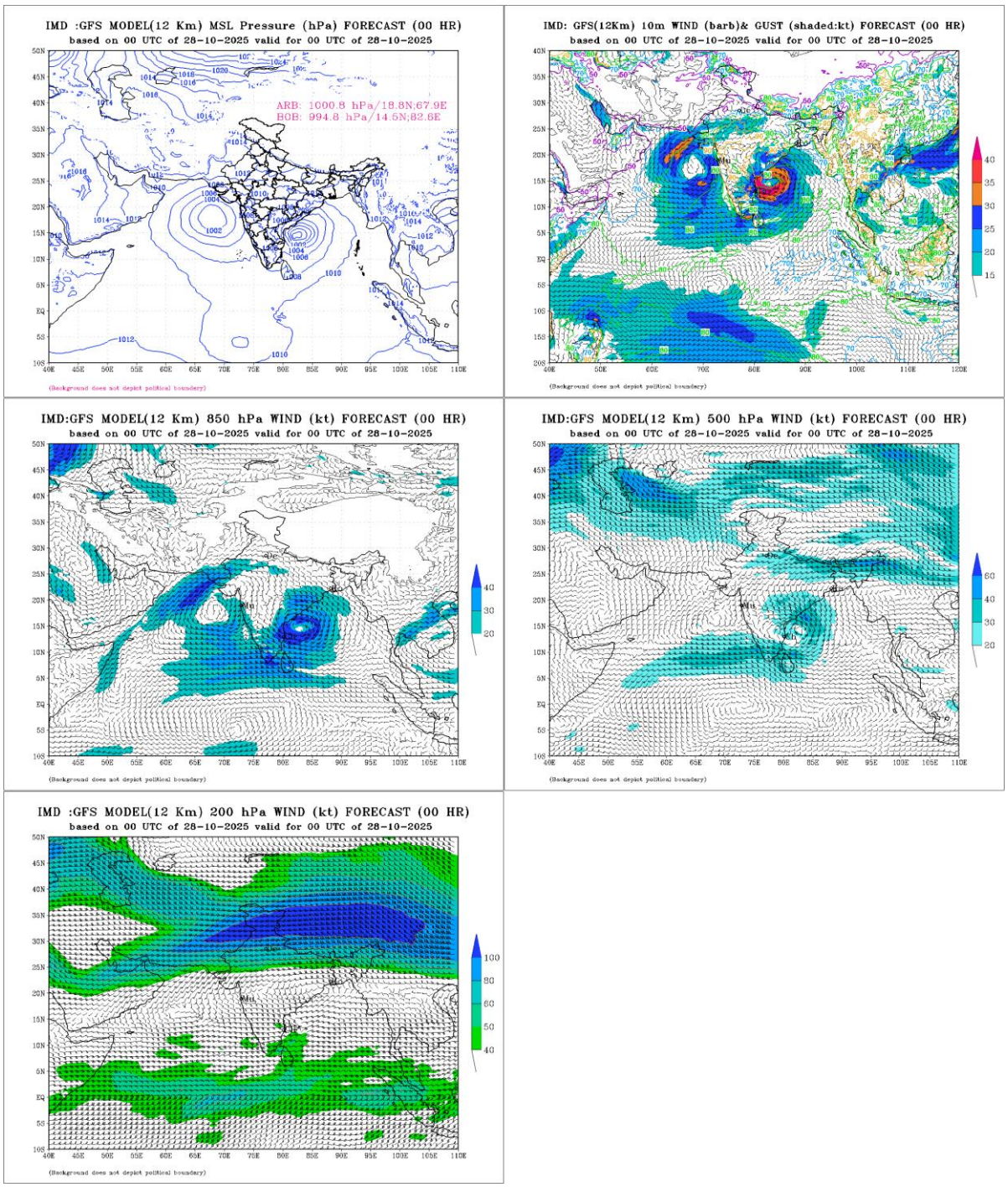


Fig.2.13.4(g): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 28th Oct 2025

IMD GFS analysis field at 0000 UTC of 29th October indicated a depression over eastcentral AS near 19^{0}N/67.8^{0}E. The associated cyclonic circulation extended upto 500 hPa tilting south-westwards with height. Upper tropospheric ridge was seen near 18^{0}N. The model indicated the severe cyclonic storm over coastal Andhra Coasts on 29/0000 UTC. Actually, system lay as depression over westcentral AS near 17.9N/69.4E. The model could capture location and intensity correctly on 29th.

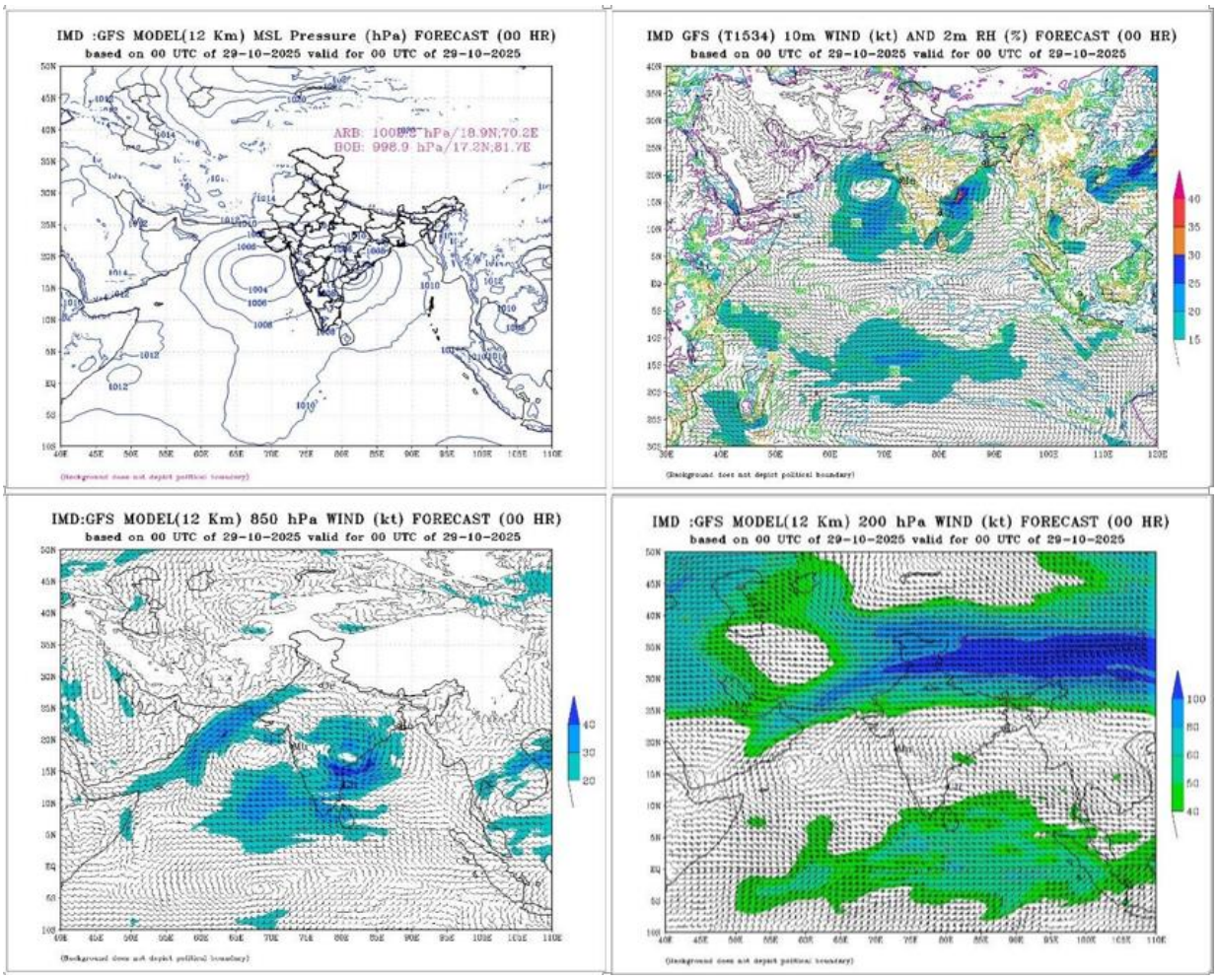


Fig.2.13.4(h): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850 and 200 hPa levels based on 0000 UTC of 29th Oct 2025

IMD GFS analysis field at 0000 UTC of 30th October indicated a depression over eastcentral AS near 18.5^{0}N/67.7^{0}E. The associated cyclonic circulation extended upto 700 hPa tilting south-westwards with height. Upper tropospheric ridge was seen near 18^{0}N. The model indicated the depression over Vidharbha 30/0000 UTC. Actually, system lay as depression over westcentral AS near 17.9N/68.2E. The model could capture location and intensity correctly on 30th.

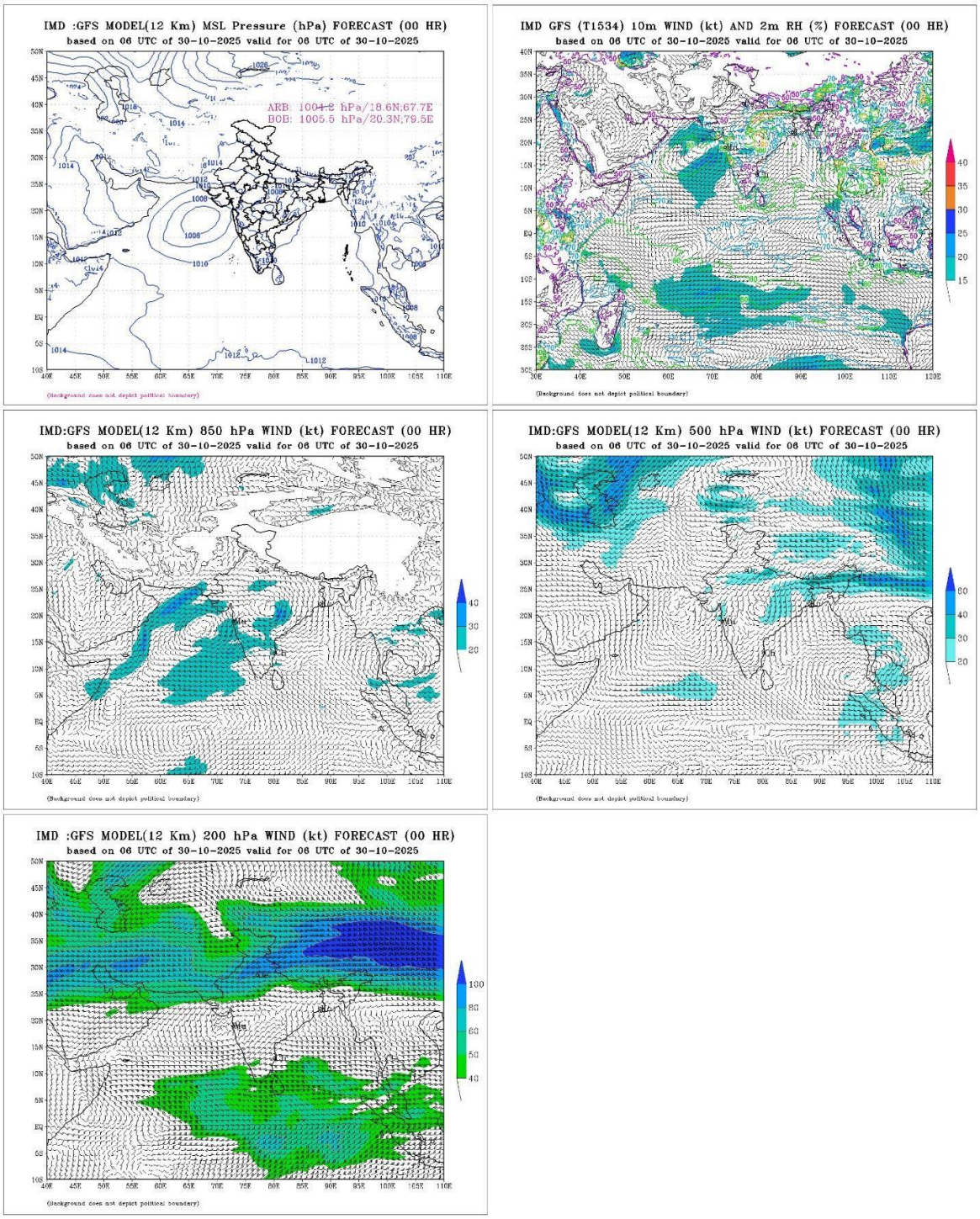


Fig.2.13.4(i): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of *30th* Oct 2025

IMD GFS analysis field at 0000 UTC of 31st October indicated a depression over northeast AS near 20^0N/68.7^0E. The associated cyclonic circulation extended upto 700 hPa tilting south-westwards with height. Upper tropospheric ridge was seen near 18^0N. Actually, system lay as depression over eastcentral AS near 18.6N/68.4E. The model could capture location and intensity correctly on 31st.

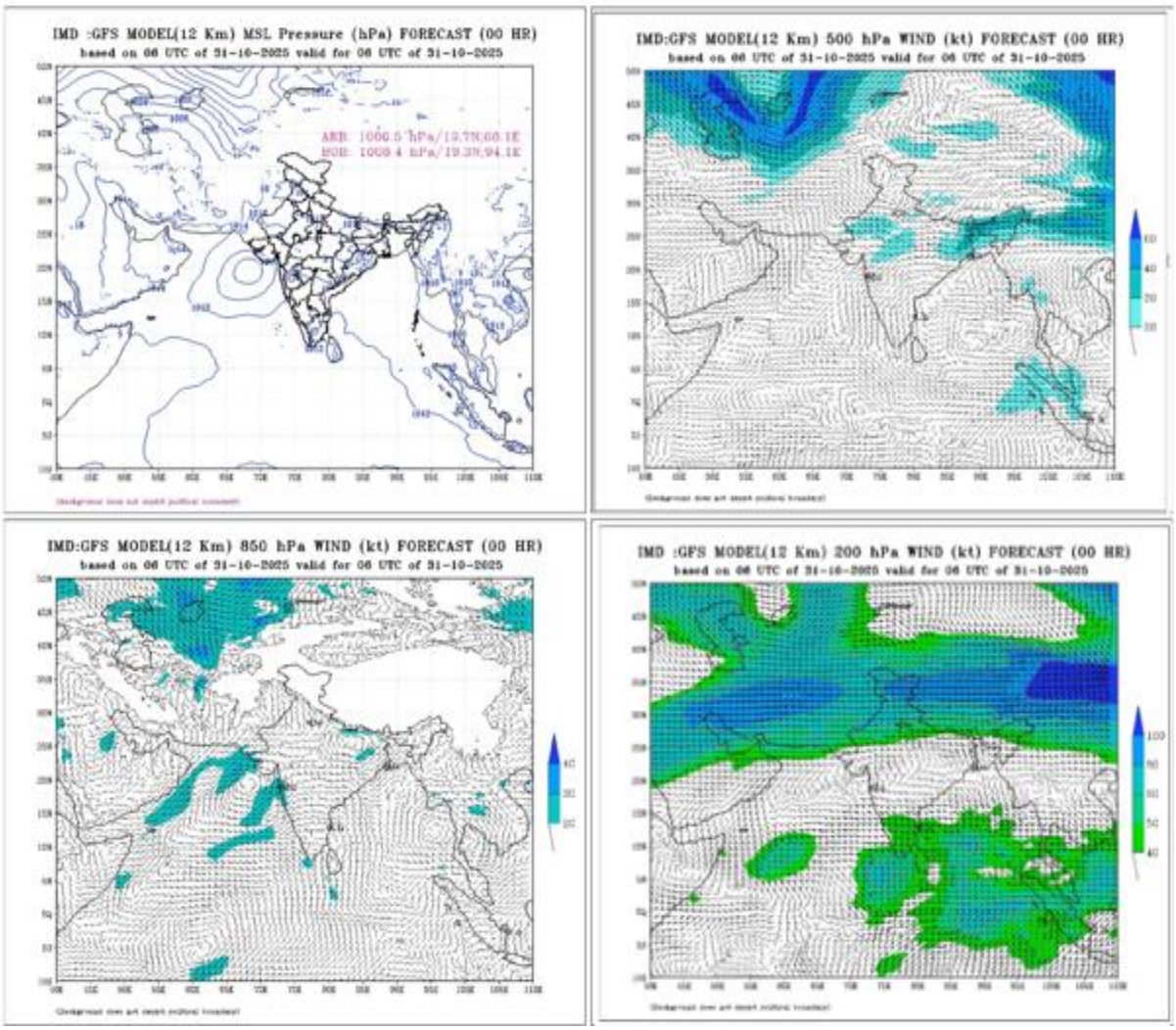


Fig.2.13.4(j): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 31st Oct 2025

Thus, overall IMD GFS could not correctly capture the location and intensity of the system. It could be mainly attributed to the fact that there were multiple vortices over the region and there was also a cyclone over the BoB. Multiple interactions led to multiple recurvatures.

2.13.6 Realized Weather

Rainfall associated with the depression based on IMD-NCMRWF satellite gauge merged data is depicted in Fig.2.13.5. It indicates light to moderate rainfall at most places with heavy to very heavy rainfall at isolated places over southeast & adjoining southwest AS, Lakshadweep, Comorin and Maldives area and coastal Kerala & Karnataka on 23rd Oct. On 24th and 25th Oct. the rainfall was mainly confined to the eastcentral & adjoining southeast AS, South Kerala & Comorin area. On 26th & 27th Oct, heavy to very heavy rainfall over eastcentral AS was observed both to the east & west of system area. Heavy rainfall also occurred over North Maharashtra on 26th and over North Maharashtra & adjoining areas of South Gujarat on 27th Oct. On 28th Oct., heavy rainfall occurred over South Gujarat, north

Maharashtra & west Madhya Pradesh. On 29th Oct., as the system indicated slight weakening, the rainfall zone was mainly confined to eastcentral & adjoining northeast AS & coastal areas of South Gujarat.

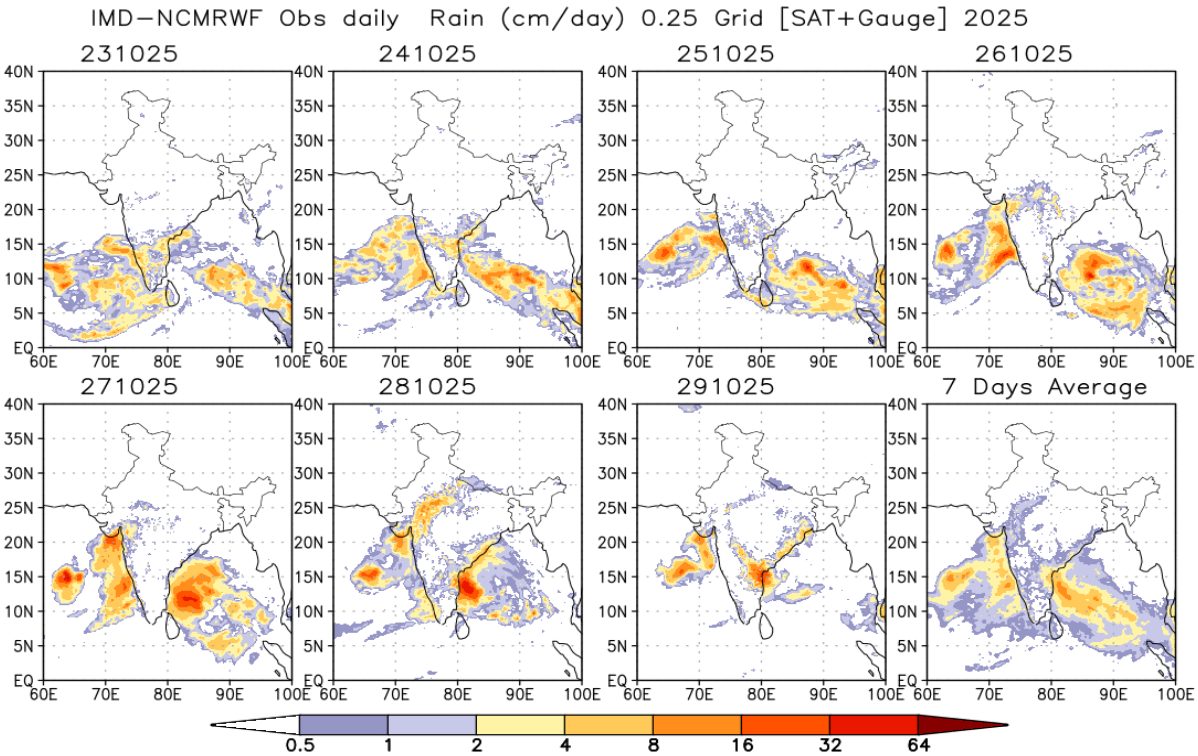


Fig.2.13.5: NCMRWF-IMD satellite gauge merged data plots of realized 24 hours accumulated rainfall from 23th - 29th October, 2025.

24 hours cumulative realised heavy rainfall (≥ 7cm) ending at 0830 hrs IST/ 0300 UTC of date is given below:

<u>23.10.2025 /0830 hrs. IST</u>

Kerala: Quilandi (Kozhikode) 14, Irinjalakuda (Thrissur) 9, Vellanikkara (Thrissur), Ernakulam South, Thrithala (Palakkad) & Angadipuram (Malappuram) 7 each.

South Interior Karnataka: Kottigehara (Chikkamagaluru) 12, Somwarpet (Kodagu) 9, Kushalnagar (Kodagu) 9, N R Pura (Chikkamagaluru), Koppa (Chikkamagaluru) & Konanur (Hassan) 7 each.

Coastal Karnataka: Mudubidre (Dakshina Kannada) 7,

<u>24.10.2025 /0830 hrs. IST</u>

North Interior Karnataka: Badami (Bagalkote) 14, Maski (Raichur) 11, Menedal (Koppala) 10, Hosakeri (Belagavi) & Markumbi (Belagavi) 10 each, Idagal (Belagavi) & Inchal (Belagavi) 9 each, Karatagi (Koppala), Belawantara (Dharwad), Jawalgera (Raichur) & Halagatti (Belagavi) 8 each, Maraladinni (Raichur), Alabanur (Raichur) & Turanur (Belagavi) 7 each

Kerala: Ponmudi (Thriuvananthapuram) 9, Chavara (Kollam) , Konni (Pathanamthitta) , Paripalli (Kollam) & Thiruvananthapuram (Thiruvananthapuram) 7 each
South Interior Karnataka: Siruguppa (Ballari) 8.

25.10.2025 /0830 hrs. IST
Goa: Canacona(South Goa) 14, Mormugao (South Goa) 11, Panjim (North Goa) 9, Dabolim (South Goa) & Mapusa (North Goa) 8 each, Quepem (South Goa) & Ponda (North Goa) 7 each;
Coastal Karnataka: Karwar Obsy (Uttara Kannada) 12; Asnoti (Uttara Kannada), Harawada (Uttara Kannada) & Belekeri (Uttara Kannada) 8 each, Vailavada (Uttara Kannada), Hattikeri (Uttara Kannada), Majali (Uttara Kannada), Shiravad (Uttara Kannada), Hegde (Uttara Kannada), Bhavikeri (Uttara Kannada), Kalbhag (Uttara Kannada) & Mudageri (Uttara Kannada) 7 each;
North Interior Karnataka: Bijangera (Raichur) & Kuknoor 1 (Koppala) 7 each.

26.10.2025 /0830 hrs. IST
Gujarat Region: Navsari (Navsari) 16, Umergam (Valsad) 9, Khergam (Navsari), Dangs (Dangs) & Jalalpor (Navsari) 7 each;
Madhya Maharashtra:
Devla (Nashik) 11, Igatpuri (Nashik) & Vani-arg (Nashik) 9 each, Niphad (Nashik) 8, Pimpalgaonbaswant (Nashik) 7;
Saurashtra & Kutch: Sutrapada (Gir Somnath) 9; **Coastal Karnataka:** Honavar (Uttara Kannada) 9, Shirali (Uttara Kannada) 8; **West Madhya Pradesh:** Bhainsdehi (Betul) 7;
Konkan & Goa: Dahanu (Palghar) 7;

27.10.2025 /0830 hrs. IST
Saurashtra & Kutch: Rajula (Amreli) 22; Diu (Diu) 15; Shihor (Bhavnagar) 13; Jafrabad (Amreli), Una (Gir Somnath) 12 Each; Savarkundla (Amreli), Vallabhipur (Bhavnagar) 9 Each; Palitana (Bhavnagar), Sutrapada (Gir Somnath), Jesar (Bhavnagar) 8 Each; Kodinar (Gir Somnath), Gariadhar (Bhavnagar) 7 Each;
Gujarat Region: Ukai (Surat) 14; Songadh (Tapi) 10; Umerpada (Surat) 9;
Konkan & Goa: Mormugao - (South Goa), Dabolim (South Goa) 13 Each; Panjim (North Goa) 11; Pernem (North Goa) 10; Canacona (South Goa), Mapusa (North Goa) 8 Each;
Madhya Maharashtra: Satna Baglan (Nashik) 9; Coastal Andhra Pradesh & Yanam: Prathipadu (Kakinada) 8;
Lakshadweep: Agathi (Lakshadweep) 8;
Coastal Karnataka: Bailur (Uttara Kannada) 12; Heble (Uttara Kannada) 10, Koppa (Uttara Kannada) & Bengre (Uttara Kannada) 9 each; Honavar (Uttara Kannada), Kumta (Uttara Kannada) 8 Each; Karwar (Uttara Kannada) 7;
Kerala & Mahe: Tellichery (Cannur) 7;
East Rajasthan: Khatoli(KTA): 7.

28.10.2025 /0830 hrs. IST
Saurashtra & Kutch: Sutrapada (Gir Somnath) 20, Diu (Diu) & Veraval (Gir Somnath) 13 each, Kodinar (Gir Somnath), Gir Gadhada (Gir Somnath) & Khambha (Amreli) 12 each, Mahuva(b) (Bhavnagar), Una (Gir Somnath) & Talaja (Bhavnagar) 11 each, Lilia (Amreli) 10, Talala (Gir Somnath) 9, Savarkundla (Amreli) 8, Talaja (Bhavnagar), Mahuva (Bhavnagar) & Mendarda (Junagadh) 7 each

Gujarat Region: Vadodara (Vadodara) 13, Vadodara (Vadodara) & Galteshwar (Kheda) 11 each, Bardoli (Surat) & Meghraj (Aravalli) 10 each, Umerpada (Surat) & Vagra (Bharuch) 9 each, Nadiad (Kheda) 8, Khanpur (Mahisagar), Nandod (Narmada), Kadana (Mahisagar), Balasinor (Mahisagar), Hansot (Bharuch), Dahod (Dahod) & Lunawada (Mahisagar) 7 each

29.10.2025 /0830 hrs. IST
Marathwada: Renapur (Latur) 19; Latur (Latur) 11; Deoni (Latur) 10; Gangakhed (Parbhani), Pathri (Parbhani), Parli Vaijnath (Beed), Badnapur (Jalna) 7 each;
North Interior Karnataka: Bhalki (Bidar) 9; Aurad (Bidar) 7;
East Rajasthan: Dung la(Chittorgarh) 7;

30.10.2025 /0830 hrs. IST
Konkan & Goa: Malvan (Sindhudurg) 12, Ratnagiri - (Ratnagiri) 12, Rameshwar_agri (Sindhudurg) 10, Savarde(Ratnagiri) 9, Guhagarh (Ratnagiri) 8, Jawhar (Palghar) & Panjim - (North Goa) 7 each;
Marathawada: Mantha (Jalna) 8;
Vidarbha: Manora (Washim) 8;
Coastal Karnataka: Uttar Kannada 7.

31.10.2025 /0830 hrs. IST
Gujarat Region: Ghandinagar_aws (Gandhinagar) , Hansot (Bharuch) , Dahegam (Gandhinagar) 7 each;
East Madhya Pradesh:
Tamia (Chindwara) & Amarkantak (Anuppur) 7 each;
West Madhya Pradesh: Alirajpur (Alirajpur) 7.

01.11.2025 /0830 hrs. IST
Konkan & Goa: Rameshwar_agri (Sindhudurg) & Lanja (Ratnagiri) 12 each, Dodamarg (Sindhudurg) & Sawantwadi (Sindhudurg) 8 each.
Saurashtra & Kutch:
Rajula (Amreli) 9, Khambha (Amreli) 8, Talaja (Bhavnagar) 7.

2.14 Severe cyclonic storm "MONTHA" over Southeast Bay of Bengal (25th – 30th) October, 2025

2.14.1 Life History:

- An upper air cyclonic circulation lay over southeast Bay of Bengal (BoB) & adjoining south Andaman Sea in the evening (1730 hrs IST/ 1200 UTC) of 23rd October, 2025.
- Under it's influence, a low-pressure area formed over southeast BoB in the early morning (0530 hrs IST/ 0000 UTC) of 24th October, 2025.
- It lay as a well marked low pressure area over the same region in the evening (1730 hrs IST/ 1200 UTC) of same day, the 24th October, 2025.
- It concentrated into a depression over the same region in the early morning (0530 hrs IST/ 0000 UTC) of 25th October, 2025.
- It moved west-northwestwards and intensified into a deep depression over the same region in the early morning (0530 hrs IST/ 0000 UTC) of 26th October.
- It then moved northwestwards and intensified into the Cyclonic Storm "MONTHA" [Pronunciation: Mon-Tha] in the same midnight (2330 hrs IST/ 1800 UTC) of 26th October, 2025 over southwest & adjoining southeast BoB.
- Continuing to move further northwestwards, it intensified into a severe cyclonic storm in the early morning (0530 hrs IST/ 0000 UTC) of 28th October, 2025 over westcentral BoB.
- Thereafter, it moved north-northwestwards till evening (1730 hrs IST/1200 UTC) of 28th October. It then suddenly changed the track and moved west-northwestwards & crossed Andhra Pradesh and Yanam coasts between Machilipatnam and Kalingapatnam to the south of Kakinada close to Narsapur near latitude 16.35ºN and longitude 81.70º E during 2330 hrs IST of 28th to 0030 hrs IST of 29th October (1800 - 1900 UTC of 28th October) with maximum sustained wind speed of 90-100 kmph (50 kt) gusting to 110 kmph (60 kt).
- Continuing to move further north-northwestwards, it weakened into a cyclonic storm over Coastal Andhra Pradesh in the early hours (0230 hrs IST) of 29th October (2100 UTC of 28th October) and into a deep depression over Coastal Andhra Pradesh and adjoining Telangana in the forenoon (0830 hrs IST/0300 UTC) of 29th October.
- Continuing to move north-northwestwards, it weakened into a Depression over south Chhattisgarh & neighbourhood in the evening (1730 hrs IST/ 1200 UTC) of 29th October.
- Further moving north-northwestwards, it weakened into a Well Marked Low Pressure Area over East Vidarbha and adjoining South Chhattisgarh in the early morning (0530 hrs IST/ 0000 UTC) of 30th October 2025.
- The observed track of the deep depression is presented in **Fig.2.14.1**. The best track parameters of the system are presented in **Table 2.14.1**.

Table 2.14.1: Best track positions and other parameters of severe cyclonic storm over Southeast Bay of Bengal during 25th – 30th October, 2025

Date	Time (UTC)	Lat. (^{0}N)	Long. (0E)	C.I. No.	ECP (hPa)	ΔP (hPa)	MSW (kt)	Category
25-10-2025	0000	10.8	89.0	1.5	1003	3	20	D
	0300	10.8	88.8	1.5	1002	4	25	D
	0600	10.8	88.6	1.5	1002	4	25	D
	1200	10.9	88.1	1.5	1002	4	25	D
	1800	11.0	87.7	1.5	1004	4	25	D
26-10-2025	0000	11.1	87.3	2.0	1000	5	30	DD
	0300	11.2	87.1	2.0	998	6	30	DD
	0600	11.3	86.9	2.0	998	6	30	DD
	1200	11.4	86.6	2.0	998	6	30	DD
	1800	11.9	85.9	2.5	997	7	35	CS
	2100	11.6	85.5	2.5	997	7	35	CS
27-10-2025	0000	12.2	85.3	3.0	997	7	35	CS
	0300	12.6	84.9	3.0	996	8	40	CS
	0600	12.8	84.6	3.0	996	8	40	CS
	0900	13.0	84.2	3.0	995	9	40	CS
	1200	13.3	84.0	3.0	994	10	45	CS
	1500	13.6	83.8	3.0	994	10	45	CS
	1800	14.0	83.5	3.0	992	12	45	CS
	2100	14.4	83.3	3.0	992	12	45	CS
28-10-2025	0000	14.7	83.0	3.0	990	14	50	SCS
	0300	14.9	82.9	3.0	990	14	50	SCS
	0600	15.2	82.7	3.0	988	14	50	SCS
	0900	15.6	82.5	3.0	988	16	50	SCS
	1200	16.0	82.2	3.0	988	16	50	SCS
	1500	16.2	82.0	3.0	988	16	50	SCS
	1800	16.3	81.7	3.0	988	16	50	SCS
		Crossed Andhra Pradesh and Yanam between Machilipatnam and Kalingapatnam to the south of Kakinada close to Narsapur near latitude 16.35^{0}N and longitude 81.70^0 E during 1800-1900 UTC of 28th October (2330 hrs IST of 28th and 0030 hrs IST of 29th October) with maximum sustained wind speed of 90-100 gusting to 110 kmph (50 kt gusting to 60 kt)						
	2100	16.5	81.5	-	994	10	40	CS

29-10-2025	0000	17.0	81.3	-	997	7	35	CS
	0300	17.3	81.2	-	999	5	30	DD
	0600	17.7	81.1	-	999	5	30	DD
	1200	18.7	80.9	-	1000	4	25	D
	1800	19.6	80.7	-	1000	3	20	D
30-10-2025	0000	Weakened into a Well Marked Low Pressure Area over east Vidarbha and adjoining south Chhattisgarh						

kt: Knots (nautical mile per hour), 1 kt=1.85 kmph, D: Depression, DD: Deep Depression, CS: Cyclonic Storm, SCS: Severe Cyclonic Storm

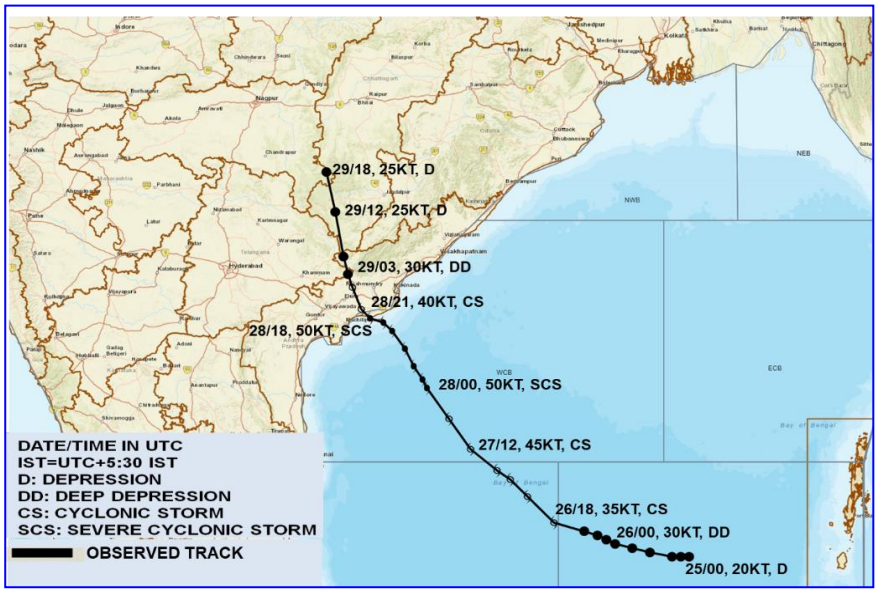


Fig.2.14.1: Observed track of severe cyclonic storm "MONTHA" over southeast Bay of Bengal during 25th-30th October, 2025

2.14.2 Salient features:

a) Climatology: During the period 1961-2024, 28 cyclonic disturbances **(**depressions and above intensity with maximum sustained wind speed (MSW)≥ 17 kt (31 kmph)) crossed Andhra Pradesh coast in the month of October. Out of these, there were 12 cyclones (MSW≥ 34 kt (63 kmph)) including 6 cyclonic storms (MSW: 63-88 kmph) and 6 severe cyclonic storms (MSW ≥ 89 kmph) **(Fig.2.14.2)**.

Considering total number of cyclones over BoB in the month of October, based on the data of 1961 **-** 2024, 12 out of 42 cyclones crossed Andhra Pradesh coast (about 29%), 10 crossed Odisha coast (about 24%), 4 crossed Tamil Nadu coast (about 10%), 3 crossed West Bengal coast (about 7%), 12 crossed Bangladesh & Myanmar coasts (29%) and 1 crossed Sri Lanka coast (0.5%) (**Fig.2.14.3a**). Similarly, if we consider area of formation, there have been 9 cyclones that developed from depression forming in the grid 9^0N-13^0N and 87^0E-91^0E, with 4 crossing Andhra Pradesh (45%), 2 each crossing Odisha & Tamil Nadu coasts (22% each) and 1 dissipating over eastcentral BoB (about 11%). Thus, highest number of cyclones developing over BoB and in the grid 9^0N - 13^0N and 87^0E - 91^0E in the month of October crossed Andhra Pradesh coast **(Fig.2.14.3b).**

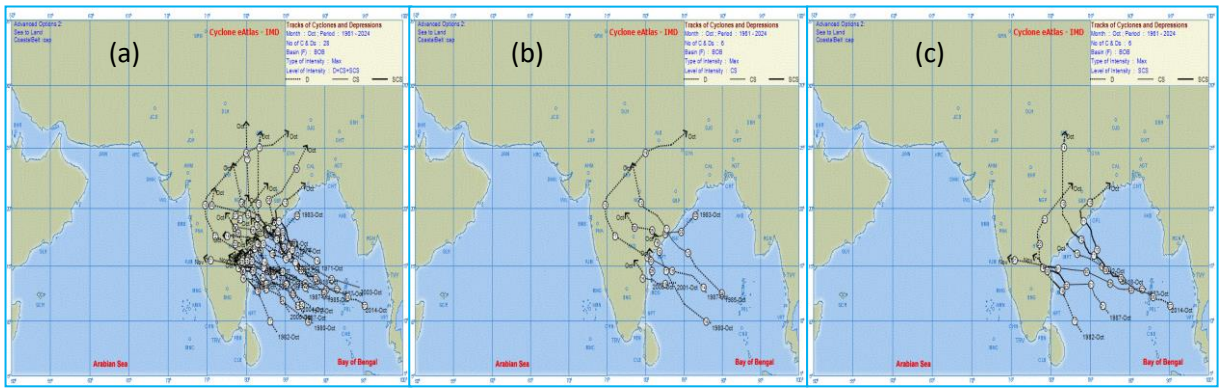


Fig.2.14.2: Tracks of (a) all cyclonic disturbances (MSW ≥ 31 kmph), (b) cyclonic storms (MSW: 63-88 kmph) and (c) severe cyclones (MSW ≥ 89 kmph) during 1961-2024

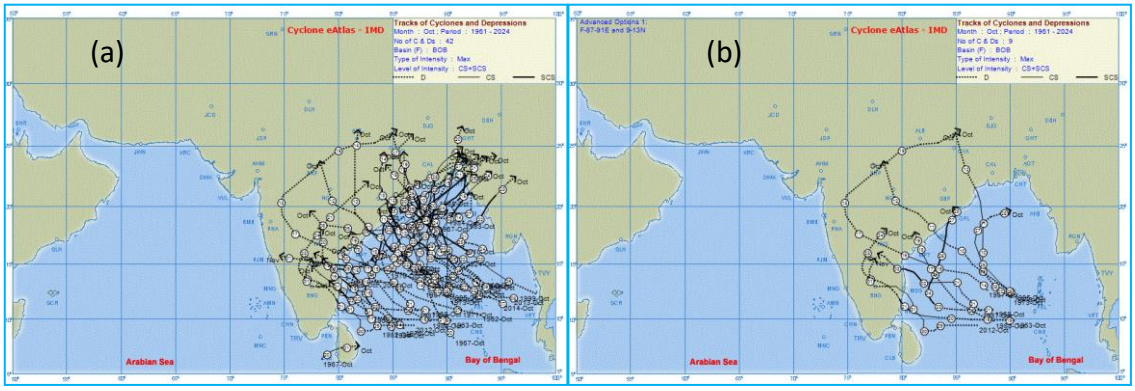


Fig.2.14.3: Tracks of (a) all cyclones and (b) cyclones developing in the grid 9-13^{0}N/87-91^{0}E over BoB in the month of October during 1961-2024

b) Sudden change in track before landfall:

MONTHA moved initially west-northwestwards till 27th early morning (0530 hrs IST/ 0000 UTC), then north-northwestwards till evening (1730 hrs IST/ 1200 UTC) of 28th Oct. and then suddenly, a few hours before landfall, it changed its track. It moved nearly west-northwestwards and crossed Andhra Pradesh and Yanam coasts between Machilipatnam and Kalingapatnam to the south of Kakinada close to Narsapur during 2330 hrs IST of 28th to 0030 hrs IST of 29th October (1800 UTC-1900 UTC of 28th October). Again, after landfall, it followed north-northwestwards track. It is mainly attributed to the interactions with the orographical features of the area.

In recent years cyclone Titli (October, 2018) had sudden change in track near coast before landfall near Palasa (North Andhra Pradesh). Similarly, cyclone Asani (May, 2022) changed its path before landfall and dissipated near coast. Tracks of both the systems are presented in **Fig.2.14.4**. Rapid changes in track and intensity need further research and development.

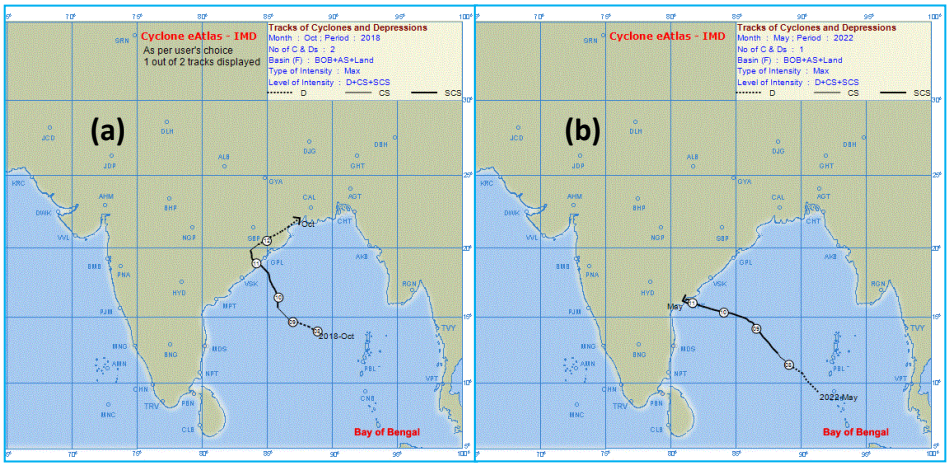


Fig.2.14.4: Tracks of cyclones (a) Titli (2018) and (b) Asani (2022) which changed path before landfall

c) **Translational Speed**: MONTHA exhibited six hourly average translational speed of 12.5 kmph against normal of 15.5 kmph for severe cyclonic storms over the BoB in the post-monsoon season based on data during 1990-2013 (**Fig.2.14.5a**). Thus, it was a slow-moving cyclone. It also moved slowly during landfall over Coastal Andhra Pradesh leading to higher rainfall activity.

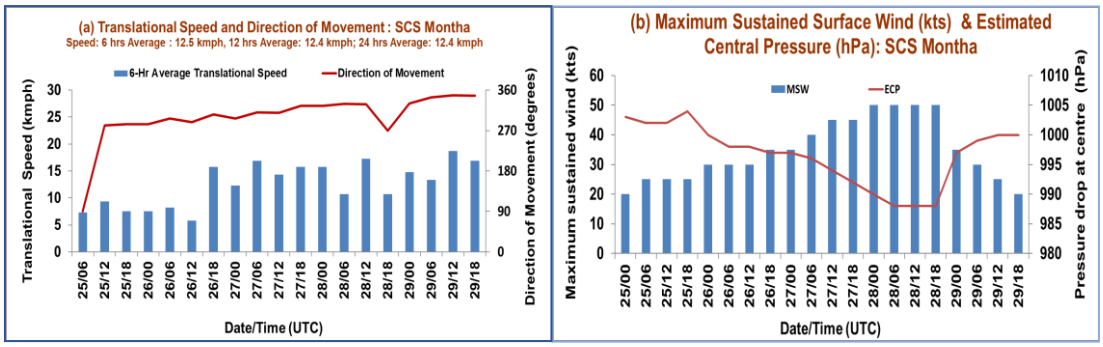


Fig.2.14.5: Six hourly (a) average translational speed & direction of movement and (b) maximum sustained surface wind speed & estimated central pressure during life period of cyclone MONTHA

d) **Life period:** The average life period of the storm (depression to depression) was 5 days against the long period average (LPA) (1990-2013) of about 4 days and 02 hours for SCS category over the BoB during post-monsoon season. Thus, MONTHA had a life period longer than the average life period of SCS over the BoB during post-monsoon season.

e) **Maximum sustained wind speed and estimated central pressure**: The system did not exhibit any rapid intensification during its life cycle. However, it exhibited rapid weakening during 28th midnight (2330 hrs IST/1800 UTC) to 29th midnight (2330 hrs IST/1800 UTC) mainly because of land interactions. The system reached its peak intensity of 50 knots during 28th early morning (0530 hrs IST/0000 UTC) to 28th midnight (2330 hrs IST/1800 UTC). The estimated central pressure during this period was 988 hPa. The six hourly maximum sustained wind speed and estimated central pressure during the life cycle of MONTHA is presented in **Fig.2.14.5b**.

f) **Damage Potential and Power Dissipation Index**: The Accumulated Cyclone Energy (a measure of damage potential) and Power Dissipation Index (a measure of loss) in association with MONTHA were 1.93 X 10^4 $knots^2$ and 0.87 X10^6 $knots^3$ respectively against the normal of 1.83 X 10^4 $knots^2$ and 0.90 X10^6 $knots^3$ for SCS category during post monsoon season over the BoB based on the data during 1990-2020. As it was a slow-moving cyclone with a longer life period, damage potential and losses due to MONTHA were slightly higher than the long period average.

2.14.3 Genesis, Intensification and Weakening:

On 24th October, Madden Julian Oscillation (MJO) index lay in phase 4 and was likely to remain in same phase with amplitude around 2 during next 1 days and decreasing amplitude reaching close to 1 till 29th October. Thereafter, it was expected to move across phase 5 with amplitude becoming less than 1 by 31st October. The phase and amplitude of MJO was highly favourable for enhancement of convective activity and also cyclogenesis over the BoB during 24th - 29th October and over North BoB during 29th -31st October. Guidance from NCICS model indicated enhanced westerly wind anomaly over southern parts of the North Indian Ocean (NIO) including the south BoB & south Arabian Sea (AS) and adjoining Equatorial Indian Ocean (EIO) during 24th to 27th October with slight decreasing trend thereafter during 28th October-2nd November. The westerly wind burst prevailed over the southern parts of the NIO and adjoining EIO till 30th October. The model also indicated prevalence of equatorial Rossby wave (ERW), MJO, low frequency background wave (LW) over the same region during 24th-30th October and prevalence of easterly wind anomaly over westcentral BoB (7-9 mps) & over south Andaman Sea (3-5 mps). Thus, equatorial waves were supporting the convective activity associated with cyclonic disturbance over the BoB during 24th to 27th October. The guidance from CIMSS indicated, positive low-level vorticity at 850 hPa of about 100-110 X 10^{-6} s^{-1} over the system area and extended to the west of the system and another positive vorticity zone (50-60 X 10^{-6} s^{-1}) was seen over south Andaman Sea. Vertically, both were extending upto 500 hPa level. The upper-level divergence was around 30-40 X 10^{-6} s^{-1} to the west of the system area and over southwest BoB. Low level convergence increased and was about 30-40 X 10^{-6} s^{-1} to the west of the system area. Vertical wind shear (VWS) of horizontal wind was anti-cyclonic and low (05-15 kt) over the system area. Upper tropospheric ridge lay along 19°N over the BoB in association with anticyclonic circulation over south Myanmar. Under these favourable features, the system lay as a well marked low pressure area over southeast & adjoining south Andaman Sea on 24th October.

On 25th October, similar sea conditions prevailed. MJO and equatorial waves were favourable for enhancement of convective activity over the BoB. Low-level vorticity at 850 hPa was 80-90 X 10^{-6} s^{-1} over the system area and extended westwards. The upper-level divergence was around 20 X 10^{-6} s^{-1} near the system area over south Andaman Sea & over south BoB. Low level convergence was about 10-20 X 10^{-6} s^{-1} over the system area and extended westward. Vertical wind shear (VWS) of horizontal wind was anti-cyclonic and low (5 - 10 kt) over the system area and along the forecasted path. Upper tropospheric ridge lay near 19.5°N over the BoB in association with anticyclonic circulation over south Myanmar. Under these favourable features, the system intensified into a depression over southeast BoB at 0000 UTC of 25th October.

On 26th October, MJO continued in phase 4. Equatorial waves were supportive with prevalence of westerly wind burst over south BoB, ERW, MJO and LW over south BoB and strong easterly wind anomaly over westcentral BoB (7-9 mps). The positive low-level vorticity at 850 hPa increased and was about 100 X $10^{-6}s^{-1}$ to the southeast of system centre, extending westward. The upper-level divergence increased significantly and was around 50 X $10^{-6}s^{-1}$ to the west of the system, and another zone of positive divergence (30 X $10^{-6}s^{-1}$) lay over south Andaman Sea. Low level convergence also increased significantly and was about 40 X $10^{-6}s^{-1}$ to the west of system centre and another zone of 20 X $10^{-6}s^{-1}$ to the southeast of the system centre. Vertical wind shear (VWS) of horizontal wind was anti-cyclonic and low (05 - 10 kt) over the system area and along the predicted path. Upper tropospheric ridge lay near 17.0°N over the BoB. IR-WV imagery showed intense convection to the northwest of system area. Total precipitable water imagery (TPW) indicated warm moist air incursion into the core. The Sea surface temperature (SST) was around 29^0C over the system area and along the predicted path. All these favourable features led to further intensification of the system into a deep depression at 0000 UTC of 26th October.

On 27th October, the MJO lay in phase 5 with amplitude around 2. The phase and amplitude of MJO is highly favourable for enhancement of convective activity over the Bay of Bengal (BoB) till 29th October and over North Bay of Bengal (BoB) during 29th -31st October. Guidance from NCICS model indicated enhanced westerly wind anomaly over south BoB and adjoining EIO on 27th October with slight decreasing trend thereafter during 28th October-2nd November. The westerly wind burst was likely to prevail over the southern parts of the NIO and adjoining EIO till 30th October alongwith prevalence of ERW, MJO and LW over the same region during 27th -30th October. The model guidance also indicated prevalence of easterly wind anomaly over westcentral BoB (7-9 mps) during 27th-30th Oct. Thus, equatorial waves were likely to support the convective activity associated with cyclonic disturbance over the southeast BoB during 27th to 30th October. The positive low-level vorticity at 850 hPa increased and was about 200 × 10^{-6} s^{-1} to the west of system centre. The upper-level divergence was around 40 × 10^{-6} s^{-1} to west of the system centre. Strong equatorward outflow was seen. Low level convergence was about 50 × 10^{-6} s^{-1} to the west of system centre. Vertical wind shear (VWS) of horizontal wind was anti-cyclonic and low (05 - 10 kt) over the system area and along the predicted path. Upper tropospheric ridge lay along 17.0°N over the BoB. IR-WV imagery showed intense convection to the northwest of system area. TPW imagery indicated warm moist air incursion into the core. The SST was around 29^0C over the system area and along the predicted path. Under these favourable features, the system intensified into a cyclonic storm at 0000 UTC of 27th Oct.

On 28th October, similar favourable features prevailed. MJO lay in phase 5 with amplitude around 2. It was expected to move across phase 5 with decreasing amplitude reaching close to 1 by 30th October and less than 1 by 31st October. The phase and amplitude of MJO was highly favourable for enhancement of convective activity over the BoB till 29th October, and further to the north till 31st October. Guidance from NCICS model indicated enhanced westerly wind anomaly over south BoB and adjoining Equatorial Indian Ocean (EIO) on 28th October with slight decreasing trend thereafter during 29th October-2nd November. The westerly wind burst was likely to prevail over the southern parts of the NIO and adjoining EIO till 30th October. The model also indicated prevalence of ERW, MJO and LW over the same region and easterly wind anomaly over westcentral BoB (7-9 mps) & over south Andaman Sea (3-5 mps) during 28th -30th October. Thus, equatorial waves were likely to support the

convective activity associated with cyclone Montha during 28th to 30th October. The positive low-level vorticity at 850 hPa increased and was about 250 × 10^{-6} s^{-1} around the system centre. The upper-level divergence was around 30 × 10^{-6} s $^{-1}$ to southwest of the system centre. Low level convergence was about 30 × 10^{-6} s^{-1} to the west of system centre. Vertical wind shear (VWS) of horizontal wind was anti-cyclonic and moderate to high (20 - 30 kt) over the system area and decreasing along the predicted path. An anticyclone lay over north Odisha and neighbourhood in the upper tropospheric levels with a ridge running along 19.0°N over the Indian region. Under it's influence, the system was being steered initially towards northwestwards and then northwards. IR-WV imagery showed intense convection to northwest of system area. TPW imagery indicated warm moist air incursion into the core. SST was around 28-29^{0}C over the system area and along the predicted path. Under these favourable features, the system intensified into a severe cyclonic storm at 0000 UTC of 28th.

However, it moved initially west-northwestwards till 27th/0000 UTC, then north-northwestwards till 1200 UTC of 28th Oct. and then suddenly, a few hours before landfall, it changed its track. It moved nearly west-northwestwards and crossed Andhra Pradesh and Yanam coasts to the south of Kakinada close to Narsapur in the midnight of 28th. Again, after landfall, it followed north-northwestwards track. It is mainly attributed to the interactions with the orographical features of the area.

Thereafter, due to land interactions and decrease in warm moist air around system area, it gradually started weakening. On 29th October, the low-level vorticity at 850 hPa decreased and was about 150 × 10^{-6} s^{-1} around the system centre. The upper-level divergence was around 20 × 10^{-6} s^{-1} system centre. Low level convergence was about 10-15 × 10^{-6} s^{-1} to the west of system centre, vertical wind shear (VWS) of horizontal wind was anti-cyclonic and low to moderate (10-15 kt) over the system area and its surroundings. On 30th October, the low-level vorticity at 850 hPa was about 130×10^{-6} s^{-1} over the east Vidarbha and adjoining south Chhattisgarh. The upper-level divergence was around 5×10-6 s -1 southwest of the system area. Low level convergence is about 10 × 10^{-6} s^{-1} south of the system area, vertical wind shear (VWS) of horizontal wind was anti-cyclonic and low to moderate (10-15 kt) over the system area and its surroundings. Under these features, it weakened into a well-marked low pressure area east Vidarbha and adjoining south Chhattisgarh at 0000 UTC of 30th Oct.

2.14.4 Monitoring of SCS, "MONTHA"

India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean and the cyclone was monitored since 9th October. First information about likely formation of low-pressure area over southeast BoB in the end of week (17-23 October) was released in the extended range outlook (EROC) issued on 9th October, 2025 (about 15 days ahead of formation of Low-pressure area over southeast BoB on 24th October). Further intensification of the low pressure was also indicated on 9th October itself. Subsequent, EROC issued on 16th October indicated development of depression over southeast BoB in the middle of week 2 (24-30 October) with moderate probability (34-67%), about 9 days ahead of formation of depression over southeast BoB on 25th October. The information was further reiterated in the subsequent EROC issued on 23rd October wherein formation of depression over southeast BoB was indicated with high probability (68-100%) (**Fig.2.14.6**). The EROCs issued since 9th October also provided information about the anticipatory actions for Marine community including Fishermen, Offshore & Onshore industries, Ports,

Shipping community, Disaster managers and forecasters for the sea area of south & westcentral BoB.

The cyclone was monitored with the help of available satellite observations from INSAT 3DR, INSAT 3DS, SCAT SAT (OCEAN SAT 3), ASCAT, microwave imageries, Doppler Weather Radars at Machilipatnam & Visakhapatnam, available ships, buoys observations & coastal observations in the region. Various global models and dynamical-statistical models run by Ministry of Earth Sciences (MoES) institutions including IMD, NCMRWF, IITM & INCOIS and guidance from models from various international agencies were utilized to predict the genesis, track and intensity of the cyclone as well as associated severe weather. The forecasts were mainly based on multi-model ensemble technique developed by IMD which were further modulated by analysis of observations and forecasters intervention at IMD through their knowledge, experience and expertise. An indigenously developed digitized forecasting system of IMD (Decision Support System) was utilized for analysis and comparison of various observations and numerical weather prediction model's guidance, decision making process and warning products generation. Typical satellite and radar-based products utilised for monitoring the system are presented in **Fig.2.14.7**.

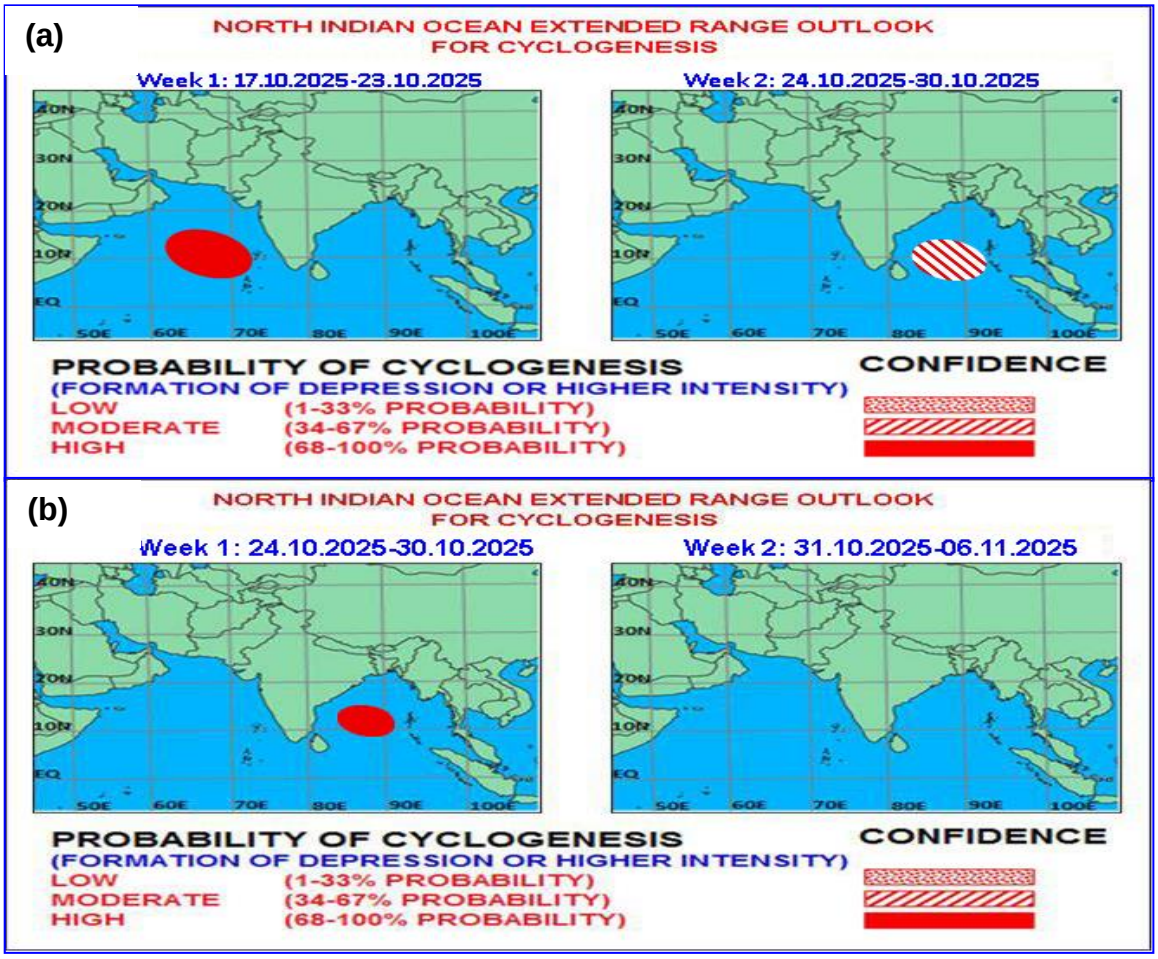


Fig.2.14.6: Extended Range Outlook dated (a) 16th October indicating moderate probability (34-67%) and (b) dated 23rd October indicating high (68-100%) probability of cyclogenesis over southeast Bay of Bengal

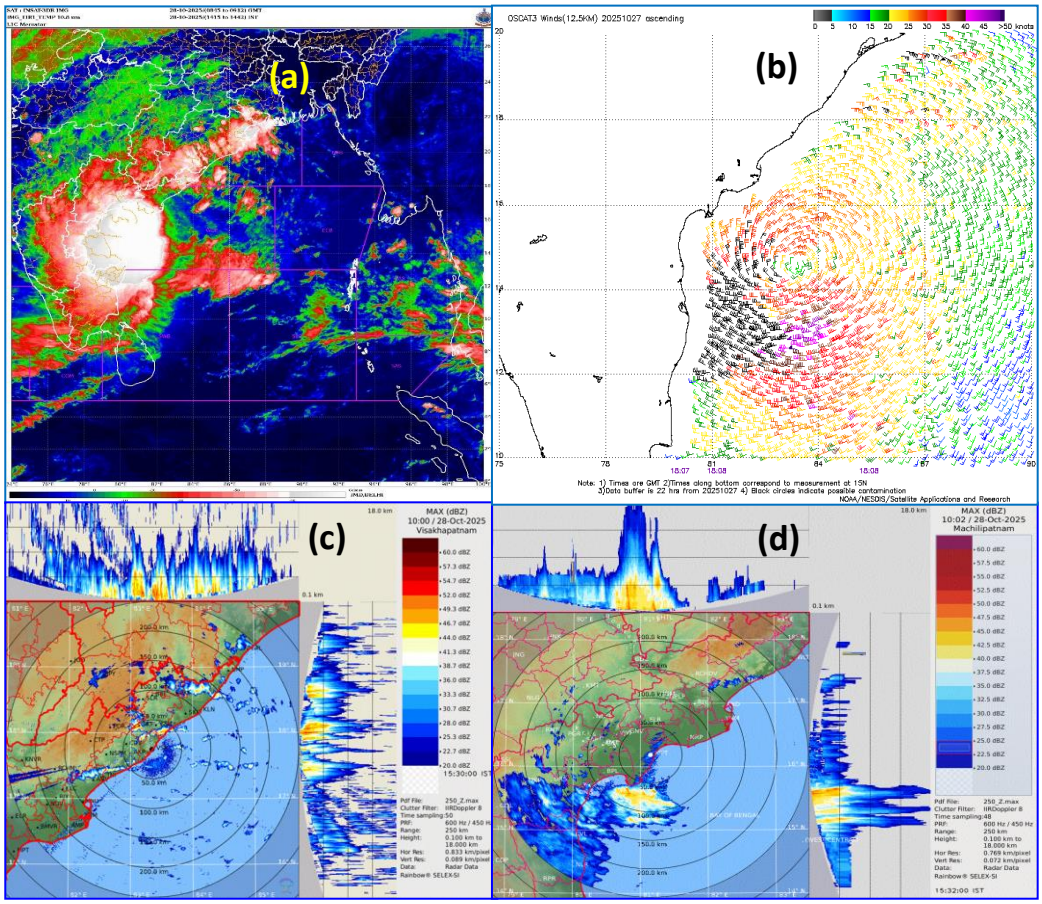


Fig.2.14.7: (a) Typical satellite imagery at 0845 UTC of 28th October, (b) OSCAT imagery (27th Oct/ 1807 UTC), Max reflectivity image of Doppler Weather **Radar (DWR)** (c) Visakhapatnam (28th Oct/ 0700 UTC) and (d) Machilipatnam (28th Oct/ 0900 UTC) during SCS MONTHA

2.14.4.1 Satellite Features:

As per INSAT 3DS imagery at 0300 UTC of 24th October, scattered to broken low and medium clouds with embedded intense to very intense convection lay over south and adjoining central BoB and minimum cloud top temperature (CTT) was minus 70^0 to 90^0 Celsius.

As per INSAT 3DS imagery at 0300 UTC of 25th October, the vortex over southeast Bay of Bengal & neighbourhood lay centred near 10.8°N/88.9° E with Intensity T1.5. Scattered to broken low/med clouds with embedded intense to very intense convection lay over south & adjoining central Bay of Bengal and minimum CTT was minus 70^0 to 90^0 degree Celsius.

As per INSAT 3DS imagery at 0300 UTC of 26th October, the vortex over southeast BoB & neighbourhood lay centred near 11.0°N/87.6° E with intensity T2.0. Scattered to broken low/med clouds with embedded intense to very intense convection lay over south & adjoining central BoB between latitude 5.0 N to 16.0 N and longitude 80.0 E to 93.0 E. Minimum CTT was minus 70^0 to 90^0 Celsius. The satellite imagery indicated development of banding features in the northern sector with area of intense convection to the northwest of system area. Large scale convection was seen over the south & central BoB suggesting large scale

release of latent heat release in the mid & upper tropospheric levels, supporting further intensification of the system. Both equatorward and poleward outflow was seen in the satellite imagery. The visible, IR, enhanced colored and brightness temperature imageries during life cycle of Montha are presented in **Fig.2.14.8.**

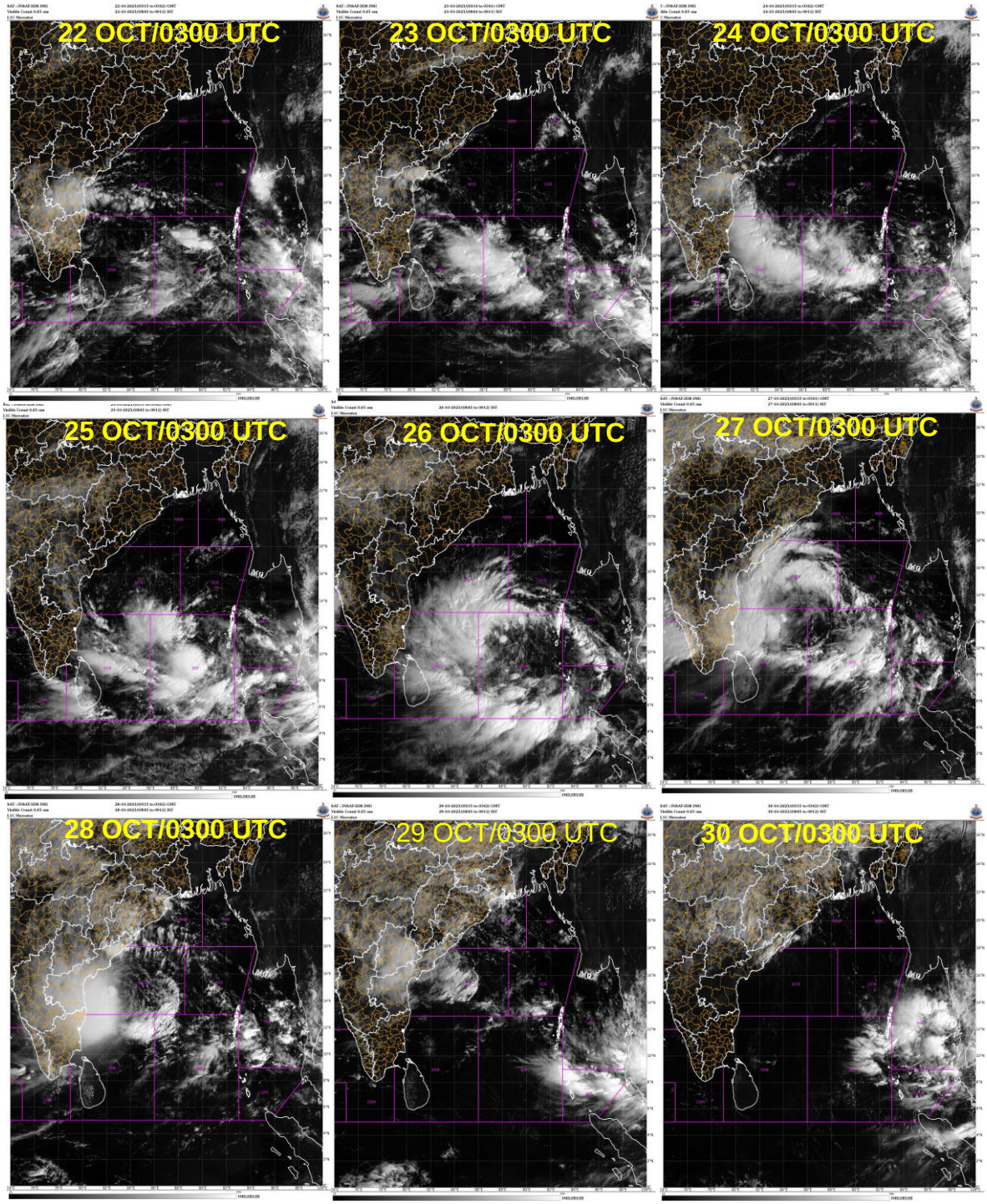


Fig.2.14.8(a): INSAT-3D visible imageries during life cycle of Severe Cyclonic Storm MONTHA over Southeast Bay of Bengal (25th – 30th) October, 2025

As per INSAT 3DS, at 0300 UTC of 27th October, the clouds indicated organisation of clouds in curved band pattern. The system lay centred near 12.5°N/85.1°E with intensity T2.5. Scattered to broken low/med clouds with embedded intense to very intense convection lay over south & adjoining central BoB between latitude 5.0^{0}N to 18.0^{0}N and longitude 80.0^0 E to 93.0^0 E. The minimum CTT was minus 70^0 to 90^0 Celsius.

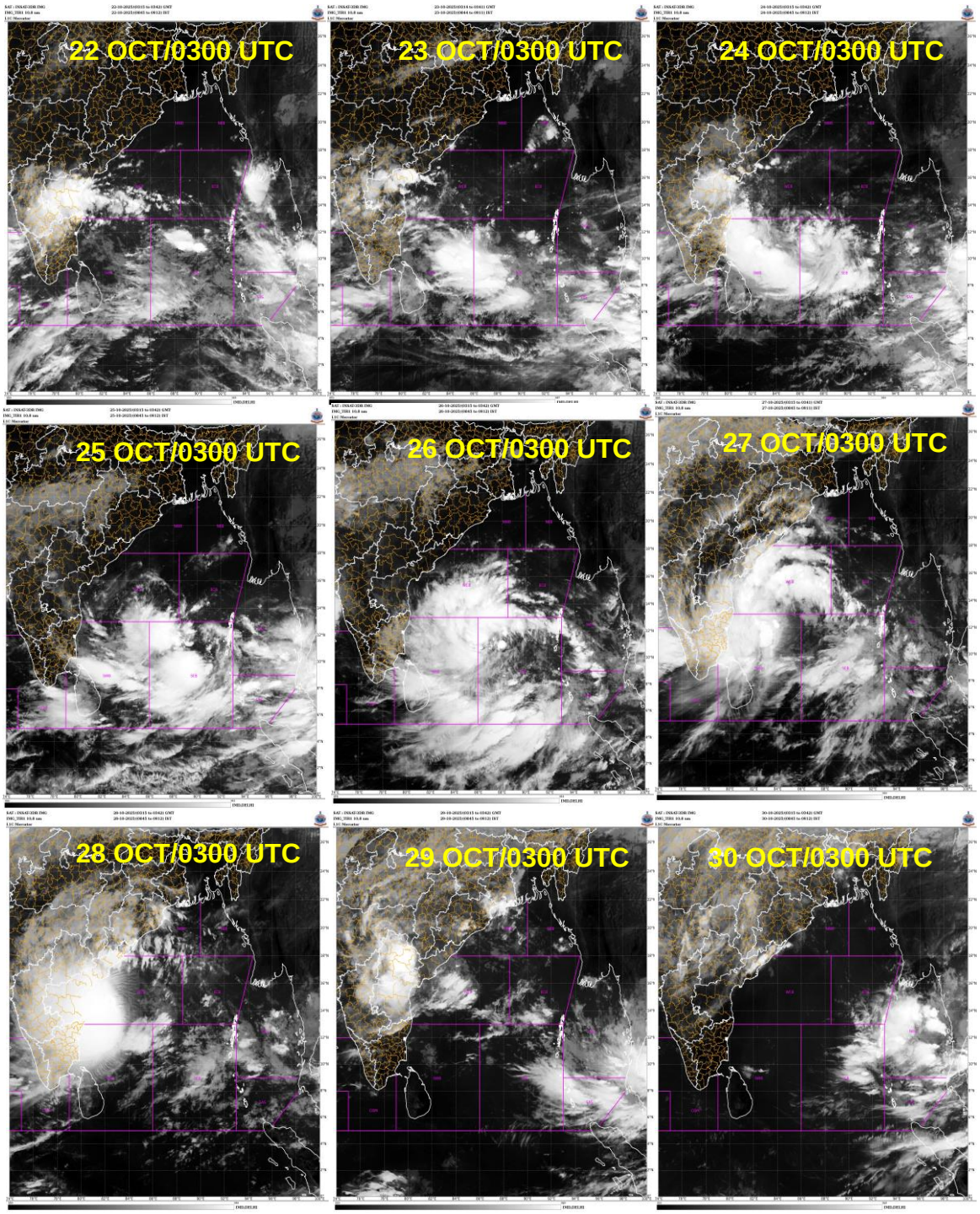


Fig.2.14.8(b): INSAT-3D IR imageries during life cycle of Severe Cyclonic Storm MONTHA over Southeast Bay of Bengal (25th – 30th) October, 2025

As per INSAT 3DS imagery at 0300 UTC of 28th October, the vortex over Westcentral Bay of Bengal & neighbourhood lay centered near 14.8 °N/ 82.9 °E with intensity T3.0. Scattered to broken low/medium clouds with embedded intense to very intense convection lay over westcentral & adjoining southwest BoB between latitude 10.0°N to 17.0°N and longitude 80.0 E to 85.0 E and Odisha, Chhattisgarh, Telangana, Rayalaseema, Coastal Andhra Pradesh, Karnataka, Tamil Nadu, Kerala (minimum cloud top temperature was minus 70 to 90 degree Celsius).

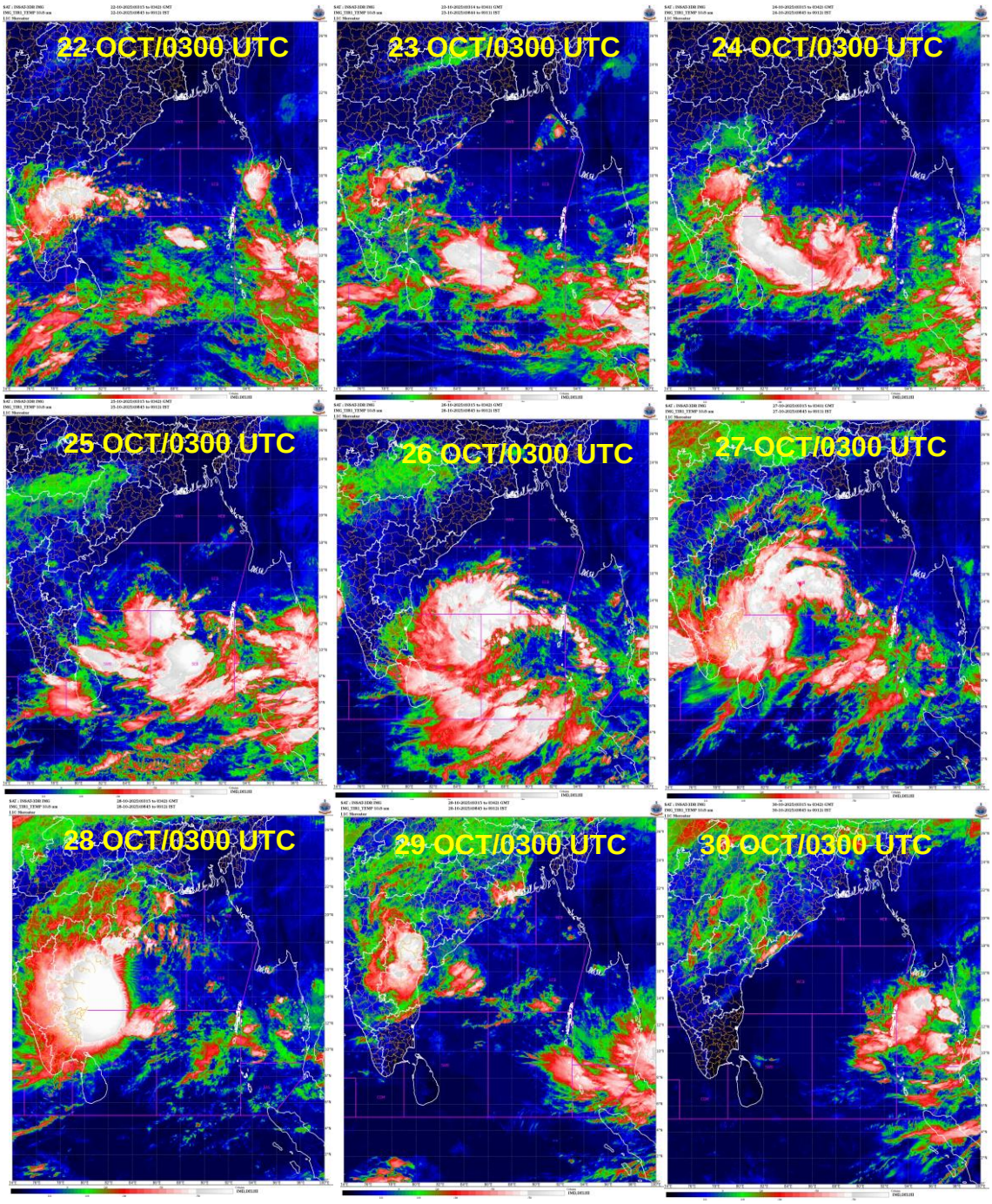


Fig.2.14.8(c): INSAT-3D NHC imageries during life cycle of Severe Cyclonic Storm MONTHA over Southeast Bay of Bengal (25th – 30th) October, 2025

As per INSAT 3DS imagery at 0300 UTC of 29th October, the system was over land and showed disorganisation. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over Telangana, Rayalaseema, Coastal Andhra Pradesh, interior Karnataka, Northeast Tamilnadu, and westcentral Bay of Bengal (minimum cloud top temperature was minus 70 to 90 degree Celsius).

As per INSAT 3DS imagery at 0300 UTC of 30th October, the clouds further disorganised. Scattered to broken low/medium clouds with embedded intense to very intense convection lay over east Madhya Pradesh, Vidharbha, Marathwada, Chhattisgarh and Telangana Minimum cloud top temperature was minus 50 to 70 degree Celsius, indicating decrease in depth of convection.

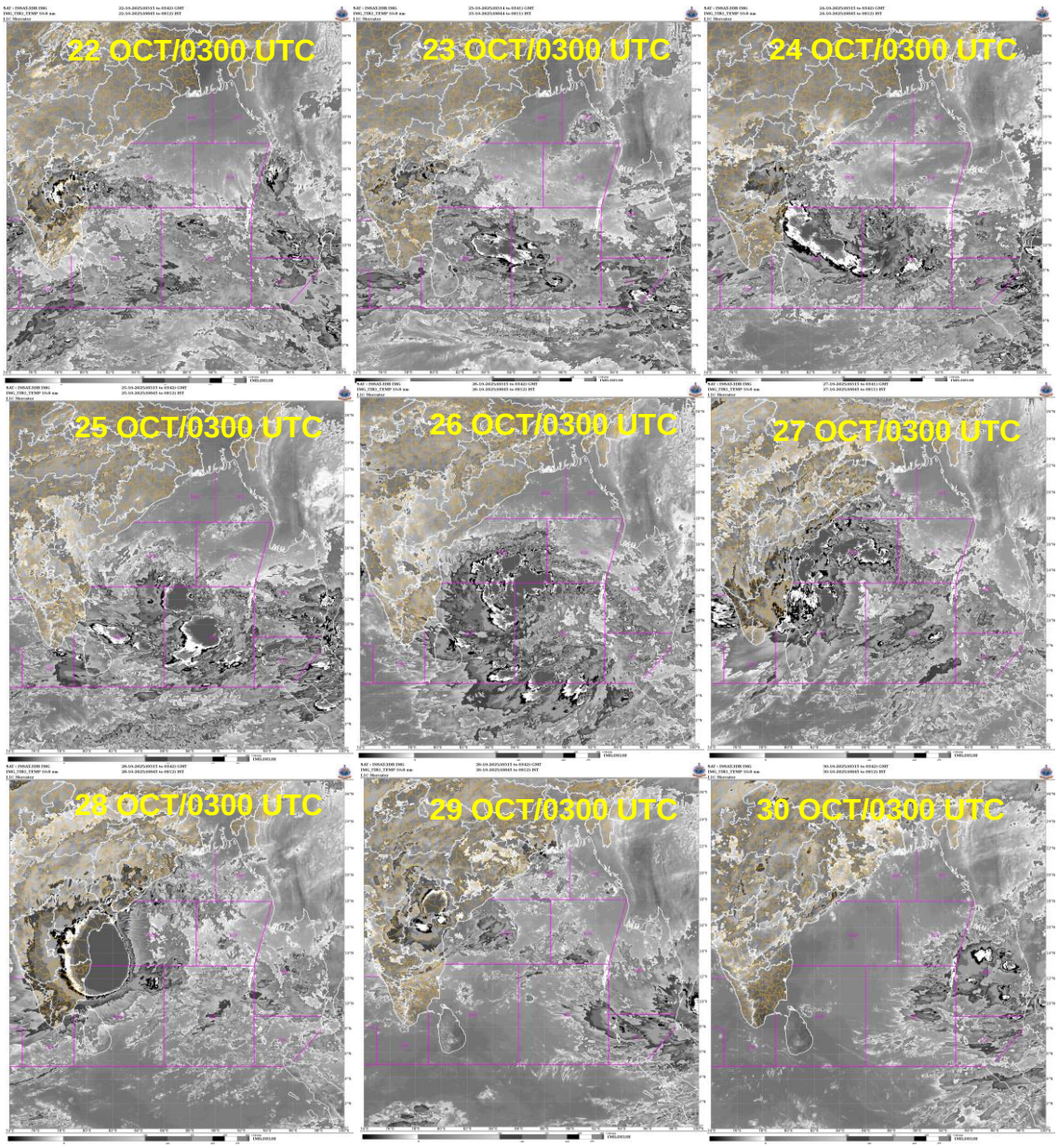


Fig.2.14.8(d): INSAT-3D BD imageries during life cycle of Severe Cyclonic Storm MONTHA over Southeast Bay of Bengal (25th – 30th) October, 2025

2.14.5 Dynamical features:

IMD maintained a round the clock watch and the system were monitored since 9th October. The analysis field of MSLP, 10m winds, winds at 850, 500 and 200 hPa are presented in **Fig.2.14.9**. At 0000 UTC of 22nd, the model indicated a cyclonic circulation over southeast bay adjoining Andaman Sea extending upto 500 hPa. Upper tropospheric ridge lay near 19.0^{0}N.

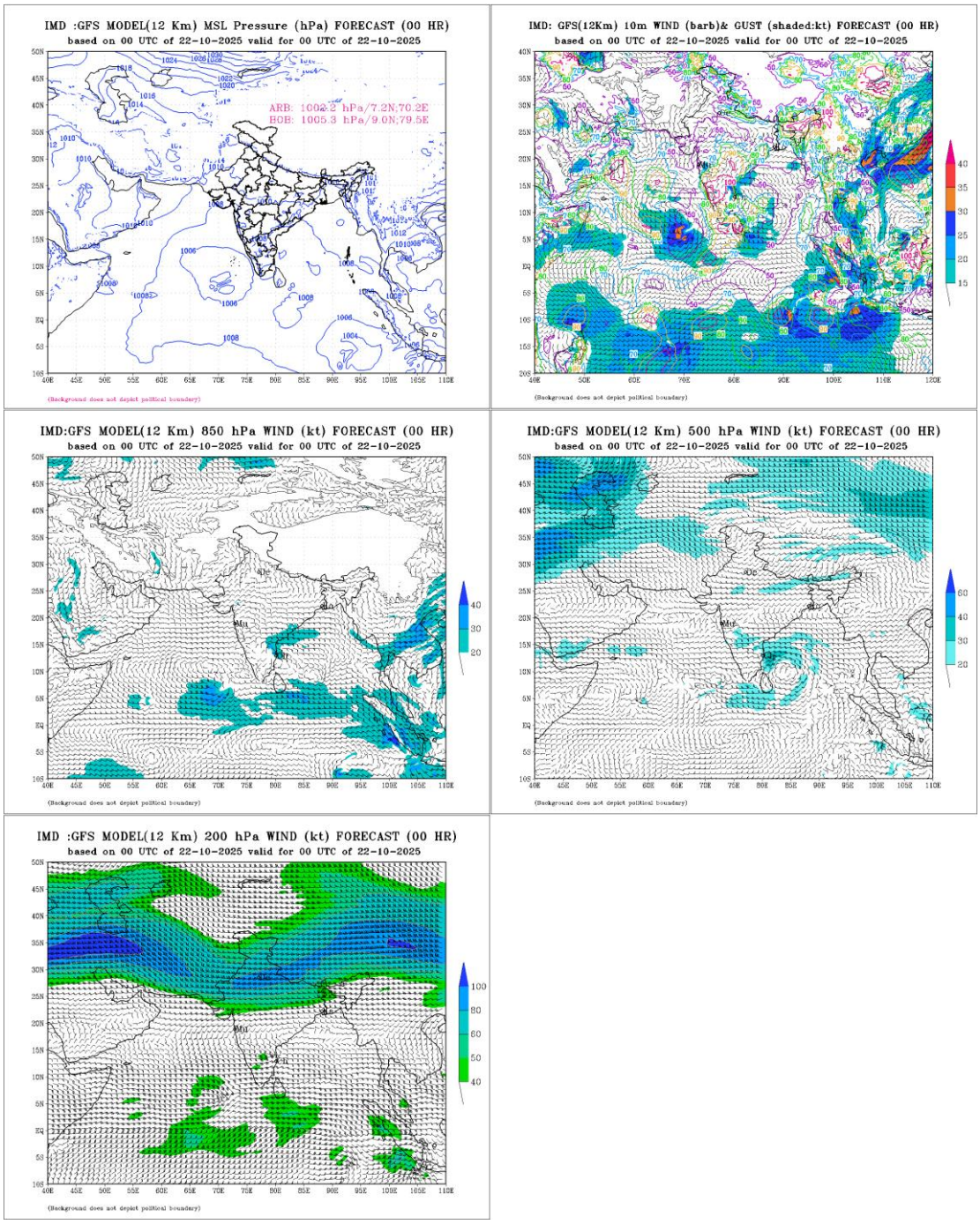


Fig.2.14.9(a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 22nd Oct 2025

At 0000 UTC of 23rd, the model still indicated a cyclonic circulation over eastcentral and adjoining southeast bay extending upto 700 hpa. Upper tropospheric ridge lay near 19.0^{0}N.

Actually, at 1200 UTC of 23rd, the system lay as an upper air cyclonic circulation over southeast BoB and adjoining south Andaman Sea.

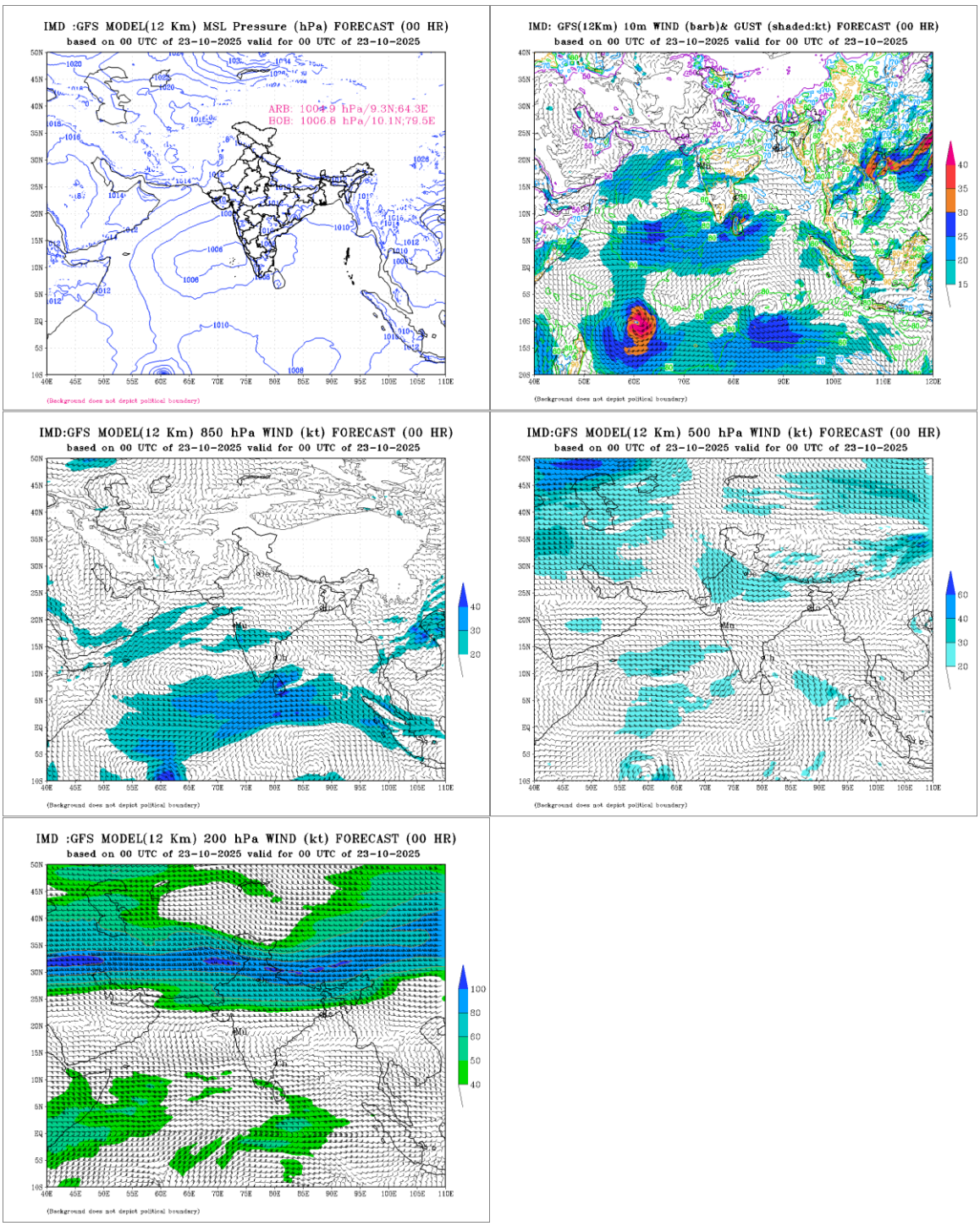


Fig.2.14.9(b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 23rd Oct 2025

At 0000 UTC of 24th, the model indicated a well-marked low-pressure area over southeast and adjoining south Andaman Sea near (11.2N/89.9E). The associated circulation extending

upto 500 hpa. Upper tropospheric ridge lay near 20.0^{0}N. Actually, it lay as a well-marked low pressure area over southeast BoB.

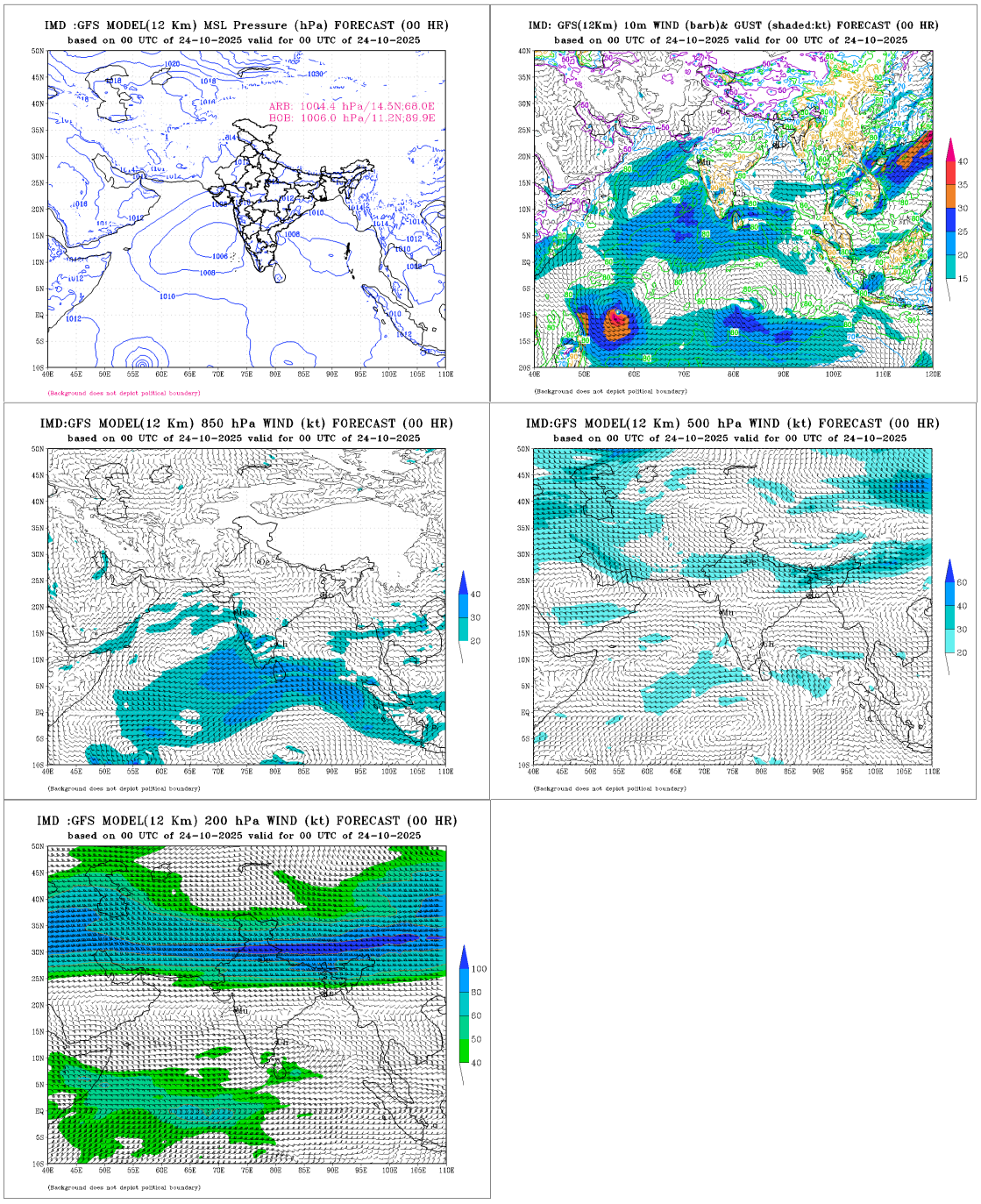


Fig.2.14.9(c): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 24th Oct 2025

At 0000 UTC of 25th, the MSLP field indicated a low-pressure area over southeast BoB near 11.1N/88.1E). The associated circulation extending upto 500 hpa. Upper tropospheric ridge lay near 19.0^{0}N. Actually, it lay as a depression over southeast BoB near 10.8N/89.0E. Thus,

the model was correctly capturing the location but underestimating the intensity of the system at 0000 UTC of 25th.

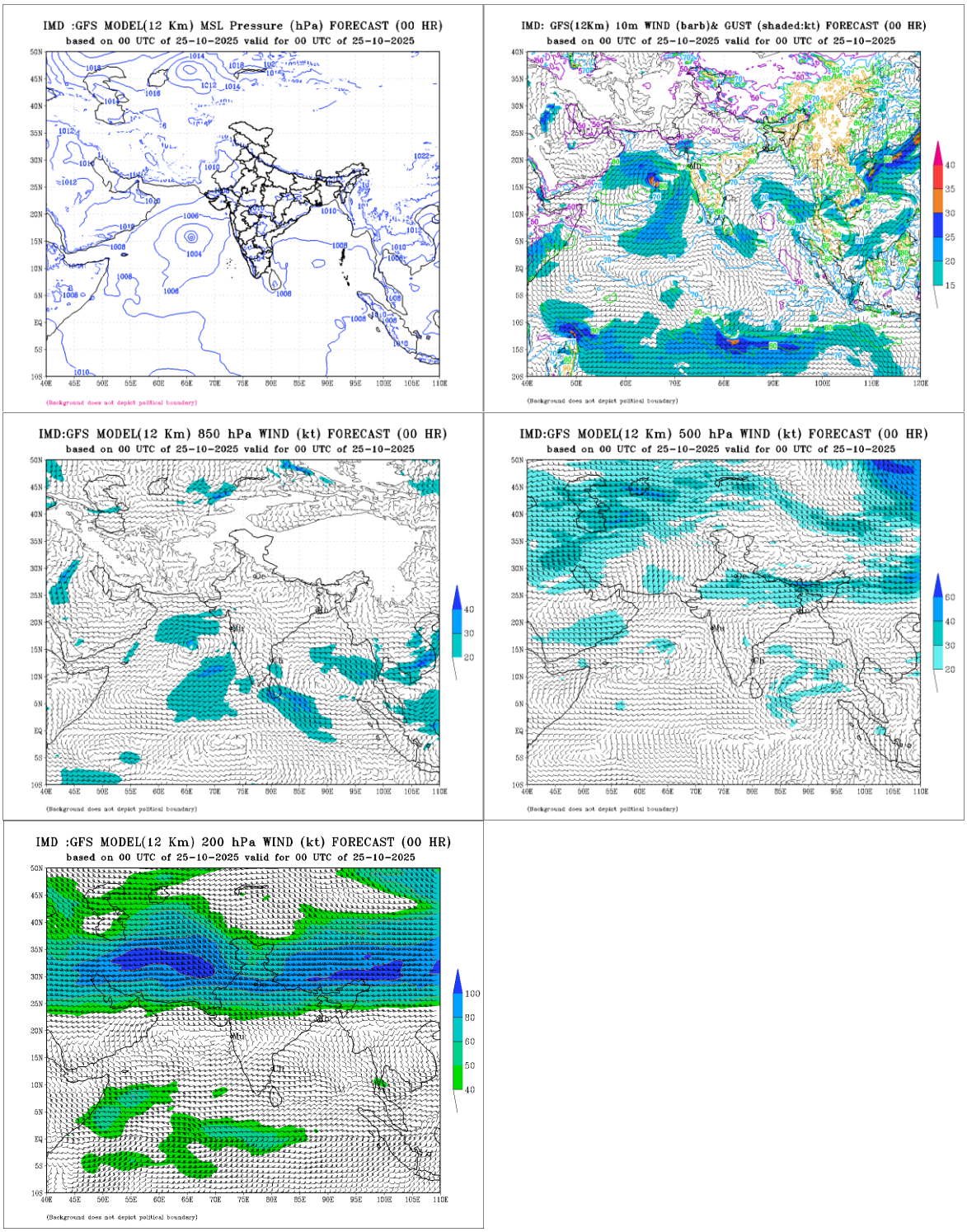


Fig.2.14.9(d): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 25th Oct 2025

At 1200 UTC of 25th, the MSLP field indicated a depression over southeast BoB near 10.3N/90.2E). The associated circulation extending upto 500 hpa and tilting south-westwards with height. Upper tropospheric ridge lay near 17.0^{0}N. East-southeasterly winds prevailing over the system area steering the system west-northwestwards. Actually, it lay as a depression over southeast BoB near 10.9N/88.1E. Thus, the model was not correctly capturing the location.

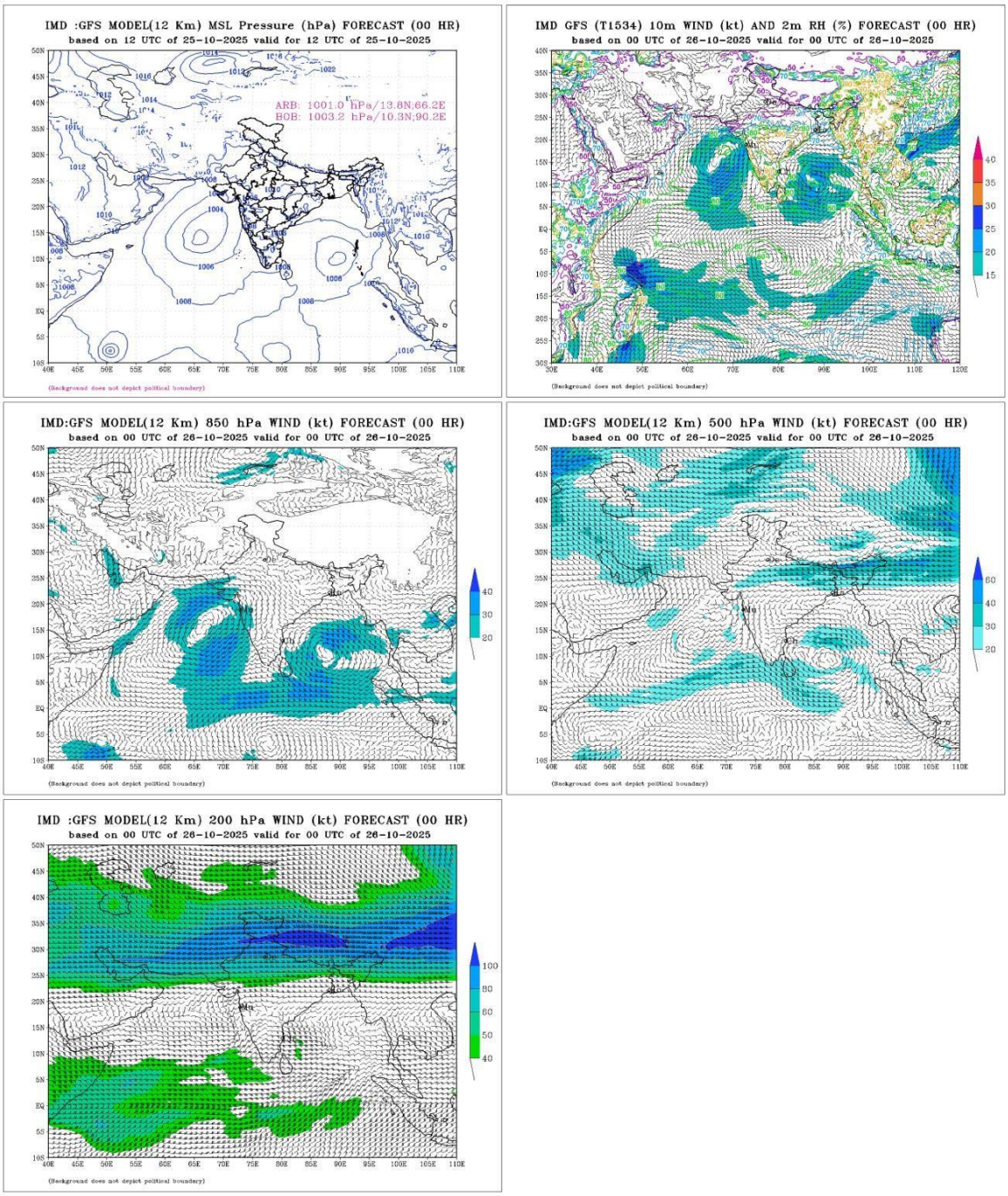


Fig.2.14.9(e): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 26th Oct 2025

At 0000 UTC of 27th, the MSLP field indicated intensification of the system into a cyclonic storm over southwest Bay near 12.4N/84.4E). The associated circulation extending upto 500 hpa. Upper tropospheric ridge lay near 20.0^{0}N. Actually, it lay as a cyclonic storm over southwest BoB near 12.2N/85.3E. Thus, the model indicated more westward location. Thus, the location was not correctly capturing the location.

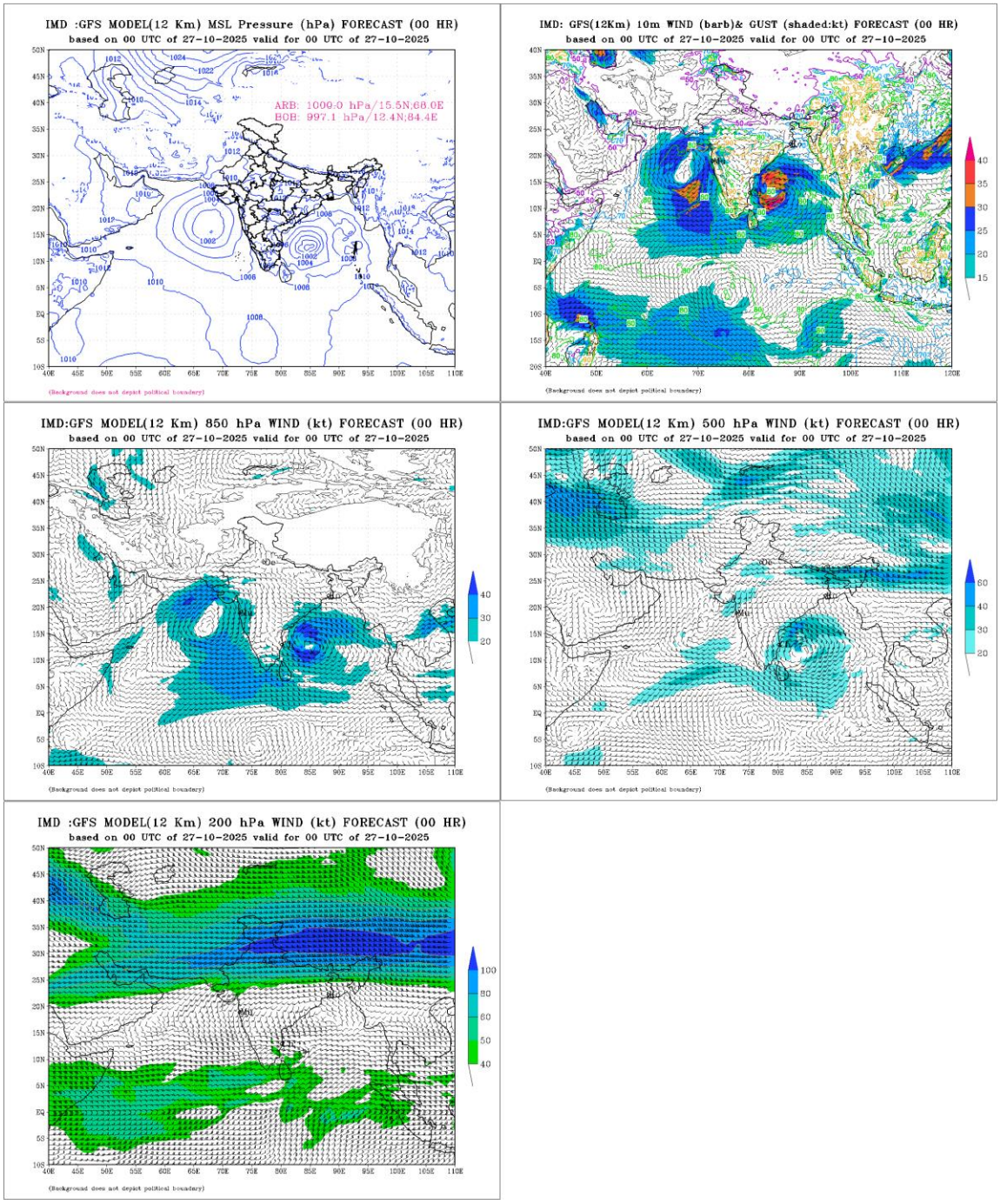


Fig.2.14.9(f): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 27th Oct 2025

At 0000 UTC of 28th, the MSLP field indicated further intensification of the system into a severe cyclonic storm over southwest BoB near 14.5N/82.5E). The associated circulation extending upto 500 hpa. Upper tropospheric ridge lay near 20.0^{0}N. Actually, it lay as a severe cyclonic storm over westcentral BoB near 14.7N/83.0E. Thus, the location was correctly capturing the location and intensity.

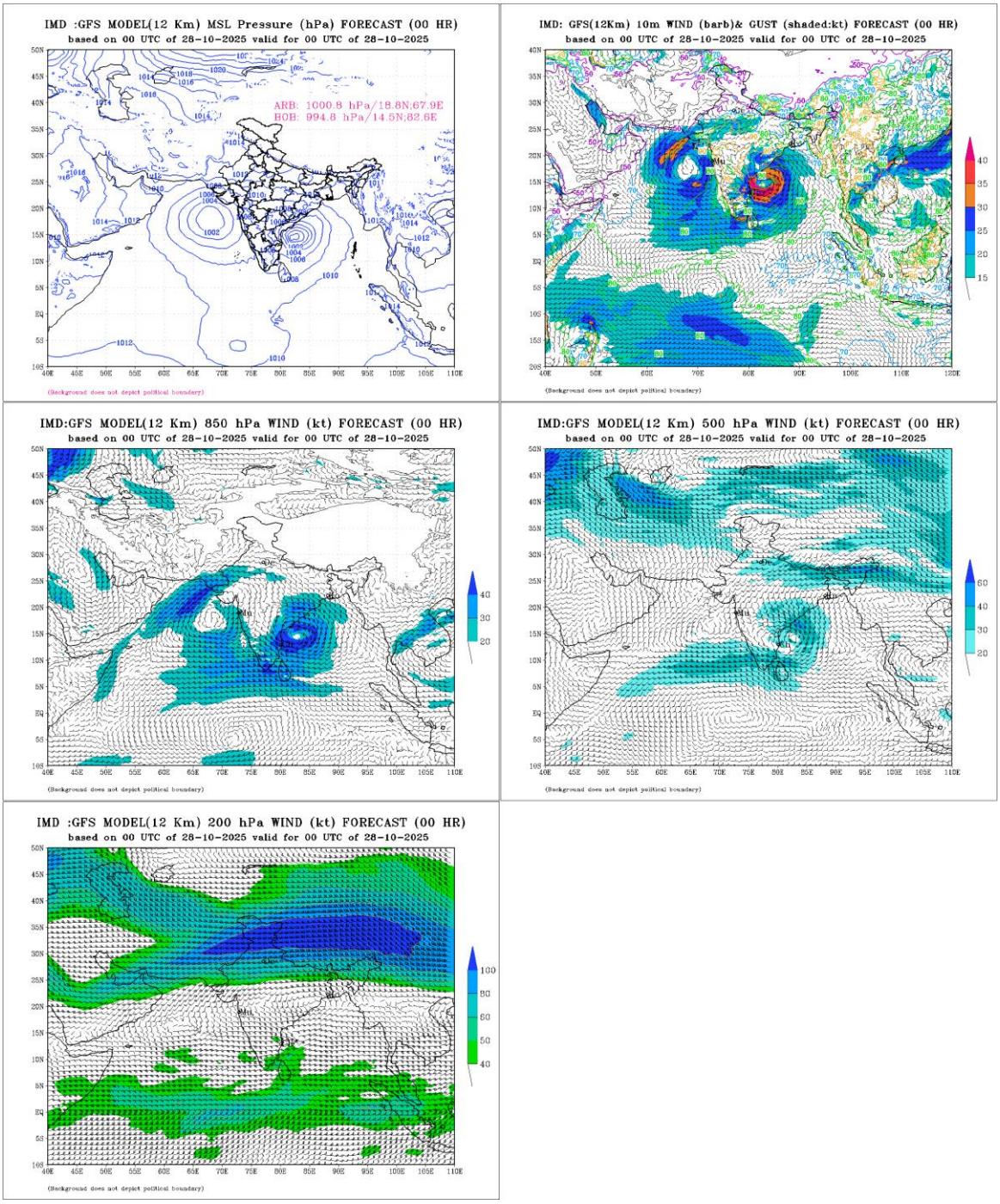


Fig.2.14.9(g): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 28th Oct 2025

At 0000 UTC of 29th, the MSLP field indicated the system over land near (17.2N/81.7E) as a cyclonic storm (45Kts). The associated circulation extending upto 500 hpa. Upper tropospheric ridge lay near 22.0^{0}N. Actually, it lay as a cyclonic storm (35Kts) over coastal Andhra Pradesh near (17.0N/81.3E). Thus, the location was slightly overestimating the intensity and indicating slower movement compared to actual.

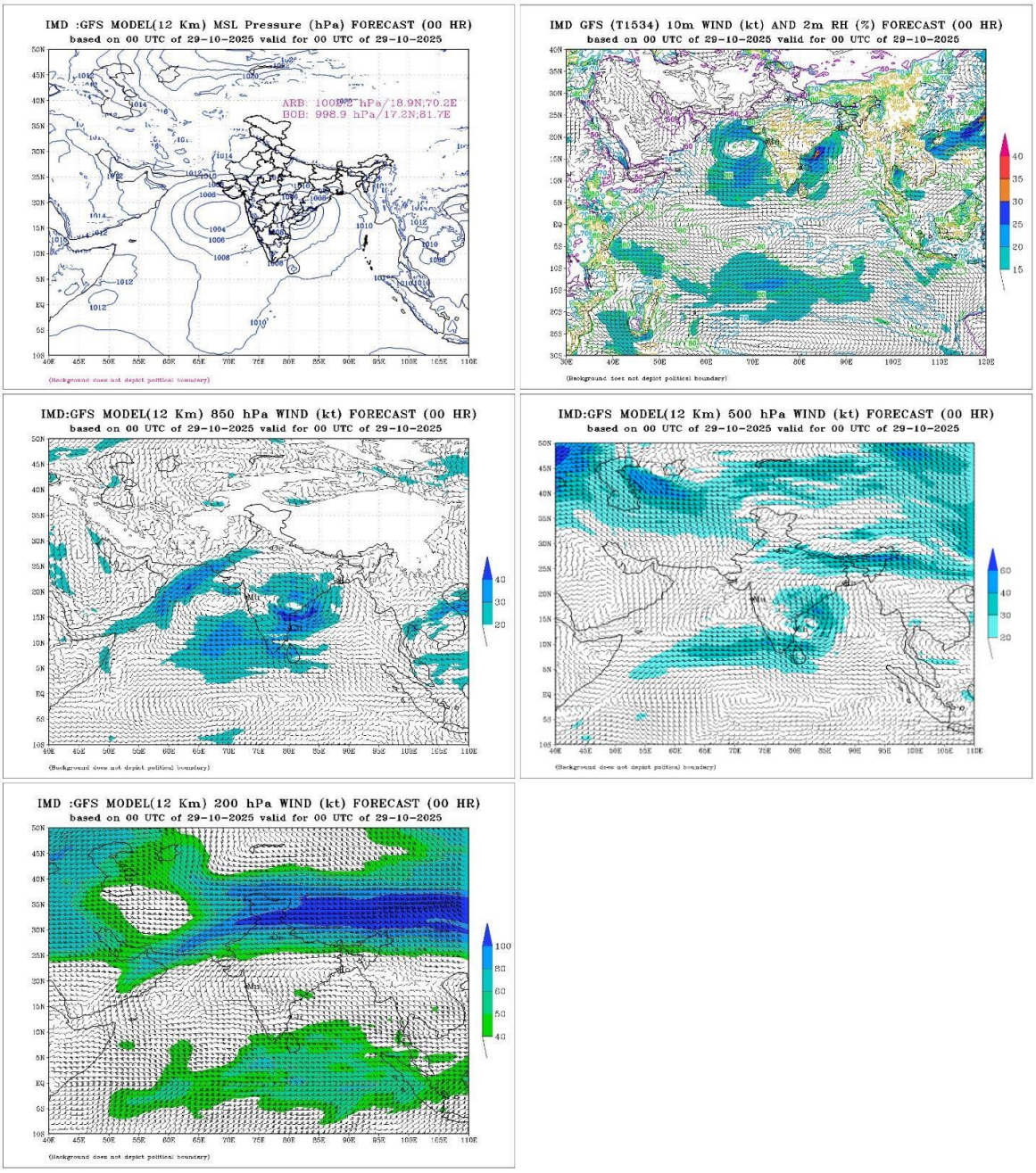


Fig.2.14.9(h): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 29th Oct 2025

At 0000 UTC of 30th, the MSLP field indicated a depression over Vidarbha near (20.3N/79.5E). The associated circulation extending upto 500 hpa. Upper tropospheric ridge lay near 21.0^{0}N. The southerly winds around the system area around 200hpa were indicating

the system to move nearly northwards. Actually, it weakened into a well marked low pressure area over east Vidarbha and south Chhattisgarh. Thus, the model was capturing the location correctly but the intensity was over estimated.

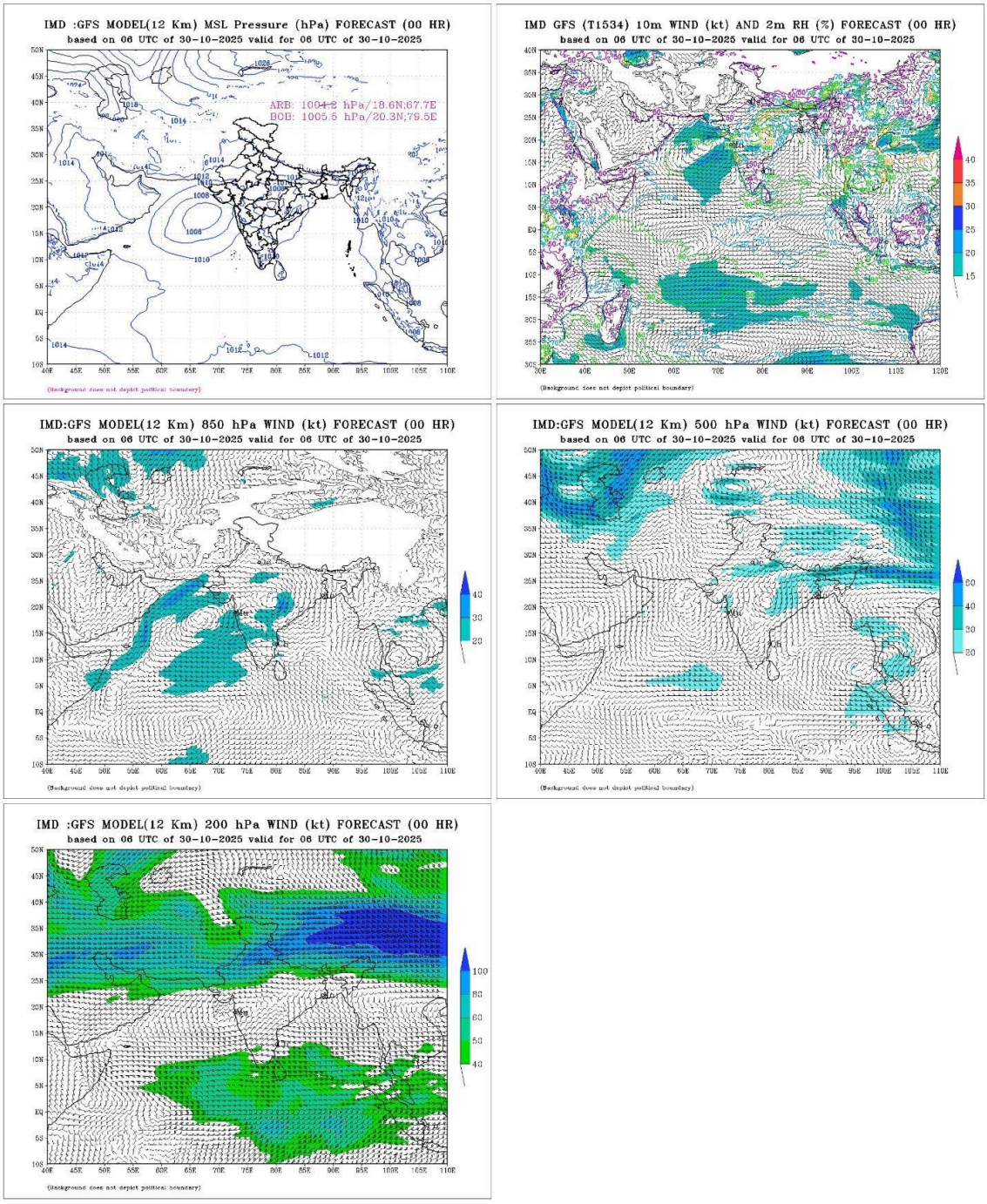


Fig.2.14.9(i): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 30th Oct 2025

2.14.6 Realised Weather

2.14.6.1 Realised Rainfall:

The system caused eextremely heavy rainfall over Coastal Andhra Pradesh & Yanam on 28th & 29th October, heavy to very heavy rainfall over south & coastal Odisha and Rayalaseema on 28th October, heavy rainfall over Gangetic West Bengal on 29th October and exceptionally heavy rainfall over Telangana on 30th October. The 24 hrs cumulative rainfall recorded over different stations ending at 0830 hrs IST of dates during 24th October to 1st November, 2025 is presented in **Fig.2.14.10** and IMD-NCMRWF satellite-gauge merged data plots are presented in **Fig.2.14.11**.

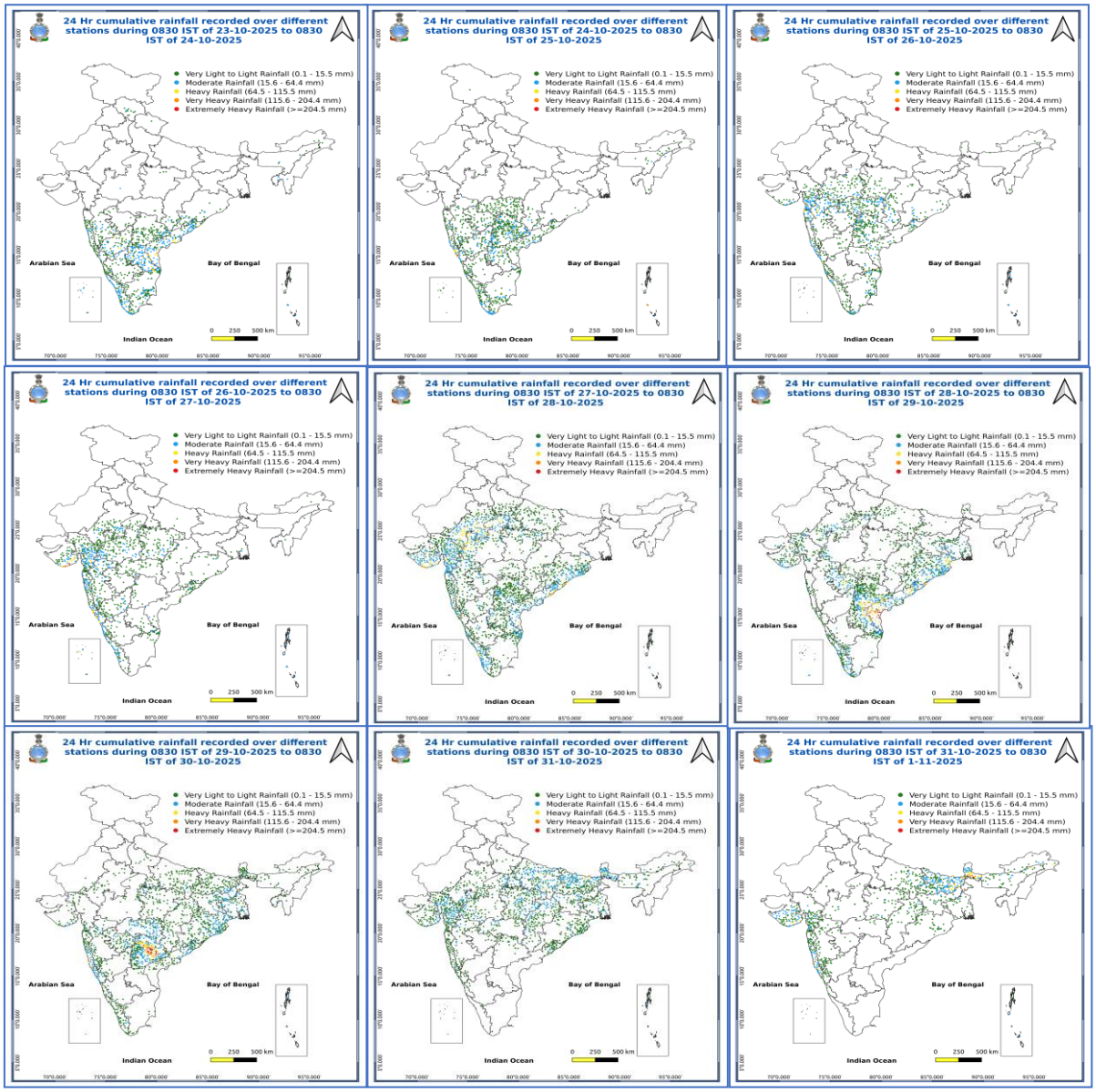


Fig.2.14.10: 24 hrs cumulative rainfall recorded over different stations ending at 0830 hrs IST of dates 23rd October to 1st November, 2025.

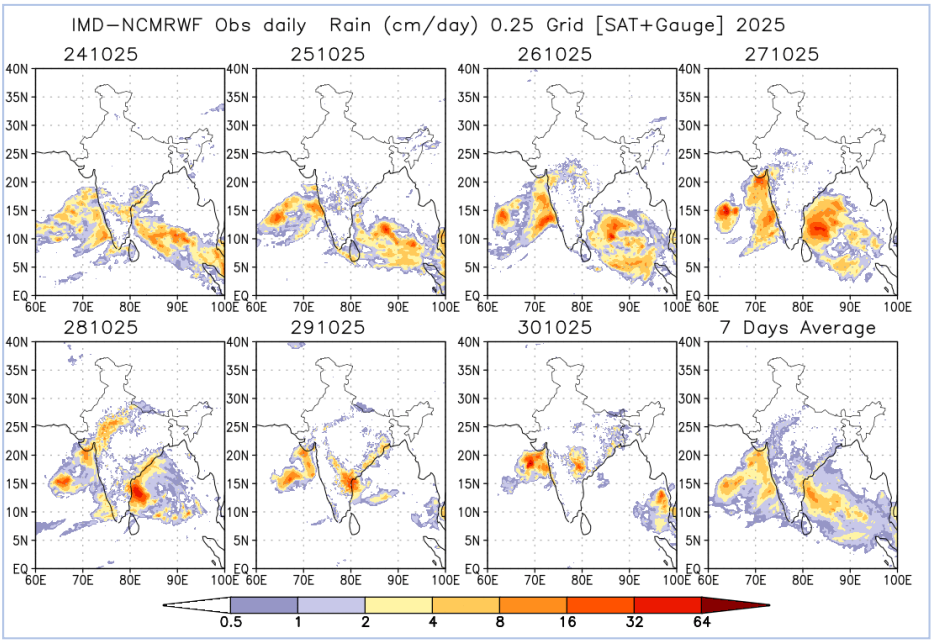


Fig.2.14.11: IMD-NCMRWF satellite-gauge merged data plots during 24th to 30th October, 2025.

2.14.6.2 24 hours cumulative heavy rainfall (≥ 7cm) ending at 0830 hours IST of date recorded over different stations (districts) is given below:

23.10.2025:

Tamil Nadu, Puducherry & Karaikal: Arakonam (Ranipet) 13, Harur (Dharmapuri) 11, Namakkal (Namakkal), Mohanur (Namakkal), Worth Estate Cherambadi (Nilgiris), Vellakoil (Tiruppur) 9 each, Avalurpettai (Tiruvannamalai), Tiruttani (Tiruvallur), Glenmorgan (Nilgiris) 8 each, Soorapattu (Chennai), Ranipet (Ranipet), Thiyagadurgam (Kallakurichi), Kedar (Nilgiris), Naduvattam (Nilgiris), Mettu / Mettupalayam (Coimbatore), Thiruvalangadu (Tiruvallur), Thuvakudi (Tiruchirappalli), Oothu (Tirunelveli), Taluk Office Pandalur (Nilgiris) 7 each.

South Interior Karnataka: Kottigehara (Chikkamagaluru) 12, Somwarpet (Kodagu) & Kushalnagar (Kodagu) 9 each, N R Pura (Chikkamagaluru), Koppa (Chikkamagaluru) & Konanur (Hassan) 7 each.

Coastal Karnataka: Mudubidre (Dakshina Kannada) 7,

Coastal Andhra Pradesh & Yanam: Yanam (Yanam) 11, Masulipatnam (Krishna), Seetharamapuram (SPSR Nellore) & Racherla (Prakasam) 9 each, Podili (Prakasam) 8, Rapur (SPSR Nellore) 7.

Rayalaseema: Penagaluru (Annamayya), Atlur (YSR), Brahmasamudram (Anantapuramu) 7 each.

24.10.2025:

Coastal Andhra Pradesh & Yanam: Kandukur (SPSR Nellore) 17, Narsapuram (West Godavari) 11, Amalapuram (B R Ambedkar Konaseema) 10, Tanuku (West Godavari) & Udayagiri (SPSR Nellore) 9 each, Vinjamur (SPSR Nellore), Kavali (SPSR Nellore),

Kalingapatnam (Srikakulam) & Ongole (Prakasam) 8 each, Palakoderu (West Godavari) & Bheemavaram (West Godavari) 7 each

Tamil Nadu: Pallipattu (Tiruvallur) 15, Nalumukku (Tirunelveli) 12, Oothu (Tirunelveli) 11, Arakonam (Ranipet)10, Balamore (Kanyakumari), Pechiparai AWS (Kanyakumari), Zone 14 Medavakkam (Chennai) 9 each, Kakkachi (Tirunelveli) 8, Thiruvalangadu (Tiruvallur), Chittar-I (Kanyakumari), Pechiparai (Kanyakumari), Perunchani Dam (Kanyakumari), Puthan Dam (Kanyakumari), Tiruttani (Tiruvallur) 7 each

North Interior Karnataka: Badami (Bagalkote) & Khanapura (Bagalkote) -14 each, Maski (Raichur) -11, Kushtagi (Koppala) & Menedal (Koppala), Ramadurga (Belagavi), Hosakeri (Belagavi), Saundatti & Markumbi (Belagavi) -10 each, Ramadurga (Belagavi), Idagal (Belagavi), Saundatti (Belagavi) & Inchal (Belagavi) 9 each, Karatagi (Koppala) & Karatagi (Koppala), Kalghatgi (Dharwad) & Belawantara (Dharwad) , Sindhanur (Raichur) & Jawalgera (Raichur), Ramadurga (Belagavi) & Halagatti (Belagavi) -8 each, Maski (Raichur), Maraladinni (Raichur), Sindhanur (Raichur) & Alabanur (Raichur), Ramadurga (Belagavi) & Turanur (Belagavi) -7 each.

Rayalaseema: Proddutur (YSR) 13, Raptadu (Anantapuramu) & Alur (Kurnool) 9 each, Atlur (YSR) 8, Porumamilla (YSR), Tirupati Aero (Tirupati), Penagaluru (Annamayya), Nagari (Chittoor), Anantpur (Anantapuramu) & Sullurpeta (Tirupati) 7 each

South Interior Karnataka: Siruguppa (Ballari) 8

25.10.2025:

Tamil Nadu & Puducherry: Oothu (Tirunelveli) 14, Nalumukku (Tirunelveli) 13, Kakkachi (Tirunelveli) 11, Balamore (Kanyakumari), Manjolai (Tirunelveli) 9 each, Thirparappu (Kanyakumari) 8, Idayapatti (Madurai), Madurai city (Madurai), Tallakulam (Madurai), Suralacode (Kanyakumari) 7 each;

Nicobar Island: Carnicobar (Nicobar) 12, Car Nicobar (Nicobar) 10;

Rayalaseema: Koilkuntla (Nandyal) 8, Dornipadu (Nandyal) 7;

Coastal Andhra Pradesh: Repalle (Bapatla) 7;

26.10.2025:

Tamil Nadu & Puducherry: Nalumukku (Tirunelveli) 13, Oothu (Tirunelveli) 12, Kakkachi (Tirunelveli) 10, Uthukottai (Tiruvallur) 9, Manjolai (Tirunelveli) 8;

Coastal Andhra Pradesh: Cumbum (Prakasam) 7;

27.10.2025:

Coastal Andhra Pradesh: Prathipadu (Kakinada) 8

28.10.2025:

Coastal Andhra Pradesh & Yanam: Visakhapatnam (Visakhapatnam) 19, Bheemunipatnam (Visakhapatnam), Visakhapatnam (Visakhapatnam) 14 each, Mandasa (Srikakulam) 12, Kalingapatnam (Srikakulam), Ichchapuram (Srikakulam), Palasa (Srikakulam) 10 each, Chodavaram (Anakapalli), Anakapalle (Anakapalli) 9 each, Yelamanchili (Anakapalli) 8, Pathapatnam (Srikakulam), Nellore (SPSR Nellore), Vizianagaram (Vizianagaram), Pusapatirega (Vizianagaram), Sompeta (Srikakulam) 7 each.

Rayalaseema: Uravakonda (Anantapuramu) 8, Sullurpeta (Tirupati), Tada (Tirupati) 7 each.

Odisha: Patrapur (Ganjam) 12, Gosani (Gajapati) 12, Sankheimundi (Ganjam), Paralakhemundi (Gajapati), Rayagada Udayagiri (Gajapati), Kukudahandi (Ganjam) 9 each, Berhampur (Ganjam) 7.

29.10.2025:

Coastal Andhra Pradesh & Yanam: Ongole (Prakasam) 25; Chimakurthi (Prakasam) 24; Kavali (SPSR Nellore), Kandukur (SPSR Nellore) 22 each; Darsi (Prakasam) 19; Addanki (Bapatla) 18; Podili (Prakasam) 17; Konakanamitla (Prakasam) 16; Markapur (Prakasam) 15; Cumbum (Prakasam) 14; Marripudi (Prakasam), Racherla (Prakasam), Yerragondapalem (Prakasam), Mundlamuru (Prakasam) 13 each; Srungavarapukota (Vizianagaram), Karamchedu (Bapatla), Bestavaripeta (Prakasam), Udayagiri (SPSR Nellore), Bapatla (Bapatla), Vinjamur (SPSR Nellore) 12 each; Veligandla (Prakasam) 11; Anakapalle AP (Anakapalli), Ardhaveedu (Prakasam), Araku Valley (Alluri Sitharamaraju), Nellore (SPSR Nellore), Piduguralla (Palnadu), Seetharamapuram (SPSR Nellore) 10 each; Nandigama (Krishna), Atmakur (SPSR Nellore) 9 each; Santhamaguluru (Bapatla), Palasa (Srikakulam), Repalle (Bapatla), Sompeta (Srikakulam), Paderu (Alluri Sitharamaraju), Bondapalle (Vizianagaram), Mentada (Vizianagaram), Jangamaheswarapuram (Palnadu), Tiruvuru (Krishna) 8 each; Chodavaram (Anakapalli), Mandasa (Srikakulam), Macherla (Palnadu), Gantyada (Vizianagaram), Merakamudidam (Vizianagaram), Guntur (Guntur) 7 each;

Rayalaseema: Srisailam (Nandyal) 20; Atmakur (Nandyal) 14; Porumamilla (YSR District) 13; Jupadu Bungalow (Nandyal) 12; Nandyal (Nandyal), Rudravaram (Nandyal) 11 each; Allagadda (Nandyal), Nandikotkur (Nandyal) 10 each; Pagidyala (Nandyal) 9; Badvel (YSR), Dornipadu (Nandyal) 8 each; Gudur (Tirupati), Koilkuntla (Nandyal), Atlur (YSR District), Duvvur (YSR) 7 each; Marathwada: Renapur (Latur) 19; Latur (Latur) 11; Deoni (Latur) 10; Gangakhed (Parbhani), Pathri (Parbhani), Parli Vaijnath (Beed), Badnapur (Jalna) 7 each;

Telangana: Achampeta (Nagarkurnool) 17; Kalwakurthy (Nagarkurnool) 16; Devarakonda (Nalgonda) 13; Pedda Adiserlapalle (Nalgonda) 12; Dornakal (Mahabubabad), Vangoor (Nagarkurnool), Midjil (Mahabubnagar) 11 each; Jadcherla (Mahabubnagar) 10; Garla (Mahabubabad), Kollapur (Nagarkurnool), Bonakal (Khammam), Nagar Kurnool (Nagarkurnool), Thollada (Khammam), Thimmajipeta (Nagarkurnool), Gopalpet (Wanaparthy) 9 each; Nagarjunsagar (Nalgonda), Madhira (Khammam), Marriguda (Nalgonda), Mattampally (Suryapet), Wyra (Khammam) 8 each; Wanaparthy (Wanaparthy), Khila Ghanpur (Wanaparthy), Bala Nagar (Mahabubnagar) 7 each;

Odisha: Gosani (Gajapati) 15; Patrapur (Ganjam) 12; Jaipur (Balasore) 11; Udala (Mayurbhanj), Purushottampur (Ganjam) 10 each; Pottangi (Koraput), Nilgiri (Balasore), Balasore (Balasore), Gumma (Gajapati), Sankheimundi (Ganjam), Aul (Kendrapara) 9 each; NH5 Gobindpur (Balasore), Mahendragarh (Gajapati), Soro (Balasore), Tihidi (Bhadrak), Aska (Ganjam), Betanati (Mayurbhanj), Kaptipada (Mayurbhanj), Polsara (Ganjam), Oupada (Balasore), Daringibadi (Kandhamal) 8 each; R. Udaigiri (Gajapati), Bhuban (Dhenkanal), Remuna (Balasore), Chandbali (Bhadrak), Balimundali (Mayurbhanj), Hatadihi (Keonjhargarh), Sheragada (Ganjam), GB Nagar (Mayurbhanj), Hinjili (Ganjam) 7 each;

Gangetic West Bengal: Contai (East Midnapore) 8;

Tamil Nadu, Puducherry & Karaikal: Nalumukku (Tirunelveli) 7;

Bihar: Dobhi (Gaya) 7.

30.10.2025:

Telangana: Bheemadevarpalle (Hanumakonda) 39, Parvathagiri (Warangal) 38, Dharmasagar (Hanumakonda) & Chigurumamidy (Karimnagar) 31 each, Huzurabad (Karimnagar) & Zaffergadh (Jangaon) 29 each, Gudurwrgl (Mahabubabad) & Sangem (Warangal) 28 each, Hasanparthy (Hanumakonda) & Chennaraopet (Warangal) 25 each, Jangaon (Jangaon) , Hanamkonda (Hanumakonda) ,& Palakurthi (Jangaon) 23 each, Narmetta (Jangaon) 22, Nanganur (Siddipet) , Shankarapatnam (Karimnagar) & Karimnagar (Karimnagar) 20 each, Thimmapur (Karimnagar) , Atmakur M (Y. Bhuvanagiri) & Narsampet (Warangal) 19 each, Ghanpur (Jangaon), Mahabubabad (Mahabubabad) & Raghunathpalle (Jangaon) 17 each, Srirampur (Peddapalle) , Kunaram(arg) (Peddapalle) , Atmakurwrgl (Hanumakonda) , Dornakal (Mahabubabad) , Garla (Mahabubabad) & Kodakandla (Jangaon) 15 each, Bachhanpet (Jangaon) , Noothankal (Suryapet) , Devaruppal (Jangaon) , Konaraopeta (Rajanna Sircilla) 14, Armur (Nizamabad) , Bayyaram (Mahabubabad) & Nandipet (Nizamabad) 14 each, Peddapalle (Peddapalle) & Bejjanki (Siddipet) 13 each, Gangadhara (Karimnagar) , Chandurthi (Rajanna Sircilla) , Shayampet (Hanumakonda) , Choppadandi (Karimnagar) , Mustabad (Rajanna Sircilla) & Kondapak (Siddipet) 12 each, Kammar Palle (Nizamabad) , Ellanthukunta (Rajanna Sircilla) , Jagadevpur (Siddipet) , Karimnagar(a) (Karimnagar) , Pegadapalle (Jagtial) , Jammikunta (Karimnagar) , Jajireddigudem (Suryapet) , Boinpalle (Rajanna Sircilla) & Velpur (Nizamabad) 11 each, Mudhole (Nirmal) , Sultanabad (Peddapalle) , Siddhapur(a) (Warangal) , Khanapur (Warangal) , Navipet (Nizamabad) , Kathlapur (Jagtial) & Nallabelly (Warangal) 10 each, Bheemgal (Nizamabad) , Kataram (J. Bhupalpally) , Balkonda (Nizamabad) , Manthani (Peddapalle) , Yadagirigutta (Y. Bhuvanagiri) , Elagaid (Peddapalle) , Parkal (Hanumakonda) , Regonda (J. Bhupalpally) , Mortad (Nizamabad) & Jakranpalle (Nizamabad) 9 each, Sarangapur (Jagtial) , Mogullapalle (J. Bhupalpally) , Sirsilla (Rajanna Sircilla) , Metpalle (Jagtial) & Mothey (Suryapet) 8 each, Bhuvanagiri (Y. Bhuvanagiri) , Mallial (Jagtial) , Kaveri_siddipet(a) (Siddipet) , Mulug (Mulugu) , Kothaguda (Mahabubabad) , Chityal (J. Bhupalpally) , Belampalle (Mancherial) , Jaipur (Mancherial) , Bhainsa(arg) (Nirmal) , Yellareddypeta (Rajanna Sircilla) , Dharmapuri (Jagtial) , Siricilla(a) (Rajanna Sircilla) , Suryapet (Suryapet) , Makloor (Nizamabad) & Sirpuru (Kumaram Bheem) 7 each;

Coastal Andhra Pradesh: Polavaram (Eluru) 9;

Odisha: Nawana (Mayurbhanj) & Gobindpur (Balasore) 9 each, Banki (Cuttack) 8, Suliapada (Mayurbhanj) & Bhuban (Dhenkanal) 7 each;

Jharkhand: Sonua (West Singbhum) 7;

31.10.2025:

Bihar: Birpur (Supaul) 15, Raghunathpur (Siwan) & Phulparas (Madhubani) 10 each, Rahghopur (Supaul), Pratapganj (Supaul), Andar (Siwan), Chapra (Saran), Pipra (Supaul), Saraigarh Bhaptiyahi (Supaul) & Basantpur (Siwan) 9 each, Nirmali (Supaul), Barhampur (Buxar), Marauna (Supaul), Pothia (Kishanganj), Itarahi (Buxar), Arrah (Bhojpur), Bhagwanpur Hat (Siwan) & Buxar (Buxar) 8 each, Gopalganj (Gopalganj), Dumraon (Buxar), Narpatganj (Araria) & Supaul (Supaul) 7 each;

Jharkhand: Dhanbad (Dhanbad) 12, Putki (Dhanbad), Putki (Dhanbad) & Barkatha (Hazaribag) 9 each;

Sub-Himalayan West Bengal: Maynaguri College (Jalpaiguri) 10, Palashbari Tea Estate (Jalpaiguri), Washabari Tea Estate (Jalpaiguri) & Mogulkata Tea Estate (Jalpaiguri) 9 each, Buxaduar (Alipurduar), Bagdogra (Darjeeling) & Moraghat Tea Estate (Jalpaiguri) 8 each, Sevoke (Darjeeling), Murti (Jalpaiguri), Bagrakote (Jalpaiguri), Siliguri (Darjeeling), Leesh River Tea Garden (Jalpaiguri), Damdim Tea Estate (Jalpaiguri), Ghish (Jalpaiguri), Jhallong (Kalimpong), Nagrakata (Jalpaiguri), Toorsa Tea Garden (Alipurduar), Darjeeling (Darjeeling) & Diana Tea Estate (Jalpaiguri) 7 each;

Chhattisgarh: Salhewara (Khairagarh) 8;

SPSR: Sri Potti Sriramulu, YSR: Yeduguri Sandinti Rajasekhara Reddy

2.14.7 Damage report in association with cyclone MONTHA

The disaster caused at least 8 deaths, including 2 in Andhra Pradesh, 6 in Telangana. In Andhra Pradesh, over 1.8 million people were affected, with 1.37 lakh evacuated to 1,464 relief camps. Additionally, 3,045 houses were damaged across 23 districts.

Agriculture suffered the highest losses, with 1.38–1.61 lakh acres of crops damaged in Andhra Pradesh and 1.81 lakh hectares in Telangana. Power infrastructure was hit, damaging 13,000 poles and 3,000 transformers. Transport networks suffered damage to 4,794 km of roads and 311 bridges.

Fig.2.14.12 The images are sourced from the Press Trust of India (PTI), The Hindu, ANI/Reuters, The Times of India.

2.15 Cyclonic Storm "SENYAR" over the Strait of Malacca (25-27 November, 2025)

2.15.1 Life History of Senyar

- An upper air cyclonic circulation lay over central parts of Strait of Malacca in the forenoon (0830 hours IST/0300 UTC) of 20th Nov.
- Under its influence, a low-pressure area developed over Strait of Malacca and adjoining South Andaman Sea in the forenoon (0830 hours IST/ 0300 UTC) of 22nd Nov., 2025.
- It lay as a well-marked low-pressure area over the same region in the forenoon (0830 hours IST/ 0300 UTC) of 23rd Nov.
- It concentrated into a depression over the Strait of Malacca in the forenoon (0830 hours IST/ 0300 UTC) of 25th Nov.
- It moved nearly westwards and intensified into a deep depression over Malacca Strait in the midnight (2330 hours IST/ 1800 UTC) of 25th Nov. and into the Cyclonic Storm Senyar over Strait of Malacca and adjoining Northeast Indonesia in the early morning (0530 hours IST/ 0000 UTC) of 26th Nov. while moving west-southwestwards.
- Continuing to move further west-southwestwards, it crossed Northeast Indonesia near 4.9^0N/97.75^0E in the forenoon (during 0830 - 0930 hours IST/ 0300-0400 UTC) of 26th Nov.
- Thereafter, it gradually recurved southeastwards & emerged back into Malacca Strait in the early hours (0030-0130 hours IST) of 27th Nov. (1900-2000 UTC of 26th Nov.) as a cyclonic storm.
- Thereafter, while moving nearly eastwards, it weakened into a deep depression during early morning (0530 hrs IST/ 0000 UTC) and into a depression around noon (1130 hrs IST/ 0600 UTC) of 27th Nov. over Malacca Strait. Continuing to move eastwards, it maintained the intensity of depression till evening (1730 hrs IST/ 1200 UTC) of 27th Nov. and weakened into a well marked low pressure area over Malacca Strait and adjoining coastal areas of Malaysia in the midnight (2330 hrs IST/ 1800 UTC) of 27th Nov. Thereafter, it moved across Malaysia into Northwest Pacific & adjoining Equatorial Pacific & weakened gradually.
- The observed track of the system (depression to depression) is presented in **Fig.2.15.1**. The best track parameters of the system are presented in **Table 2.15.1.**

Table 2.15.1: Best track positions and other parameters of the CS SENYAR over Strait of Malacca 25th – 27th November 2025

Date	Time (UTC)	Lat. (^{0}N)	Long. (^{0}E)	C.I. No.	ECP (hPa)	ΔP (hPa)	MSW (kt)	Category
25-11-2025	0300	5.4	99.7	1.5	1004	3	20	D
	0600	5.3	99.5	1.5	1004	3	20	D
	1200	5.1	99.0	1.5	1003	4	25	D
	1800	5.1	98.5	2.0	1002	5	30	DD
26-11-2025	0000	5.0	98.0	2.5	999	8	40	CS
		Crossed Indonesia coast near 4.90^0N/97.75^0E between 0200-0300 UTC with maximum sustained wind speed of 70-80 gusting to 90 kmph (40 kt gusting to 50 kt)						

	0300	4.9	97.8	-	999	8	40	CS
	0600	4.7	97.8	-	999	8	40	CS
	0900	4.6	97.8	-	999	8	40	CS
	1200	4.3	98.1	-	1000	7	35	CS
	1500	4.1	98.3	-	1000	7	35	CS
	1800	4.0	98.5	-	1000	7	35	CS
		Emerged into Strait of Malacca during 1900-2000 UTC						
	2100	3.8	98.8	2.5	1001	6	35	CS
27-11-2025	0000	3.7	99.2	2.0	1002	5	30	DD
	0300	3.7	99.6	2.0	1002	5	30	DD
	0600	3.6	99.8	1.5	1003	4	25	D
	1200	3.6	100.7	1.5	1004	3	20	D
	1500	3.6	100.9	1.5	1004	3	20	D
	1800	Weakened into a well marked low pressure area over Malacca Strait and adjoining Malaysia						

Kt: Knots (nautical mile per hour), 1 kt=1.85 kmph, D: Depression (17-27 kt), D: Deep depression (28-33kt), CS: Cyclonic Storm (34-47 kt), lat.: Lalitude, long.: Longitude, ECP= Estimated central pressure, ΔP: Pressure drop at centre, MSW: 3-minute average maximum sustained wind speed

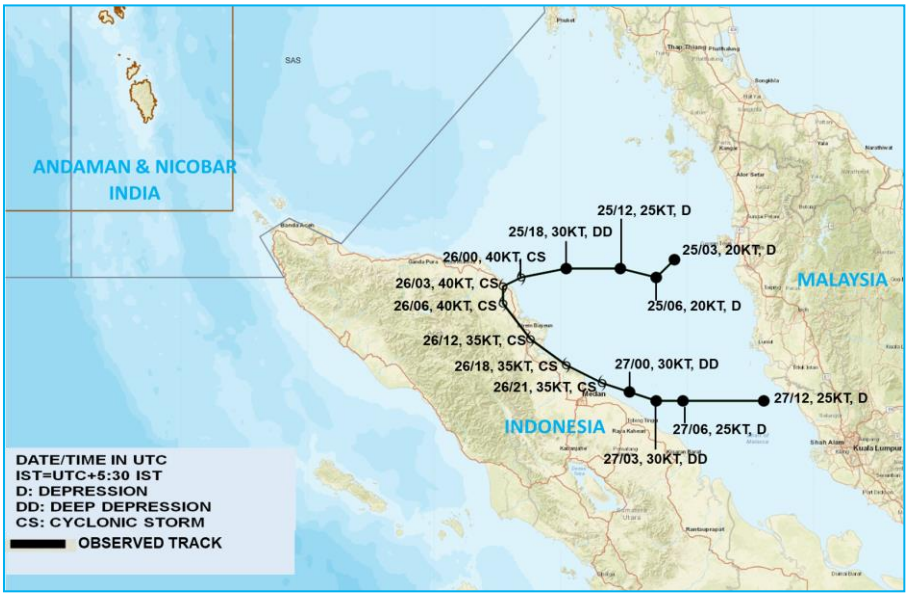


Fig.2.15.1: Observed track of cyclonic storm "Senyar" over Strait of Malacca during 25th to 27th November, 2025

2.15.2 Salient Features

- It was a unique system, as cyclogenesis in lower latitudes is very rare and development of a cyclonic storm in Malacca strait is also quite rare. It was the first cyclone in that region as per IMD's recorded history since 1891.
- **Recurving track:** Senyar had a recurving track. Initially, it moved west-southwestwards till 26th early morning (0530 hrs IST/ 0000 UTC). Thereafter, it gradually recurved & moved southeastwards till 27th early hours (0230 hrs IST/ 2100 UTC of 26th) and then eastwards from 27th early morning (0530 hrs IST/ 0000 UTC) till midnight (2330 hrs IST/ 1800 UTC) (**Fig.2.15.1**).
- **Translational Speed:** Senyar exhibited six hourly average translational speed of 10.5 kmph against normal of 15.5 kmph for cyclonic storms over the BoB in the post monsoon season during 1990-2013 (**Fig.2.15.2a**). Thus, it was a slow moving cyclone, leading to extremely heavy rainfall activity over Indonesia.
- **Life period:** The life period of the storm (depression to depression) was about 2 days and 15 hours against the long period average (LPA) (1990-2013) of about 3 days and 14 hours for CS category over the BoB during post-monsoon season.
- **Maximum sustained wind speed and estimated central pressure:** The system did not exhibit any rapid intensification/weakening during its life cycle. The system reached its peak intensity of 40 knots at 0000 UTC of 26th November and maintained it till 0600 UTC of 26th November. The estimated central pressure during this period was 999 hPa. The six hourly maximum sustained wind speed and estimated central pressure during the life cycle of Senyar are presented in **Fig.2.15.2(b).**
- **Damage Potential and Power Dissipation Index**: The Accumulated Cyclone Energy (a measure of damage potential) and Power Dissipation Index (a measure of loss) in association with Senyar were 0.57 X 10^4 knots^2 and 0.21 X10^6 knots^3 respectively against the normal of 1.0 X 10^4 knots^2 and 0.40 X10^6 knots^3 for CS during post monsoon season over the BoB based on the data during 1990-2020. It indicates wind impact was less.

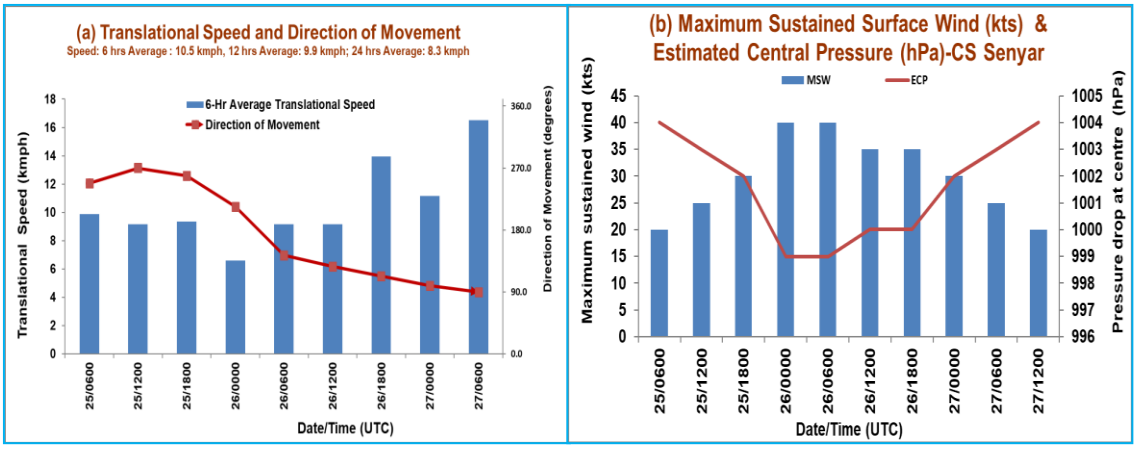


Fig.2.15.2: (a) Six hourly average translational speed & direction of movement and **(b)** maximum sustained surface wind speed & estimated central pressure during CS Senyar over Strait of Malacca.

2.15.3 Genesis, intensification and movement

On 22nd, the Madden–Julian Oscillation (MJO) index is lay in phase 6 with amplitude more than 1. The sea surface temperature (SST) was around 28°C over South Andaman Sea and adjoining areas of the Malacca Strait & southeast Bay of Bengal (BoB). It was higher, around 30°C, over the central BoB and along & off the Odisha and Andhra Pradesh coasts. Ocean thermal energy was 150–175 kJ/cm² over the South Andaman Sea and 100–120 kJ/cm² over the southeast BoB. However, it was less than 50 kJ/cm² over the westcentral BoB and along & off the Odisha and Andhra Pradesh coasts. The guidance from NCICS model indicated westerly wind anomaly (5–7 m/s) along with prevalence of MJO, Equatorial Rossby Wave (ERW), low-frequency background wave (LW) over south BoB and easterly wind anomaly (3–5 m/s) over the central parts of the BoB during 22nd-24th November. These features indicated a favorable environment for cyclogenesis (development of a depression) over the southeast BoB around 24th November. During 25th–26th November, the model is indicating prevalence of westerly wind anomaly (5–7 m/s) along with MJO, ERW and LW over the south BoB and prevalence of easterly wind anomaly (1–3 m/s) over the northern parts of the BoB. Thus, during 25th–26th November, the equatorial waves may support further intensification of the system over the southwest & westcentral BoB. The model is also indicating weakening of easterlies during 30th November to 2nd December over the northern parts of the BoB, which may lead to weakening of the system as it recurves north-northeastwards and reaches the central & adjoining north BoB. The low-level relative vorticity at 850 hPa was about (90–100) × 10^{-6} s^{-1} over the Malacca Strait, and another positive vorticity zone (50–60 × 10^{-6} s^{-1}) was seen over the South Andaman Sea. Vertically, the positive vorticity zone over the Malacca Strait was extending up to 500 hPa. Upper-level divergence was around 20 × 10^{-6} s^{-1} over the Malacca Strait and another zone of 20 × 10^{-6} s^{-1} over the South Andaman Sea. Low-level convergence was around 20 × 10^{-6} s^{-1} over the Malacca Strait and another zone of 15 × 10^{-6} s^{-1} over the South Andaman Sea. Mid-level vertical wind shear (VWS) of horizontal wind was low (5–10 kt) and cyclonic over the entire south Bay & South Andaman Sea. The upper-tropospheric ridge lay along 10°N over the BoB. The system was lying to the south of the ridge. The system was steered nearly westwards under the influence of east-southeasterly winds prevailing to the south of the ridge. Under these features, a low pressure area formed over the Strait of Malacca and adjoining South Andaman Sea at 0300 UTC of 22nd Nov.

At 0300 UTC of 23rd November, the MJO continued in phase 6 with amplitude more than 1. Similar sea conditions prevailed. Equatorial waves continued to provide favourble environment for enhancement of convective activity over the Malacca Strait. The low-level relative vorticity at 850 hPa was the same and about 90–100 × 10^{-6} s^{-1} over Malacca Strait. Vertically, the positive vorticity zone over Malacca Strait was extending up to 500 hPa. Upper-level divergence increased and was around 30×10^{-6} s^{-1} over Malacca Strait and adjoining south Andaman Sea. Low-level convergence was the same (around 20 × 10^{-6} s^{-1}) over Malacca Strait. Mid-level vertical wind shear (VWS) of horizontal wind was low (5–10 kt) and cyclonic over entire south Bay & south Andaman Sea. Upper-tropospheric ridge lay along 10°N over the BoB. The system was lying to the south of the ridge. East-southeasterly winds prevailing to the south of the ridge were steering the system nearly west-northwestwards.

At 0300 UTC of 24th November, the Madden Julian Oscillation (MJO) continued in phase 6 with amplitude more than 1. Similar sea conditions prevailed. Westerly wind anomaly (5–7 m/s) along prevailed alongwith MJO, ERW, LW over south BoB and easterly

wind anomaly (3–5 m/s) to its north over south & adjoining central parts of BoB during 24th–28th November. These features indicated a favorable environment for cyclogenesis (development of depression) over south BoB and South Andaman Sea during this period. The low-level relative vorticity at 850 hPa was the same and was about 100 × 10^{-6} s^{-1} over the Malacca Strait. Vertically, the positive vorticity zone over Malacca Strait was extending up to 500 hPa. Upper-level divergence was around 20 × 10^{-6} s^{-1} over the Malacca Strait and adjoining South Andaman Sea. Low-level convergence was the same (around 20 × 10^{-6} s^{-1}) over Malacca Strait. Mid-level vertical wind shear (VWS) of horizontal wind was low (5–10 kt) and cyclonic along ITCZ over the entire south Bay & South Andaman Sea. Upper-tropospheric ridge ran along 12°N across the BoB. The system was lying to the south of the ridge. East-southeasterly winds prevailing to the south of the ridge were likely to steer the system nearly west-northwestwards. Under these features, the system lay as a well marked low pressure area over Strait of Malacca on 24th November.

At 0300 UTC of 25th November, similar conditions wrt MJO, SST and equatorial waves continued. The low-level relative vorticity at 850 hPa increased and was the same about 100 × 10^{-6} s^{-1} over Malacca Strait. Vertically, the positive vorticity zone over Malacca Strait was extending up to 500 hPa. Upper-level divergence was around 20×10^{-6} s^{-1} over Malacca Strait and adjoining South Andaman Sea. Low-level convergence was around 30 × 10^{-6} s^{-1} over Malacca Strait and adjoining South Andaman Sea. Mid-level vertical wind shear (VWS) of horizontal wind was around 10–15 kt over the entire south Bay & South Andaman Sea. Upper-tropospheric ridge lay along 12°N across the BoB. Under these favourble features the well marked low pressure area intensified into a Depression over Strait of Malacca at 0300 UTC of 25th November. Similar features prevailed and the system intensified into a deep depression at 1800 UTC of 25th November.

At 0000 UTC of 26th November, similar conditions wrt MJO, SST and equatorial waves continued. The low-level relative vorticity at 850 hPa was the same about 100 × 10^{-6} s^{-1} over the Malacca Strait. Vertically, the positive vorticity zone over the Malacca Strait was extending up to 500 hPa. Upper-level divergence was the same around 20 × 10^{-6} s^{-1} over the Malacca Strait and adjoining south Andaman Sea. Low-level convergence was around 20–30 × 10^{-6} s^{-1} over the Malacca Strait and adjoining south Andaman Sea. Mid-level vertical wind shear (VWS) of horizontal wind was around 10–15 kt over the entire south Bay and south Andaman Sea. The upper-tropospheric ridge lay along 12°N across the BoB. The system was lying to the south of the ridge. East-southeasterly winds prevailing to the south of the ridge were steerin the system nearly west-northwestwards. Under these conditions, the system lay as a cyclonic storm over Strait of Malacca and adjoining Indonesia.

At 1200 UTC of 26th November, similar conditions wrt MJO, SST and equatorial waves prevailed. The low level relative vorticity at 850 hPa was about 100 × 10^{-6} s^{-1} over Indonesia and vertically extending up to 500 hPa. Upper-level divergence was around 20 × 10^{-6} s^{-1} over Indonesia & adjoining EIO, Malacca Strait and south Andaman Sea. Low-level convergence was around 30–40 × 10^{-6} s^{-1} over Indonesia & adjoining Malacca Strait and south Andaman Sea. Mid-level vertical wind shear (VWS) of horizontal wind was around 10–15 kt over Malacca Strait, low (05–10 kt) over south Bay & north Andaman Sea. Upper tropospheric ridge lay along 12°N across the BoB. Under these conditions, the system maintained its intensity of cyclonic storm.

At 0000 UTC of 27th November, the low level relative vorticity at 850 hPa decreased and was about (70–80) × 10^{-6} s^{-1} over Malacca Strait & adjoining areas and vertically extended up to 500 hPa. Upper-level divergence was around 30 × 10^{-6} s^{-1} over Indonesia &

adjoining EIO, Malacca Strait and south Andaman Sea. Low-level convergence was around 30–40 × 10^{-6} s^{-1} over Indonesia & adjoining Malacca Strait and south Andaman Sea. Mid-level vertical wind shear (VWS) of horizontal wind was around 10–15 kt over Malacca Strait. Upper tropospheric ridge runs along 12°N across the BoB. Under these conditions, the system weakened into a deep depression at 0000 UTC of 27th and into a depression at 0600 UTC of 27th November.

Thereafter, unfavourable conditions continued. At 1800 UTC of 27th November, the low level relative vorticity at 850 hPa decreased and was about 40–50 × 10^{-6} s^{-1} over Malacca Strait and adjoining areas and vertically extending up to 500 hPa. Upper-level divergence also decreased and was around 20 × 10^{-6} s^{-1} over Indonesia & adjoining Equatorial Indian Ocean and Malacca Strait. Low-level convergence was around 20 × 10^{-6} s^{-1} over Indonesia & adjoining Malacca Strait and south Andaman Sea. Mid-level vertical wind shear (VWS) of horizontal wind was high (25–30 kt) over Malacca Strait. Upper tropospheric ridge runs along 13°N across the BoB. Under these features, the system weakened into a well marked low pressure area over Malacca Strait and adjoining Malaysia.

2.15.4 Monitoring of CS, "Senyar"

The India Meteorological Department (IMD) maintained round the clock watch and the system was monitored wrt genesis, track, intensity and landfall since 13th November. The cyclone was monitored with the help of available satellite observations from INSAT 3DR, SCAT SAT (OCEAN SAT 3), ASCAT, microwave imageries, available ships, buoys & coastal observations in the region. Various global models and dynamical-statistical models run by Ministry of Earth Sciences (MoES) institutions including IMD, NCMRWF, IITM & INCOIS and guidance from models from various international agencies under bilateral arrangement were utilized to predict the genesis, track and intensity of the cyclone as well as associated severe weather. The forecasts were mainly based on multi-model ensemble technique developed by IMD which were further modulated by analysis of observations and forecasters intervention at IMD through their knowledge, experience and expertise. An indigenously developed digitized forecasting system of IMD (Decision Support System) was utilized for analysis and comparison of various observations and numerical weather prediction models guidance, decision making process and warning products generation. Typical satellite products utilised for monitoring the system are presented in **Fig.2.15.3**

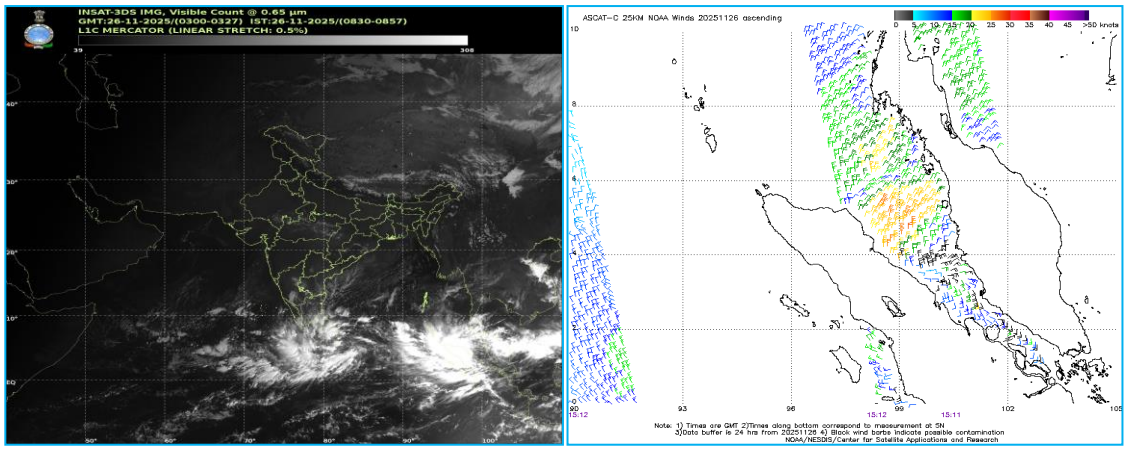


Fig.2.15.3: INSAT 3DS image of 0830hrs IST (0300 UTC) of 26th November of (b) ASCAT image at 2030hrs IST (1500 UTC) of 26th Nov, 2025 of cyclonic storm "Senyar" over Strait of Malacca.

Typical INSAT 3DS Visible, IR, Brightness temperature and enhanced coloured images utilised for monitoring the system are presented in **Fig.2.15.4**. The satellite imagery during the stage of cyclone suggested organisation of clouds in curved band pattern during intensification phase (25th to 27th November) and shear pattern during weakening phase (1st-2nd September).

As per INSAT 3DS imagery at 0300 UTC of 22nd November, scattered low and medium clouds with embedded intense to very intense convection lay over south Bay of Bengal and south Andaman Sea. The cloud mass gradually organized and at 0300 UTC of 23rd November, the vortex lay over the Strait of Malacca and adjoining South Andaman Sea & neighbourhood within half a degree of 5.5°N/99.3°E. Intensity of the system was T1.0. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over the South Andaman Sea, Strait of Malacca & neighbourhood (minimum cloud top temperature (CTT) was –70 to –90°C**).**

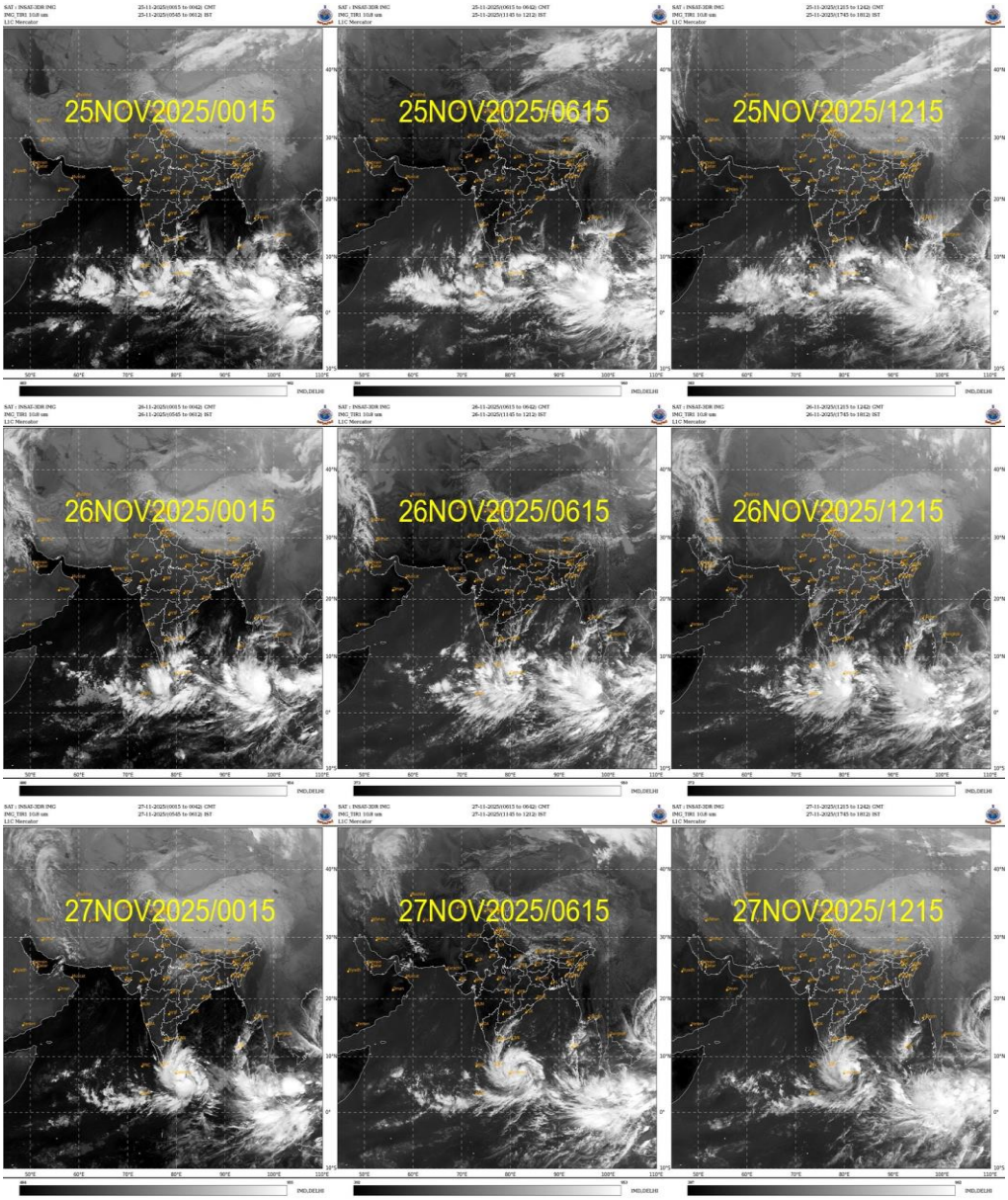


Fig.2.15.4(a): INSAT-3D IR imageries during life cycle of CS SENYAR over Strait of Malacca 25th – 27th November 2025

As per INSAT-3DS imagery at 0300 UTC of 24th November, the convection persisted over the Strait of Malacca and adjoining South Andaman Sea & neighbourhood and was centered within half a degree of 5.0°N/100.0°E. Intensity was T1.0. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over the South Andaman Sea, Strait of Malacca & neighbourhood (minimum CTT was –70 to –90°C).

At 0300 UTC of 25th November, the vortex over the Strait of Malacca & neighbourhood was centered within half a degree of 5.0°N/99.8°E. Intensity was T1.5. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over the South Andaman Sea, north Sumatra, Strait of Malacca adjoining Malaysia & neighbourhood (minimum CTT was –70 to –90°C).

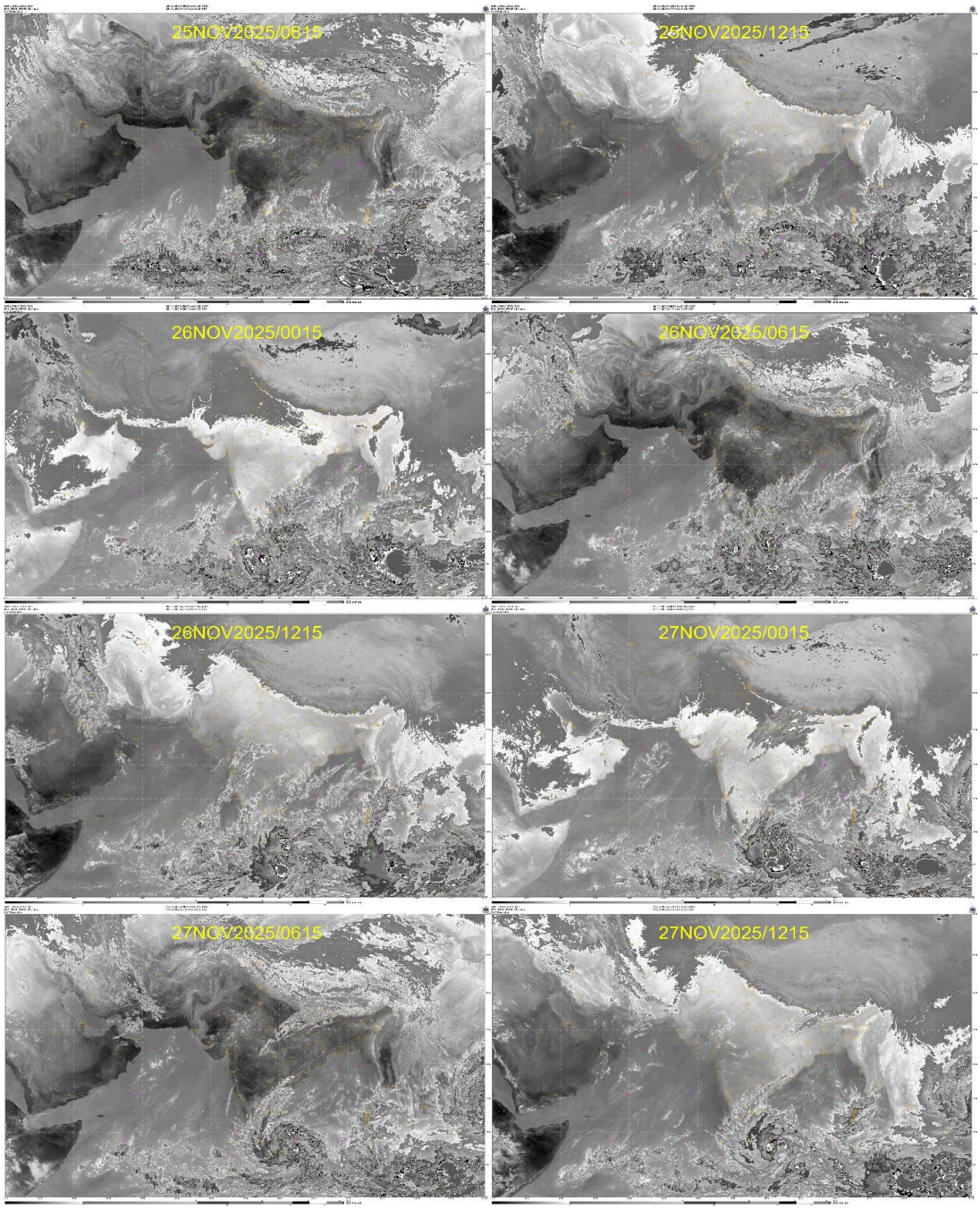


Fig.2.15. 4(b): INSAT-3D BD imageries during life cycle of CS SENYAR over Strait of Malacca 25th – 27th November 2025

At 1200 UTC of 25th November, the convective cloud mass indicated further organization. The intensity of the system was T1.5 with scattered to broken low and medium clouds with embedded intense to very intense convection lay over south Andaman Sea, north Sumatra, Strait of Malacca adjoining Malaysia & neighbourhood (minimum CTT was −70 to −90°C).
At 1800 UTC of 25th November, the intensity of the system was T2.0 with scattered to broken low and medium clouds with embedded intense to very intense convection lay over south Andaman Sea, north Sumatra, Strait of Malacca adjoining Malaysia & neighbourhood (minimum CTT was –70 to –90°C).
Sumatra, Strait of Malacca & Malay Peninsula and minimum CTT was −70 to −90 °C).
At 0000 UTC of 26th November, 2025, the intensity of the system was T2.5 with scattered to broken low and medium clouds with embedded intense to very intense convection lay over southeast Bay of Bengal, south Andaman Sea, north Sumatra, Strait of Malacca adjoining Malaysia & neighbourhood (minimum CTT was –70 to –90°C).

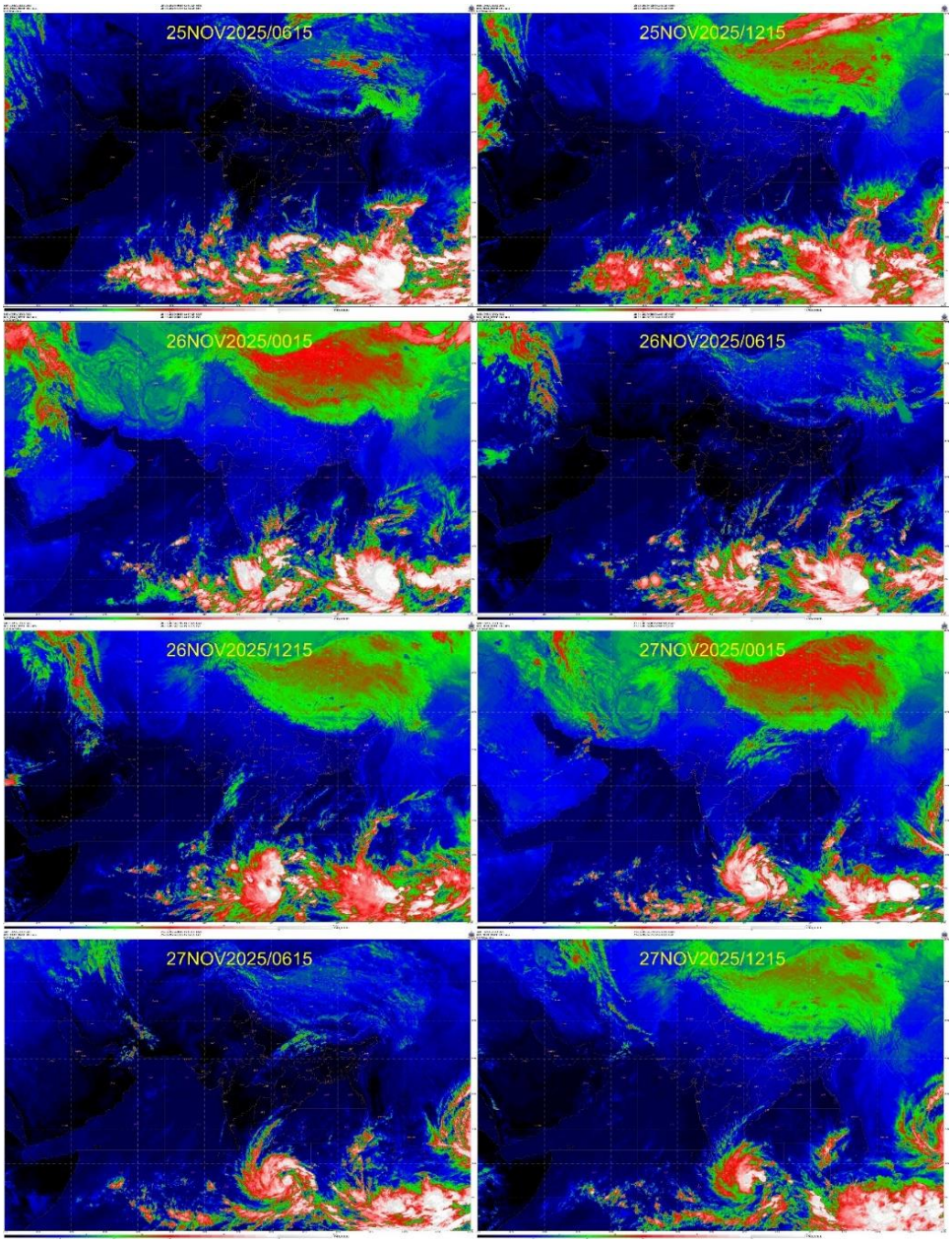


Fig.2.15. 4(c): INSAT-3D NHC imageries during life cycle of CS SENYAR over Strait of Malacca 25th – 27th November 2025

At 1200 UTC of 26th November, the system was over land. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over South Andaman Sea, north Sumatra, Strait of Malacca (minimum CTT was −70 to −90°C).
At 0000 UTC of 27th November, scattered to broken low and medium clouds with embedded intense to very intense convection lay over South Andaman Sea, Southeast Bay of Bengal & adjoining Equatorial Indian Ocean, north Sumatra, Strait of Malacca (minimum CTT was −70 to −90 °C).
At 0600 UTC of 27th November, the system emerged into the Strait of Malacca. The intensity was T2.0 with scattered to broken low and medium clouds with embedded intense to very intense convection lay over South Andaman Sea and adjoining Southeast Bay of Bengal & adjoining Equatorial Indian Ocean, north Sumatra, Strait of Malacca and minimum CTT was –70 to –90°C**.**

At 1800 UTC of 27th November, the system weakened into a well-marked low pressure area over the land of Malaysia adjoining Strait of Malacca was centered near 3.7°N / 101.2°E with scattered to broken low and medium clouds with embedded intense to very intense convection lay over

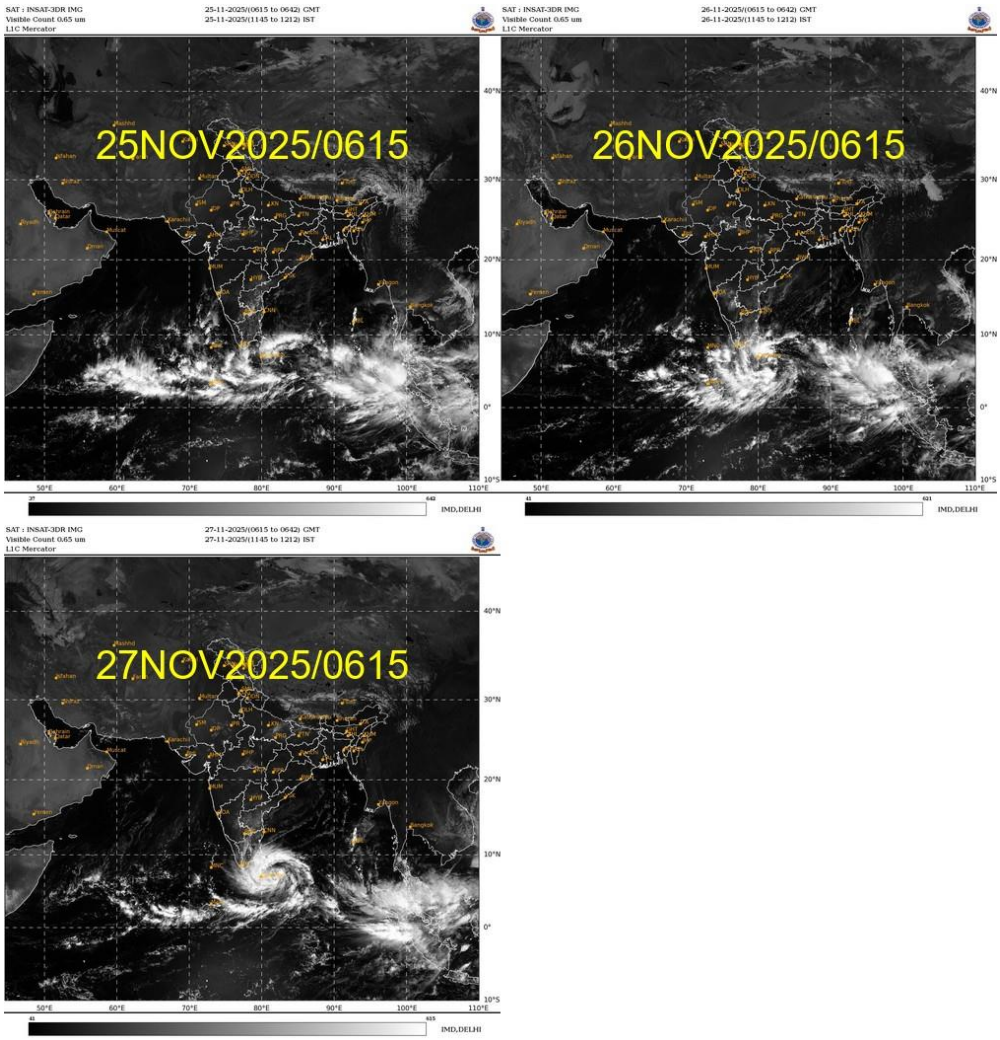


Fig.2.15.4(d): INSAT-3D visible imageries during life cycle of CS SENYAR over Strait of Malacca 25th – 27th November 2025

2.15.5 Dynamical features

IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels during 25th November- 27th November, 2025 are presented in **Fig.2.15.5.1 – Fig.2.15.5.4.**

At 0600 UTC of 25th November, the model indicated an upper air cyclonic circulation over North Indonesia with vertical extension upto 500hPa. The upper tropospheric ridge lay near 15.0^{0}N. However, on 25th, the system lay as depression over Strait of Malacca near (5.4N/99.7E). The model was not capturing the intensity and location correctly.

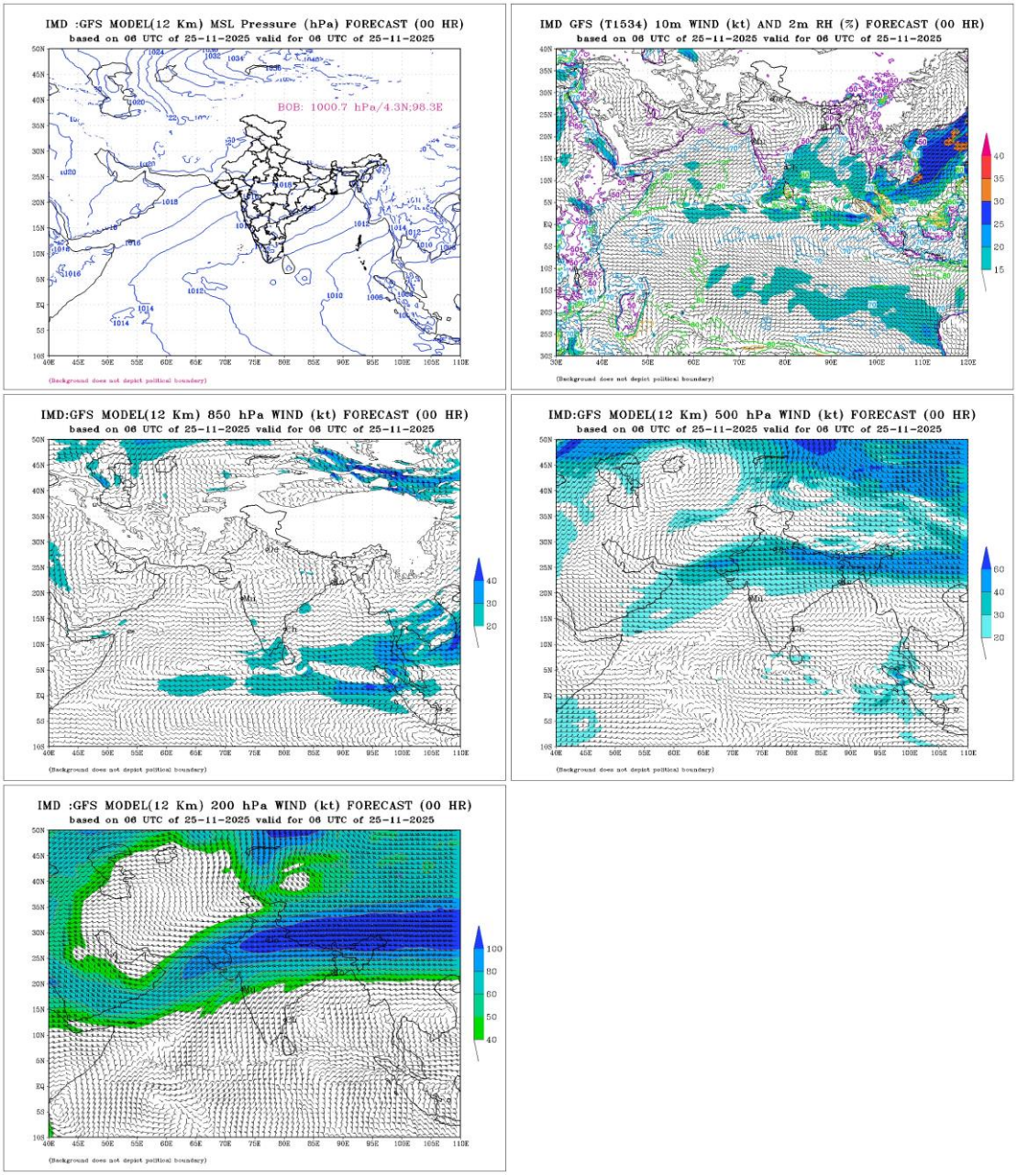


Fig.2.15.5.1: IMD GFS mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 25th November, 2025

At 0000 UTC of 26th November, the model indicated an upper air cyclonic circulation at 850hPa near (3.9N/98.0E) over North Indonesia with vertical extension upto 500hPa. However, on 26th, the system lay as cyclonic storm over Strait of Malacca near (5.0N/98.0E). The model was not capturing the intensity and location correctly.

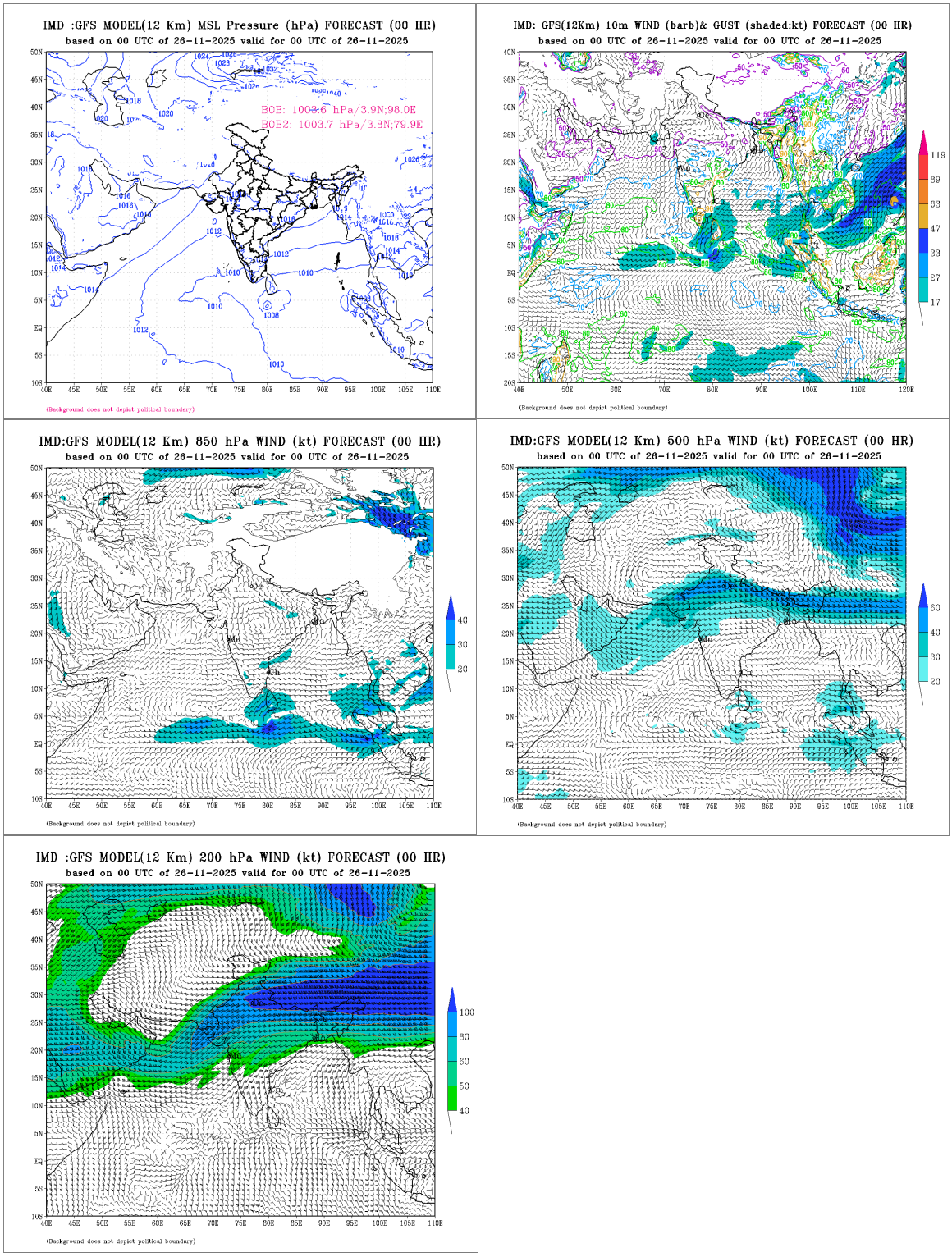


Fig.2.15.5.2: IMD GFS mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 26th November, 2025

At 0000 UTC of 27th November, the model still indicated an upper air cyclonic circulation over Malacca Strait near (4.4N/98.7E) with vertical extension upto 500hPa. However, the system crossed Indonesia around 03 UTC of 26th and gradually recurved east-southeastwards while moving across costal Indonesia and lay as a deep depression over Strait of Malacca at 0000 UTC of 27th near (3.7N/99.2E). The model was not capturing the intensity and location correctly.

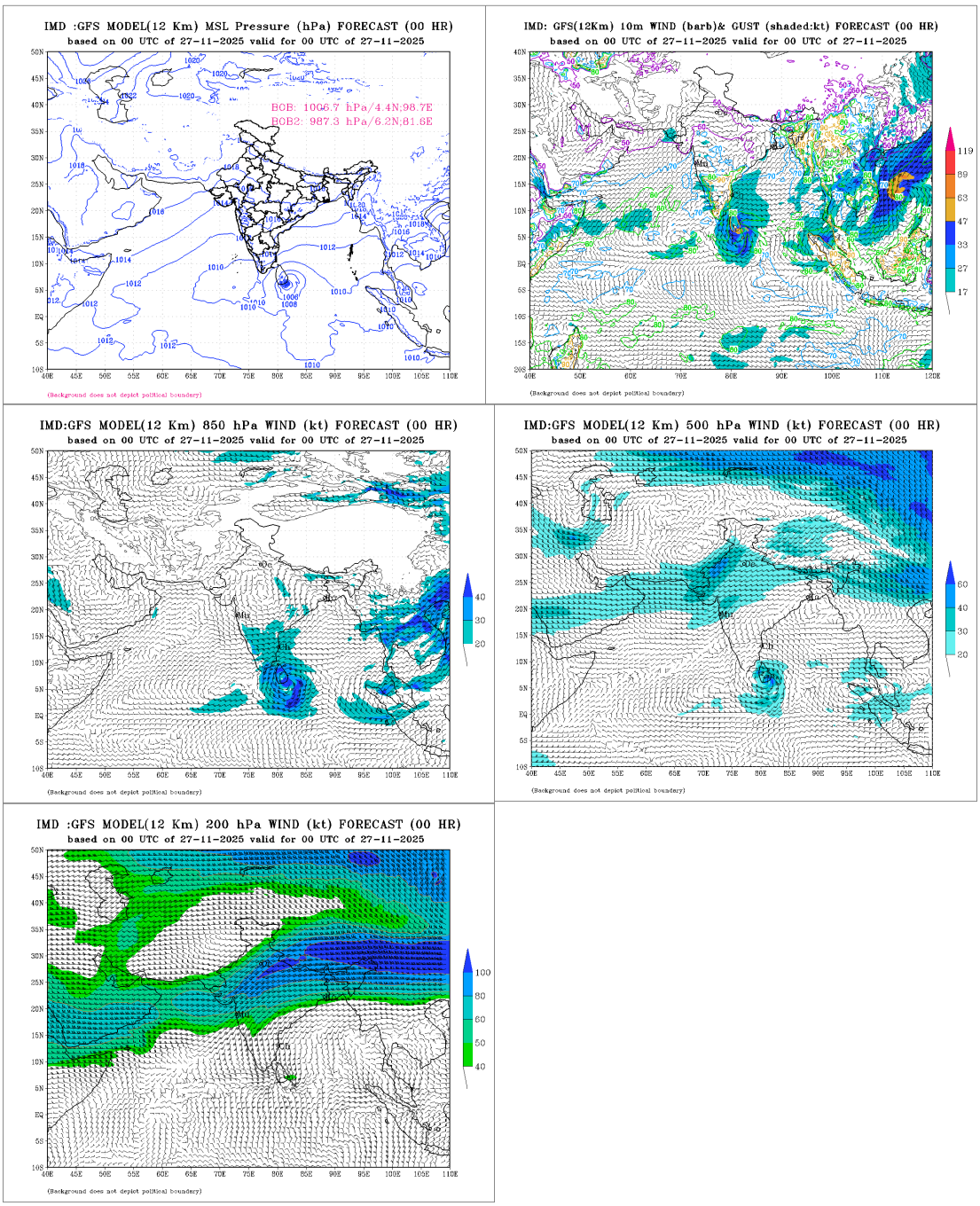


Fig.2.15.5.3: IMD GFS mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 27th November, 2025

At 0000 UTC of 28th November, the model indicated an upper air cyclonic circulation over South China Sea off southeast Malaysia at 850hPa near (4.0N/104.9E) with vertical extension upto 500hPa. However on 26th, the system crossed Indonesia around 03 UTC of 26th and gradually recurved east-southeastwards while moving across costal Indonesia and lay as a deep depression over Strait of Malacca at 0000 UTC of 27th near (3.7N/99.2E). The model was not capturing the intensity and location correctly.

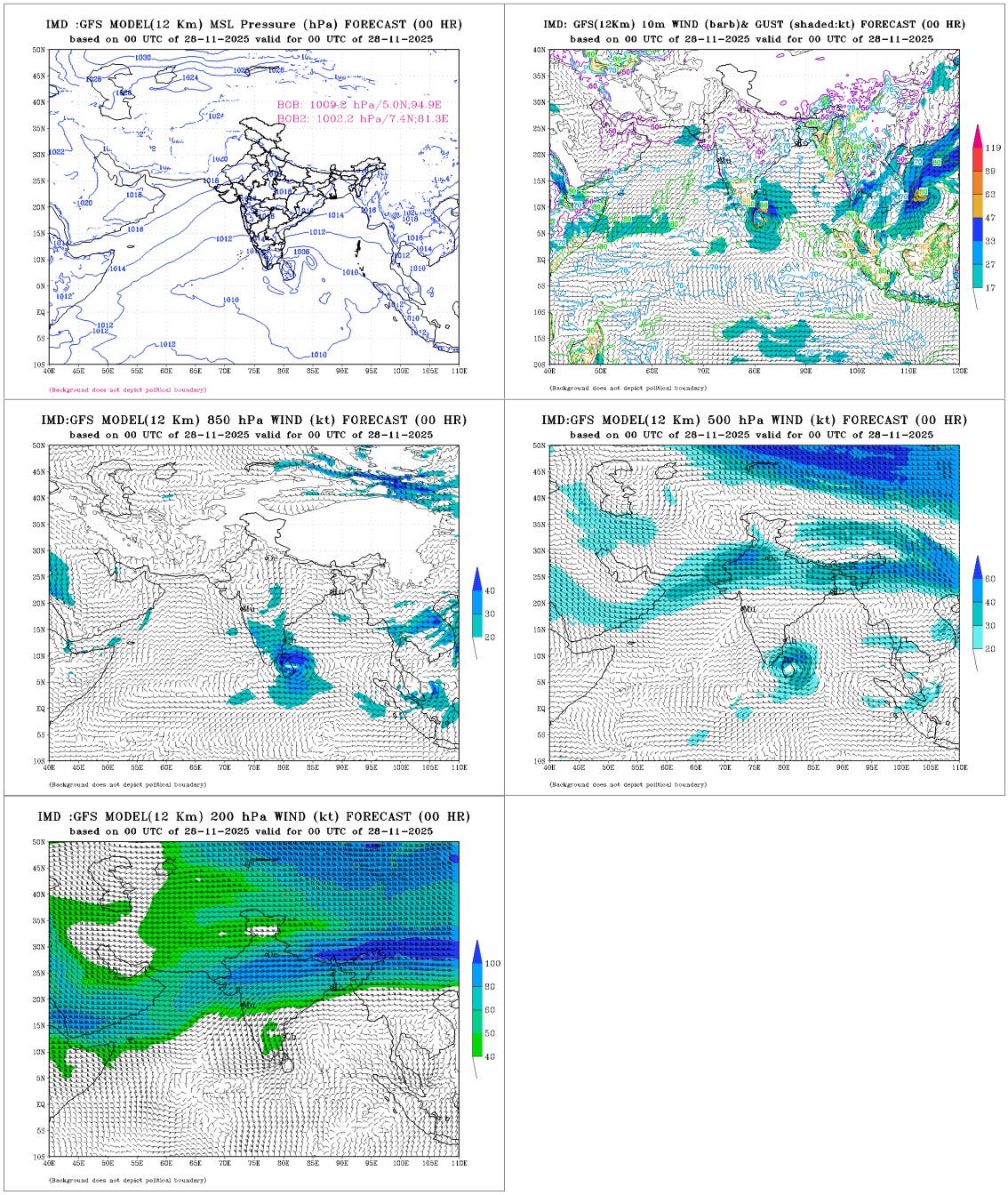


Fig.2.15.5.4: IMD GFS mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 28th November, 2025

Overall the model could not capture the genesis, location, movement and intensity of the system correctly.

2.15.6 Realized Weather

2.15.6.1 Realized rainfall

As per media reports, Cyclone Senyar influenced weather conditions across parts of Southeast Asia during the period 25 to 27 November, leading to episodes of heavy rainfall in several countries, particularly Indonesia, with indirect impacts observed in Thailand and Malaysia. Vietnam experienced rainfall during this period; however, available reports indicate that these were largely associated with other weather systems rather than Cyclone Senyar.

In Indonesia, the impacts of Cyclone Senyar were most pronounced. According to reports from the Indonesian Meteorological Agency (BMKG) and the National Disaster Management Authority (BNPB), West Sumatra recorded approximately 261 mm of rainfall on 25 November. The rainfall intensified on 26 November, with Aceh province receiving about 411 mm, indicating extreme precipitation conditions. On 27 November, North Sumatra recorded rainfall totals of approximately 390 mm. These high rainfall amounts led to flooding and landslides in several regions, making Indonesia the worst-affected country during this event.

In Thailand, weather advisories issued by the Thai Meteorological Department (TMD) and reported by national news outlets indicated heavy to very heavy rainfall across southern and central provinces during the same period. While the influence of Cyclone Senyar was noted in enhancing moisture and instability, no specific station-wise rainfall totals were published in news reports for the dates 25–27 November. Nevertheless, persistent rainfall contributed to localize flooding in low-lying areas.

Similarly, Malaysia experienced widespread rainfall during the period due to the broader circulation and moisture associated with Cyclone Senyar. Regional assessments and GDACS model estimates suggested rainfall exceeding 100 mm in several parts of Peninsular Malaysia, although exact observed station data were not reported in news sources. Media reports highlighted flood risks and ongoing heavy rain across multiple states.

In contrast, Vietnam did not record rainfall directly attributable to Cyclone Senyar. Reports from the World Meteorological Organization (WMO) indicate that rainfall occurring over Vietnam during late November was primarily linked to monsoon activity and other synoptic systems, rather than the cyclone itself. As a result, no Senyar-specific realised rainfall amounts were documented for Vietnam during this period.

Overall, Cyclone Senyar significantly influenced rainfall patterns across the region, with Indonesia experiencing extreme realised rainfall, while Thailand and Malaysia saw heavy but less well-quantified impacts. The event highlights the importance of both observational data and regional meteorological assessments in understanding cyclone-related rainfall and its associated hazards.

<u>Realised Rainfall during Cyclone Senyar (25–27 November 2025)</u>

Table 2. Day wise daily 24 hours cumulative rainfall forecast verification with station observations of the Severe Cyclonic Storm "SENYAR".

H: Heavy (7-11 cm), VH: Very Heavy (12-20 cm), EH: Extremely Heavy (>20 cm)

Date	Country	Location	Realised Rainfall (mm)	News / Official Source
25 Nov 2025	Indonesia	West Sumatra	≈261 mm	BMKG (Indonesian Meteorological Agency)
25 Nov 2025	Thailand	Southern	Heavy rainfall	Nation Thailand /

		Provinces		TMD
25 Nov 2025	Malaysia	Peninsular Malaysia	Heavy rainfall	GDACS / The Star
26 Nov 2025	Indonesia	Aceh	≈411 mm	BMKG / BNPB
26 Nov 2025	Thailand	Southern & Central Thailand	Continued heavy rainfall	Nation Thailand
26 Nov 2025	Malaysia	Multiple states	Widespread rainfall	GDACS
27 Nov 2025	Indonesia	North Sumatra	≈390 mm	BMKG / BNPB
27 Nov 2025	Thailand	Southern Thailand	Rainfall continued	Thai Meteorological Department
27 Nov 2025	Malaysia	Peninsular Malaysia	>100 mm	GDACS

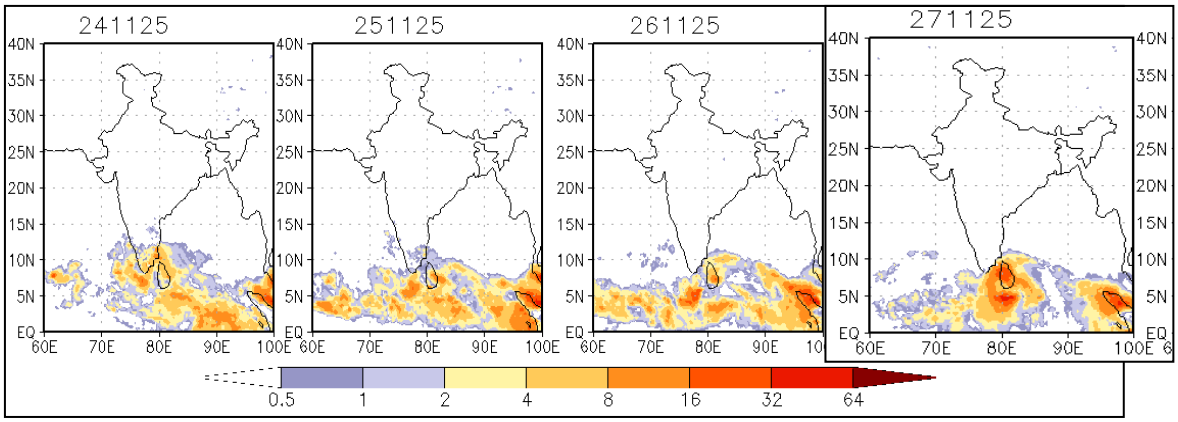


Fig.2.15. 6: NCMRWF-IMD satellite gauge merged data plots of 24 hours accumulated realized rainfall ending at 0830 IST of 24th November to 27th November, 2025

H: Heavy rainfall, VH: Very heavy rainfall, EH: Extremely heavy rainfall

2.15.6.2 <u>Maximum sustained wind speed (MSW)</u>

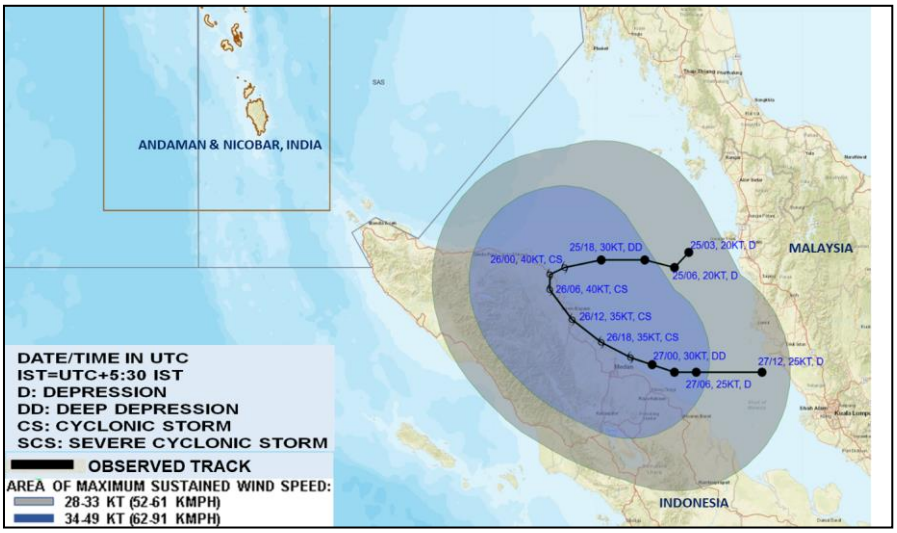


Fig.2.15. 7: Estimated maximum sustained wind during the life cycle of CS SENYAR

The system reached its peak intensity of maximum sustained wind speed of 40 knots gusting to 50 knots (70-80 kmph gusting to 90 kmph) at 0000 UTC (0530 IST) 26st November estimated central pressure (ECP) of 999 hPa and pressure drop of about 8 hPa over Indonesia coast Sea **(Fig.2.15. 7).**

2.15.7 Damage due to CS SENYAR

As per media reports, since mid-November, overlapping tropical storms and intensified monsoon systems have triggered catastrophic flooding and landslides across Indonesia, Thailand, Malaysia and Vietnam.

In Indonesia, relentless downpours between 22 and 25 November triggered deadly floods and landslides across Aceh, West Sumatra and North Sumatra, devastating dozens of districts.Official figures indicate more than 830 deaths, with at least 500 people still missing, and more than 880,000 displaced. In total, over three million people have been affected by floodwaters, collapsed hillsides and destroyed infrastructure. Entire villages have been submerged, bridges washed away and roads cut off, isolating communities and slowing rescue efforts. Emergency teams are relying on helicopters and boats to deliver aid to areas unreachable by land.

Source: https://news.un.org/en/story/2025/12/1166516

Fig.2.15. 8: (a) Bridges and access roads swept away by a landslide in West Sumatra, Indonesia. (b): A teacher inspects the damage in a kindergarten classroom at a school in Thailand.

2.16 Cyclonic Storm "DITWAH" over the Bay of Bengal (26th November– 03rd December, 2025)

2.16.1 Life History of "DITWAH":

- An upper air cyclonic circulation lay over Comorin area and neighbourhood in the forenoon (0830 hours IST/ 0300 UTC) of 23rd November, 2025.
- Under its influence, a low pressure area formed over Comorin and adjoining Southwest Bay of Bengal (BoB) & Sri Lanka in the early morning (0530 hrs IST/ 0000 UTC) of 25th November, 2025.
- It lay as well marked low pressure area over southwest Bay of Bengal and adjoining areas of Southeast Sri Lanka & Equatorial Indian Ocean in the early morning (0530 hrs IST/0000 UTC) of 26th November, 2025.
- It concentrated into a depression over southwest BoB and adjoining Sri Lanka in the midnight (2330 hrs. IST/ 1800 UTC) of 26th November, 2025.
- It moved north-northwestwards and intensified into a deep depression over the same region in the early morning (0530 hours IST/ 0000 UTC) and into the cyclonic storm "DITWAH" over the same region in the noon (1130 hours IST/ 0600 UTC) of 27th November.
- Continuing to move to north-northwestwards, it crossed Sri Lanka coast around noon (between 1130 to 1230 hrs. IST/0600 UTC to 0700 UTC) of 27th November as a Cyclonic Storm with the wind speed of 60 to 70 gusting to 80 kmph.
- Thereafter, it continued to move slowly north-northwestwards across coastal Sri Lanka & southwest BoB maintaining the intensity of 60 to 70 gusting to 80 kmph till night of 27th November (2030 hrs. IST/ 1500 UTC) and increase marginally becoming 65-75 gusting to 85 kmph during 27th midnight (2330 hrs. IST/ 1800UTC) to early morning of 29th November (0530 hrs. IST/0000 UTC).
- Thereafter, it emerged into southwest BoB and adjoining North Sri Lanka coasts in the early morning (0530 hrs. IST/0000 UTC) of 29th November. Thereafter, it moved nearly northwards and intensified slightly by reaching the maximum sustained wind speed of 70-80 gusting to 90 kmph during 0830 hrs. IST of 29th to 0530 hrs. IST of 30th November and lay centered about 50 km east of Chennai.
- Continuing to moving further northwards over southwest BoB and adjoining Tamil Nadu-Puducherry coast, it lay about 70km east of north Tamil Nadu- Puducherry coast at 0830 hrs. IST of 30th November and about 30km east of Chennai coast at 1130 hrs. IST of 01st December. While moving northwards, it weakened into a deep depression in the evening (1730 hours IST/ 1200 UTC) of 30th November.
- Thereafter, it remains practically stationary till midnight (2330 hrs. IST/1800 UTC) of 01st December.
- Then it gradually recurved south-southwestwards & weakened into a depression in the early morning (0530 hrs. IST/ 0000 UTC) of 2nd December with its center about 25 km away from North Tamil Nadu coast and into a well-marked low pressure area over North Tamil Nadu-Puducherry coasts and neighbourhood in the early morning (0530 hrs

IST/0000 UTC) of 3rd December. The observed track of the system is presented in **Fig.2.16.1.** The best track parameters are presented in **Table 2.16.1**.

Table 2.16.1: Best track positions and other parameters of the Cyclonic Storm "Ditwah" over Southwest Bay of Bengal and adjoining areas of southeast Sri Lanka & Equatorial Indian Ocean during 26th November – 02nd December, 2025

Date	Time (UTC)	Lat. (0N)	Long. (0E)	C.I. No.	ECP (hPa)	ΔP (hPa)	MSW (kt)	Category
26.11.25	1800	5.9	82.6	1.5	1004	4	25	D
27.11.25	0000	6.3	82.4	2.0	1003	5	30	DD
	0300	6.7	82.1	2.0	1003	5	30	DD
	0600	6.9	81.9	2.5	1002	6	35	CS
	0900	7.2	81.8	2.5	1002	6	35	CS
	1200	7.6	81.6	2.5	1002	6	35	CS
	1500	7.7	81.5	2.5	1002	6	35	CS
	1800	7.9	81.3	2.5	1002	6	35	CS
	2100	8.1	81.2	2.5	1002	6	35	CS
28.11.25	0000	8.2	81.1	2.5	1002	6	35	CS
	0300	8.3	81.0	2.5	1002	6	35	CS
	0600	8.4	81.0	2.5	1002	6	35	CS
	0900	8.5	81.0	2.5	1002	6	35	CS
	1200	8.7	80.9	2.5	1002	6	35	CS
	1500	8.8	80.8	2.5	1002	6	35	CS
	1800	9.0	80.8	2.5	1002	6	35	CS
	2100	9.2	80.8	2.5	1001	7	35	CS
29.11.25	0000	9.4	80.7	2.5	1001	7	35	CS
	0300	9.6	80.7	2.5	1000	8	40	CS
	0600	9.9	80.7	2.5	1000	8	40	CS

	0900	10.1	80.6	2.5	1000	8	40	CS
	1200	10.4	80.6	2.5	1000	8	40	CS
	1500	10.5	80.6	2.5	1000	8	40	CS
	1800	10.7	80.6	2.5	1000	8	40	CS
	2100	10.8	80.6	2.5	1000	8	40	CS
30.11.25	0000	11.1	80.6	2.5	1000	8	40	CS
	0300	11.4	80.6	2.5	1000	8	40	CS
	0600	11.5	80.6	2.5	1001	7	35	CS
	0900	11.7	80.6	2.5	1002	6	35	CS
	1200	11.8	80.6	2.0	1003	5	30	DD
	1800	12.3	80.6	2.0	1003	5	30	DD
01.12.2025	0000	12.8	80.6	2.0	1003	5	30	DD
	0300	12.8	80.6	2.0	1003	5	30	DD
	0600	13.0	80.6	2.0	1003	5	30	DD
	1200	13.0	80.6	2.0	1003	5	30	DD
	1800	13.0	80.6	2.0	1003	5	30	DD
02.12.2025	0000	12.9	80.5	1.5	1004	4	25	D
	0300	12.8	80.5	1.5	1004	4	25	D
	0600	12.5	80.4	1.5	1004	4	25	D
	1200	12.3	80.3	1.5	1004	4	25	D
	1800	12.1	80.2	1.5	1005	3	20	D
03.12.2025	0000	Weakened into a Well-Marked Low Pressure Area over North Tamil Nadu-Puducherry coasts and neighbourhood						

Kt: Knots (nautical mile per hour), 1 kt=1.85 kmph, D: Depression, DD: Deep Depression, CS: Cyclonic Storm

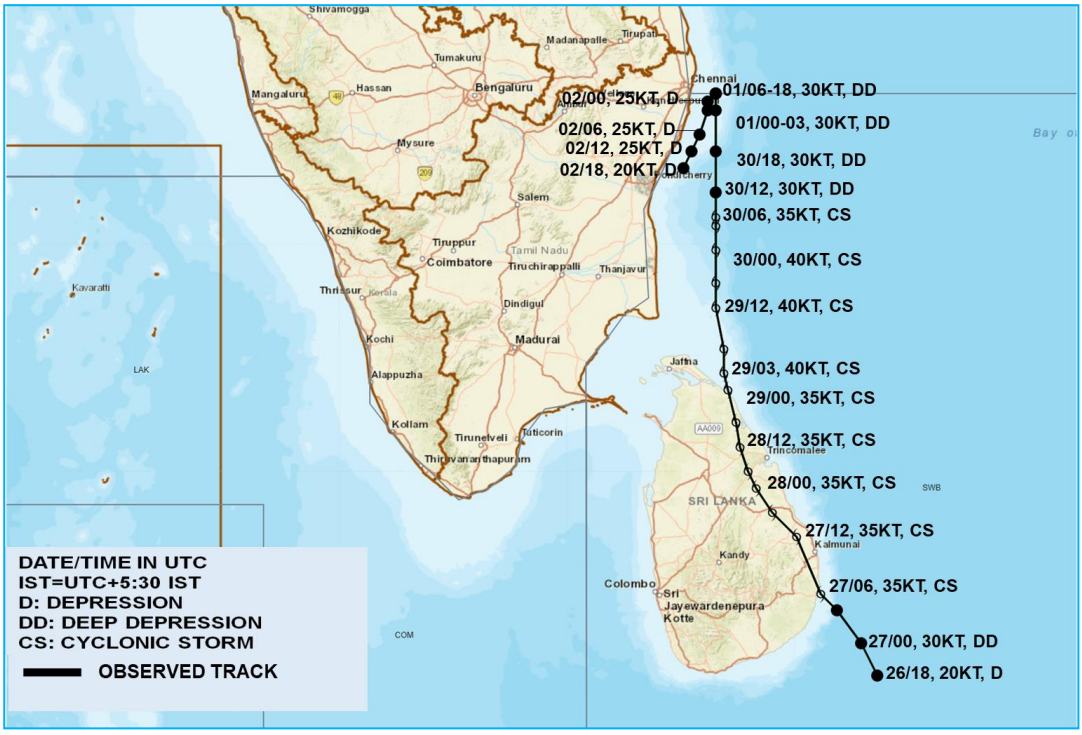


Fig.2.16.1: Observed track of cyclonic storm "DITWAH" over Bay of Bengal during 26th November- 03rd December, 2025

2.16.2 Salient Features

a. There have been 21 cyclonic disturbances (depressions (maximum sustained wind speed (MSW) ≥ 17 kt and cyclones MSW ≥ 34 kt during 1960-2024 that crossed Sri Lanka coast (**Fig.2.16.2a**). Out of these, there was a cyclone in 1967 (4-8 December) which moved from South to North across Sri Lanka. However, the cyclone in 1967 moved from central Sri Lanka to Southwest BoB near Tamil Nadu coast while moving northwards (**Fig.2.16.2b**).

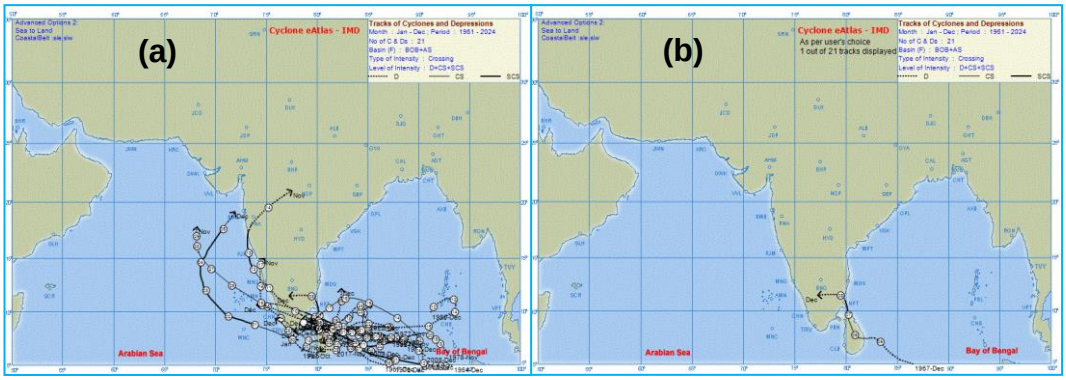


Fig.2.16.2: Tracks of (a) all cyclonic disturbances (MSW ≥ 17 kt) crossing Sri Lanka coast during 1961-2024 and (b) track of 1967 cyclone that moved south to north across Sri Lanka

b. **Frequency of cyclones crossing Sri Lanka:** About 12 cyclones crossed Sri Lanka coast during 1961-2024 including 7 severe cyclonic storms **(Fig.2.16.3)**. Out of 12 cyclones, 7 crossed during post-monsoon season (Oct-Dec) and 5 during remaining

part of the year. It included six, five and one in the months of December, November, October respectively **(Fig.2.16.4)**.

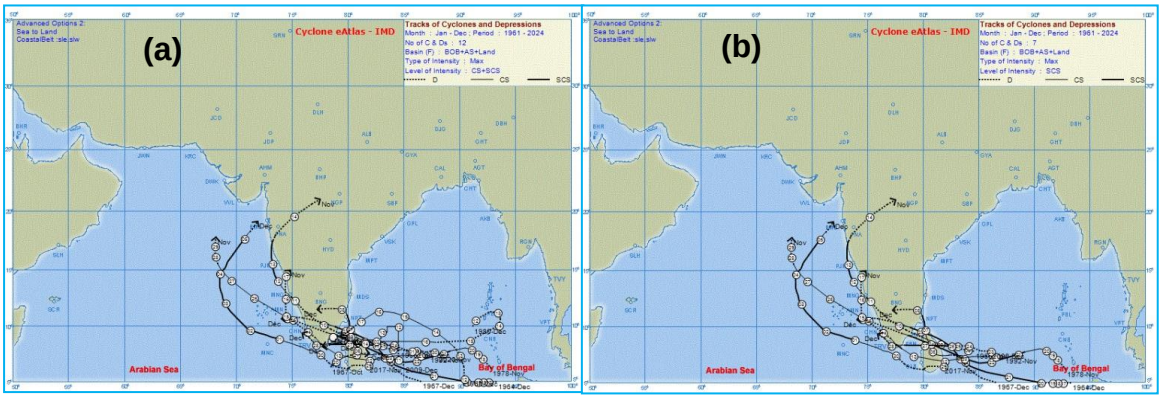


Fig.2.16.3: Tracks of (a) all cyclones (MSW≥34 knots) and (b) all severe cyclones (MSW≥48 knots) crossing Sri Lanka coast during 1961-2024

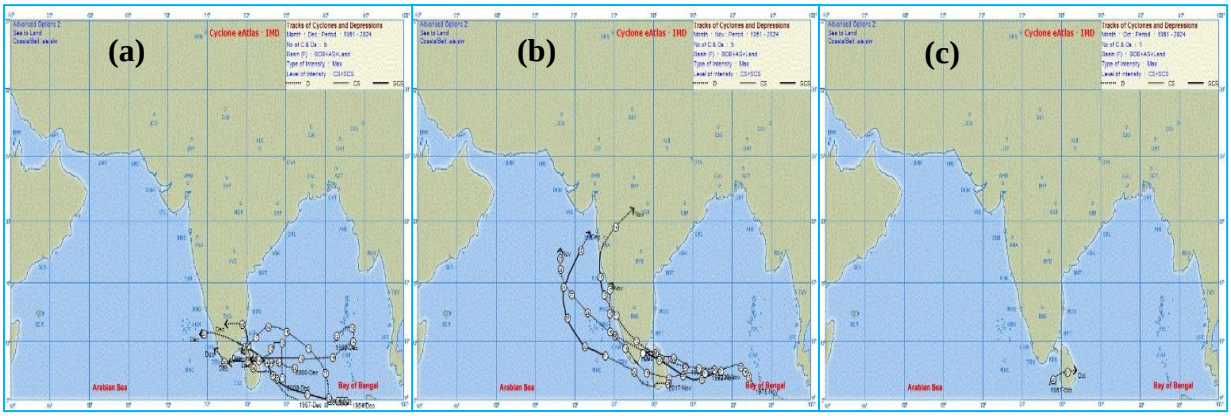


Fig.2.16.4: Tracks of cyclones crossing Sri Lanka coast in the months of (a) December, (b) November and (c) October during 1961-2024

c. **Ditwah was the first cyclone** after cyclone Burevi (30 Nov-02 Dec) which crossed east Sri Lanka coast on 2nd Dec., 2020.

d. **Simultaneous occurrence:** 2 cyclonic disturbances prevailed over the BoB during last week of November. Earlier such occurrence over BoB was seen in 2013, with two back-to-back cyclones Helen (19th-23rd November) and Lehar (23rd-28th November). Both crossed Andhra Pradesh coast. Helen developed over westcentral BoB on 19th Nov. early morning (0530 hrs IST/ 0000 UTC), intensified into cyclonic storm on 20th morning (0830 hrs IST/0300 UTC), into severe cyclonic storm on 21st Nov. early morning (0530 hrs IST/ 0000 UTC), crossed Andhra Pradesh coast on 22nd Nov. afternoon (1330-1430 hrs IST/ 0800-0900 UTC) and weakened into a well-marked low pressure area over coastal Andhra Pradesh on 23rd early morning (0530 hrs IST/0000 UTC). Another cyclone Lehar developed over South Andaman Sea in the evening (1730 hrs IST/ 1200 UTC), intensified into a cyclonic storm on 24th early morning (0530 hrs IST/ 0000 UTC), further into very severe cyclonic storm in the early hours (0230 hrs IST) of 26th Nov. (2100 UTC of 25th Nov.), weakened over westcentral BoB and crossed Andhra Pradesh coast as deep depression on 28th Nov. afternoon (around 1400 hrs IST/0830 UTC) on 28th Nov and

weakened into a well-marked low pressure area over coastal Andhra Pradesh and adjoining Telangana (**Fig.2.16.5**).

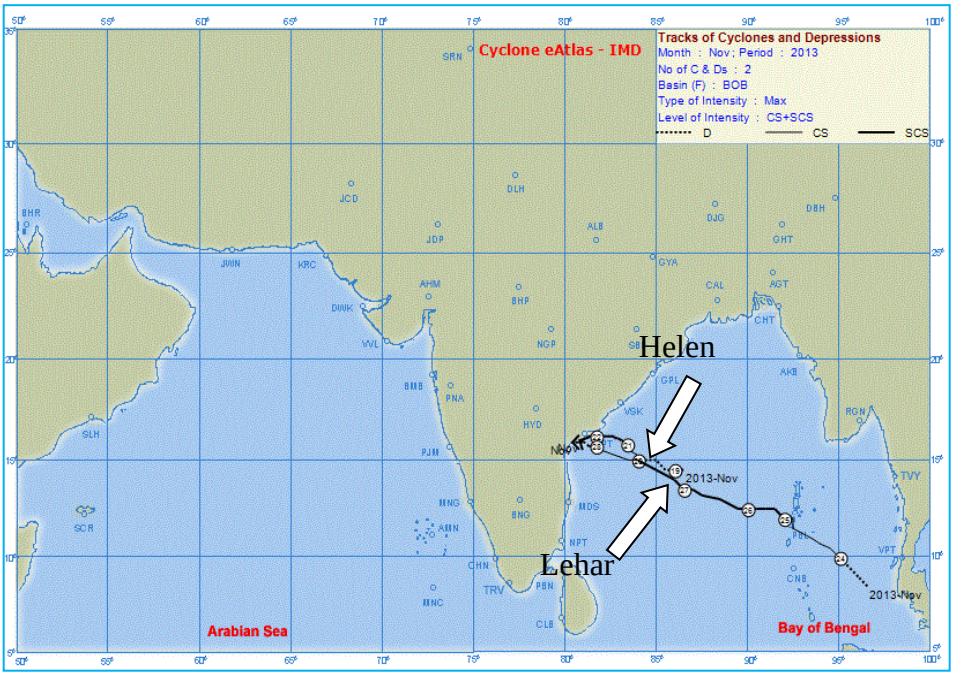


Fig.2.16.5: Tracks of back-to-back cyclones Helen and Lehar in Nov., 2013

e. **Unique Track:** The track of cyclone Ditwah was unique, as there has been no such track during the satellite era in the recorded history of IMD (since 1961 onwards) over that region. It had almost northward track from South of Sri Lanka to Southwest BoB close to North Tamil Nadu coast.

f. **Recurving track:** Ditwah moved initially north-northwestwards till afternoon (1430 hrs IST/ 0900 UTC) of 29th Nov. and then northwards till morning (0830 hrs IST/ 0300 UTC) of 1st Dec., practically stationary till midnight (2330 hrs IST/ 1800 UTC) of 1st Dec., and then slowly recurved south-southwestwards till early morning (0530 hrs IST/ 0000 UTC) of 3rd Dec. **(Fig.2.16.1 and Fig.2.16.6a).** The system moved initially north-northwestwards and then northwards along the periphery of the ridge over the BoB around 12°N. However, as it remained almost stationary close to coast, persistent rainfall led to lowering of sea surface temperature. Further while moving northwards, it exhibited weakening due to land interactions, increase in cold dry air incursion from northwest and increased vertical wind shear. Consequently, the depth of convection reduced and the steering mechanism also changed. Thereafter, the north-northeasterly winds in the mid-tropospheric levels steered the system south-southwestwards.

g. **Translational Speed**: Ditwah exhibited six hourly average translational speed of 9.8 kmph against normal of 15.5 kmph for cyclonic storms over the BoB in the post monsoon season during 1990-2013 (**Fig.2.16.6a**). Thus, it was a very slow-moving cyclone. The average translational speed as it moved across Sri Lanka during 27th noon (1130 hrs IST/0600 UTC) to 29th early morning (0530 hrs IST/0000 UTC) was even further slower (about 7 kmph), leading to extremely heavy rainfall activity over Sri Lanka during 25th to

29th November. Further, the interaction with orography over central Sri Lanka led to enhancement of rainfall activity.

h. **Life period:** The life period of the storm (depression to depression) was about 6 days and 06 hours against the long period average (LPA) (1990-2013) of about 3 days and 14 hours for CS category over the BoB during post-monsoon season. Thus, Ditwah had a life period longer than the average life period of cyclonic storms over the BoB during post-monsoon season.

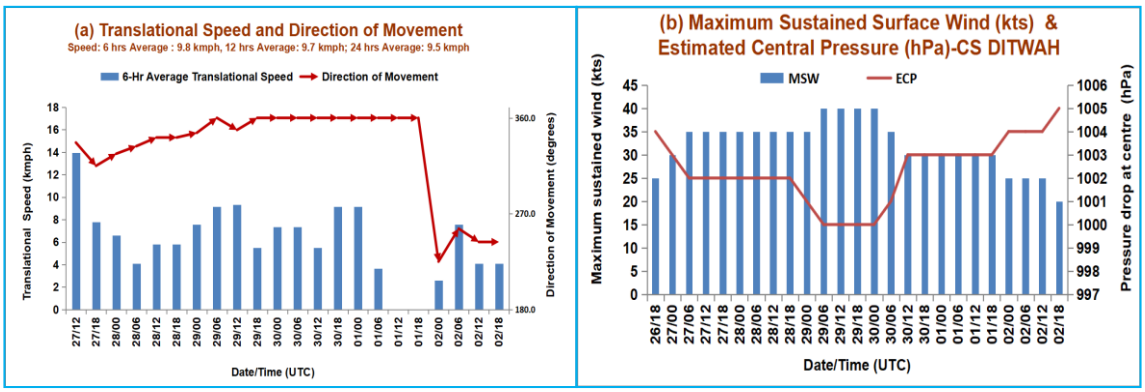


Fig.2.16.6: Six hourly (a) average translational speed & direction of movement and (b) maximum sustained surface wind speed & estimated central pressure during life period of cyclone Ditwah

i. **Maximum sustained wind speed and estimated central pressure:** The system did not exhibit any rapid intensification/weakening during its life cycle. The system reached its peak intensity of 40 knots at 1130 hrs IST/0600 UTC of 29th November and maintained it till 0000 UTC of 30th November. The estimated central pressure during this period was 1000 hPa. The six hourly maximum sustained wind speed and estimated central pressure during the life cycle of Ditwah is presented in **Fig.2.16.6b**.

j. **Damage Potential and Power Dissipation Index**: The Accumulated Cyclone Energy (a measure of damage potential) and Power Dissipation Index (a measure of loss) in association with Ditwah were 1.74 X 10^4 $knots^2$ and 0.64 $X10^6$ $knots^3$ respectively against the normal of 1.0 X 10^4 $knots^2$ and 0.40 $X10^6$ $knots^3$ for CS during post monsoon season over the BoB based on the data during 1990-2020. As it was a slow-moving cyclone with a longer life period, damage potential and losses due to Ditwah were higher than the long period average.

k. **The storm surge** mostly impacted north Sri Lanka coast.

2.16.2.1 Genesis, intensification and movement

2.16.2.1.1. Genesis

An upper air cyclonic circulation lay over Comorin area and neighbourhood at 0300 UTC of 23rd November, 2025. Under its influence, a low pressure area formed over Comorin and adjoining Southwest BoB & Sri Lanka at 0000 UTC of 25th November. It lay as a WML over southwest BoB and adjoining areas of Southeast Sri Lanka & East EIO at 0000 UTC of 26th November. It concentrated into a depression over southwest BoB and adjoining Sri Lanka at 1800 UTC of 26th November, 2025

During this period, the Madden–Julian Oscillation (MJO) index lay in phase 6 with amplitude more than 1. Most of the models suggested that the MJO index would continue in phase 6 with a slow eastward propagation and increasing amplitude till 1st December. The sea surface temperature (SST) was around 28°C over the south Andaman Sea and adjoining Malacca Strait and southeast BoB. It was higher, around 30°C, over central BoB and along & off Odisha and Andhra Pradesh coasts. Ocean thermal energy was 150–175 kJ/cm² over the south Andaman Sea and 100–120 kJ/cm² over southeast BoB. However, it was less than 50 kJ/cm² over westcentral BoB and along & off Odisha and Andhra Pradesh coasts.

The guidance from the NCICS model indicated westerly wind anomaly (5–7 m/s) along with the prevalence of MJO signal, Equatorial Rossby Wave (ERW), and low-frequency background wave (LW) over south BoB and easterly wind anomaly (3–5 m/s) to its north over south and adjoining central parts of BoB during 26th to 28th November. These features indicated a favourable environment for cyclogenesis (development of depression) over south BoB and adjoining south Andaman Sea during this period. The Kelvin Wave (KW) was also seen propagating eastward gradually across central AS and south BoB during 26th November to 1st December. Various equatorial waves were in phase over south BoB during 26th November to 1st December. The environmental condition is likely to remain favourable for development and further intensification of the system over southwest & westcentral BoB till 1st December. The guidance from CIMSS indicated, theta at 0300 UTC of 23rd Nov, the low level relative vorticity at 850 hPa was about 70-80 × 10^{-6} s^{-1} over Comorin Area and adjoining southwest Sri Lanka. Vertically, the positive vorticity zone was extending upto 500hPa. Upper-level divergence was around 30×10^{-6} s^{-1} over Comorin Area and adjoining southwest Sri Lanka. Low-level convergence was around 30×10^{-6} s^{-1} over Comorin and adjoining areas. Mid-level vertical wind shear (VWS) of horizontal wind was low (5-10 kt) and cyclonic over the region. By 1800 UTC of 26th Nov., the features further consolidated and the low-level relative vorticity at 850 hPa was about 150 × 10^{-6} s^{-1} over the Comorin Area and adjoining southwest Sri Lanka. Vertically, the positive vorticity zone was extending up to 500 hPa. Upper-level divergence was around 30 × 10^{-6} s^{-1} over the Comorin Area and adjoining southwest Sri Lanka. Low-level convergence was around 30 × 10^{-6} s^{-1} over the Comorin and adjoining areas. Mid-level vertical wind shear (VWS) of horizontal wind was low (10–15 kt) and cyclonic over the region. Under these favourable features, the upper air cyclonic circulation over Comorin on 23rd gradually concentrated into a depression by 26th Nov./ 1800 UTC.

2.16.2.1.2 Intensification:

At 0000 UTC of 27th November, the MJO continued in phase 6. Similar sea conditions prevailed. There was prevalence of westerly wind anomaly (5–7 m/s) along with ERW, LW over south BoB & southeast AS and easterly wind anomaly (3–5 m/s) to its north over south & adjoining central parts of BoB during 27th to 28th November. KW was also seen propagating eastward gradually across central AS and south BoB during 27th November to 1st December over south BoB. The equatorial waves continued to support convective activity associated with the depression over the southwest BoB. The low level relative vorticity at 850 hPa increased and was about 200 × 10^{-6} s^{-1} over south Sri Lanka. Vertically, the positive vorticity zone was extending up to 200 hPa. Upper-level divergence was around 20 × 10^{-6} s^{-1} over Comorin Area & adjoining Equatorial Indian Ocean and southwest Sri Lanka.

Low-level convergence was around 20 × 10^{-6} s^{-1} over south Sri Lanka and adjoining regions. Mid-level vertical wind shear (VWS) of horizontal wind was low (10–15 kt) and cyclonic over the region. All these features supported the intensification of the system into a deep depression at 0000 UTC of 27th November.

At 0600 UTC of 27th November, similar conditions wrt MJO, SST and equatorial waves continued. The low level relative vorticity at 850 hPa was about 200 × 10^{-6} s^{-1} over southwest BoB and adjoining south Sri Lanka. Vertically, the positive vorticity zone was extending up to 200hPa. Upper-level divergence increased and was around 30×10^{-6} s^{-1} over Comorin Area to the west of system centre. Low-level convergence was around 10×10^{-6} s^{-1} over southwest BoB and adjoining Sri Lanka. VWS of horizontal wind was low (10-15 kt) over the system area. These favourable features led to further intensification of the system into the cyclonic storm "Ditwah" over coastal Sri Lanka and adjoining southwest BoB at 0600 UTC of 27th November.

At 0300 UTC of 28th November, MJO lay in phase 7 with amplitude more than 1. The SST was around 28 °C over southwest BoB and along & off Sri Lanka, Tamil Nadu & South Andhra Pradesh coasts along the forecast track. The westerly wind anomaly (7–9 m s^{-1}) along with prevalence ERW and LW prevailed over the southern parts of the BoB and easterly wind anomaly (3–5 m s^{-1}) to its north over southwest BoB off Tamil Nadu coast. KW was also seen over the region on 28th November. Thus, equatorial waves continued to support convective activity over southwest BoB. The low-level relative vorticity at 850 hPa was about 150 × 10^{-6} s^{-1} over coastal Sri Lanka and adjoining southwest BoB to the southwest of system centre. Vertically, the positive vorticity zone was extending up to 200 hPa. Upper-level divergenceincreased and was around 40 × 10^{-6} s^{-1} over Comorin Area to the southwest of system centre. Low-level convergence increased and was around 50 × 10^{-6} s^{-1} over Comorin Area adjoining Sri Lanka to the southwest of system centre. Vertical wind shear (VWS) of horizontal wind was moderate (15–20 kt) and anti-cyclonic over the system area and was indicated to become high to the north of 13°N. Total precipitable water imagery indicated warm moist air incursion into the core. However, cold dry air from northwest was approaching upto 10°N. Favourable environment like prevalence of equatorial waves, moderate & anti-cyclonic vertical wind shear, warm moist air incursion into the core and poleward outflow supported the system to maintain its intensity despite land interactions. On emergence of system into the sea, slight intensification was expected. However, environmental features also indicated that as the system would reach to the north of 12°N, it would encounter unfavorable environment due to cold dry air incursion, high VWS and decrease in tropical cyclone heat potential (<50 KJ cm^{-2}) after 30th November.

At 0300 UTC of 29th November, 2025, similar sea, MJO and equatorial waves conditions prevailed. The low-level relative vorticity at 850 hPa was about 150 × 10^{-6} s^{-1} over Sri Lanka and adjoining southwest Bay of Bengal to the south of system centre. Vertically, the positive vorticity zone was extending up to 200 hPa and tilting slightly southwestwards with height. Upper-level divergence was around 20 × 10^{-6} s^{-1} to the west of system centre and was southwest–northeast oriented. Low-level convergence was 30 × 10^{-6} s^{-1} around the system centre. Mid-layer shear was around 10–15 kt and anticyclonic over the system area. The deep layer mean wind shear of horizontal wind was moderate (15–20 kt) and anticyclonic over the system area and hence favorable to maintain intensity. Warm air advection was

continuously taking place from south and southeast sector into the core of the system. However, cold and dry air from the southern peninsular was touching the northwest sector. As a result, with the northwards movement of the system, incursion of more dry and cold air was likely. However, favorable outflow, warm moist air incursion, support from equatorial waves and favorable thermodynamic features led to marginal intensification of the system on emergence into sea at 0300 UTC of 27th Nov. The environmental features also indicated gradual weakening of the system due to high wind shear, low ocean thermal energy, and cold dry air incursion from northwest sector, during its northward journey towards North Tamil Nadu coast. Under these features, the system marginally intensified further at 0300 UTC of 29th November.

At 0300 UTC of 30th November, 2025, MJO continued in phase 7. Similar sea conditions prevailed. The guidance from NCICS model indicated westerly wind anomaly (7–9 m s^{-1}) along with prevalence of ERW, KW and LW over the southern parts of the BoB, and easterly wind anomaly (3–5 m s^{-1}) to its north over southwest BoB off Tamil Nadu–Andhra Pradesh coasts on 29th & 30th November. Thereafter, slight weakening of these features was indicated. The low-level relative vorticity at 850 hPa was about 100 × 10^{-6} s^{-1} over Sri Lanka and adjoining southwest BoB to the south of system centre. Vertically, the positive vorticity zone was extending up to 200 hPa and tilting slightly southwestwards with height. Upper-level divergence was 10 × 10^{-6} s^{-1} around the system. Low-level convergence was around 10 × 10^{-6} s^{-1} around the system centre. Mid-layer vertical wind shear was around 10–15 kt and anticyclonic over the system area. The deep-layer wind shear of horizontal wind was moderate (15–20 kt) and anticyclonic over the system area and hence favorable to maintain intensity. However, warm air advection around the system centre reduced. Under these features, the system maintained its intensity. However, the environmental features were indicating gradual weakening thereafter.

2.16.2.1.3. Weakening

At 1200 UTC of 30th November, 2025, MJO lay in phase 7 with amplitude more than 1. The SST was around 28^{0}C over southwest BoB and along & off Sri Lanka, Tamil Nadu & South Andhra Pradesh coast along the forecast track. The SST was less to the north of 15^{0}N being 27^{0}C. It was also less over Gulf of Mannar and adjoining southwest BoB near Sri-Lanka Coast due to continuous heavy rain over the region. The cooler SST in these regions was expected to reduce the convection in the region and hence convective cloud were likely to be mostly limited between 10-15^{0}N. The spiral band of convective clouds over southeast and adjoining eastcentral BoB were associated with higher SST of 29^{0}C over that region. The guidance from NCICS model indicated westerly wind anomaly (7-9 mps) along with prevalence of ERW, KW and LW over the southern parts of the BoB and easterly wind anomaly (3-5 mps) to its north over southwest BoB near Tamil Nadu-Andhra Pradesh coasts on 30th November. Thereafter, slight weakening of these features was indicated. The Low level relative vorticity at 850 hPa decreased and was about 150×10^{-6} s^{-1} over southwest BoB to the south of system centre. Vertically the positive vorticity zone was extending up to 500 hPa and tilting slightly southwestwards with height. Upper-level divergence decreased and was around 10×10^{-6} s^{-1} to the south of system centre. Low-level convergence also decreased and was around 15×10^{-6} s^{-1} to the north of system centre. Mid layer shear was around (15-25 kts) and anticyclonic over the system area. The deep layer wind shear of horizontal wind was moderate to high (20-30 kt) and anticyclonic over the system area. Both

mid and deep layer wind shear showed increasing trend, leading to weakening of the system. Cold and dry air incursion also reached upto northeast sector. Under these features, the system weakened into a deep depression at 1200 UTC of 30th November.

At 0300 UTC of 01st December, 2025, MJO lay in phase 7 with amplitude more than 1. The SST was around 28 °C over southwest BoB and along & off Sri Lanka, Tamil Nadu & South Andhra Pradesh coast along the forecast track, becoming 27 °C to the north of 15° N. The westerly wind anomaly (7–9 m s^{-1}) along with ERW, KW and LW prevailed over the southern parts of the BoB, and easterly wind anomaly (3–5 m s^{-1}) to its north over southwest BoB near Tamil Nadu–Andhra Pradesh coasts on 1st December. Thereafter, slight weakening of these features was indicated from 2nd December onwards. The low-level relative vorticity at 850 hPa decreased and was about 120–130 × 10^{-6} s^{-1} over southwest BoB to the south of system centre. Vertically, the positive vorticity zone was extending upto 500 hPa, tilting southwestward with height. Upper-level divergence was around 20 × 10^{-6} s^{-1} over the system centre. Low-level convergence was around 10–15 × 10^{-6} s^{-1} to the southeast of the system centre. Mid-layer shear was high (around 20–25 kt) and anticyclonic over the system area and to its north. Cold and dry air incursion reached up to the northeast sector. The system was in a moderately favorable environment lay as a deep depression over southwest BoB.

At 0000 UTC of 02nd December, 2025, MJO continued in phase 7. The sea surface temperature (SST) was around 28°C over the southwest BoB and along & off Sri Lanka, Tamil Nadu and South Andhra Pradesh coasts along the forecast track. The SST was 27°C to the north of 15°N. Guidance from the NCICS model indicated a westerly wind anomaly (7–9 mps) along with the prevalence of ERW, KW and LW over the southern parts of the BoB. Easterly wind anomaly (3–5 mps) was prevalent to its north over the southwest BoB near the Tamil Nadu–Andhra Pradesh coasts. A slight weakening of these features was indicated from 2nd December onwards. The equatorial waves over the southwest BoB were moving away. The low-level relative vorticity at 850 hPa was about 80–100 × 10^{-6} s^{-1} over the southwest BoB over the system centre. Vertically, the positive vorticity zone was extending up to 500 hPa. Upper-level divergence was around 10 × 10^{-6} s^{-1} over the system centre. Low-level convergence was around 10 × 10^{-6} s^{-1} over the system centre. Mid-layer shear was moderate to high (around 20–25 kts) and anticyclonic over the system area and to its north. The system was in a moderately favourable environment and thus weakened into a depression over the southwest Bay of Bengal and adjoining areas of Westcentral Bay of Bengal and North Tamil Nadu-Puducherry & South Andhra Pradesh coasts and into a well marked low pressure area over North Tamil Nadu-Puducherry coasts and neighbourhood at 0000 UTC of 3rd December.

Movement: The system moved initially north-northwestwards and then northwards along the periphery of the ridge over the BoB around 12°N. However, as it remained almost stationary close to coast, persistent rainfall led to lowering of sea surface temperature. Further while moving northwards, it exhibited weakening due to land interactions, increase in cold dry air incursion from northwest and increased vertical wind shear. Consequently, the depth of convection reduced and the steering mechanism also changed. Thereafter, the north-northeasterly winds in the mid-tropospheric levels steered the system south-southwestwards.

2.16.3 Monitoring of CS, "DITWAH"

India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean and the cyclone was monitored since 13th November, about 13 days prior to formation of depression on 26th November. First information about likely genesis over the south BoB was issued in the extended range outlook issued on 13th November. The cyclone was monitored with the help of available satellite observations from INSAT 3DR, SCAT SAT (OCEAN SAT 3), ASCAT, microwave imageries, Doppler weather Radar at Chennai & Karaikal, available ships, buoys & coastal observations in the region. Typical satellite and radar-based products utilized for monitoring the system are presented in **Fig.2.16.7**.

Various global models and dynamical-statistical models run by Ministry of Earth Sciences (MoES) institutions including IMD, NCMRWF, IITM & INCOIS and guidance from models from various international agencies under bilateral arrangement were utilized to predict the genesis, track and intensity of the cyclone as well as associated severe weather. The forecasts were mainly based on multi-model ensemble technique developed by IMD which were further modulated by analysis of observations and forecasters intervention at IMD through their knowledge, experience and expertise. An indigenously developed digitized forecasting system of IMD (Decision Support System) was utilized for analysis and comparison of various observations and numerical weather prediction model's guidance, decision making process and warning products generation.

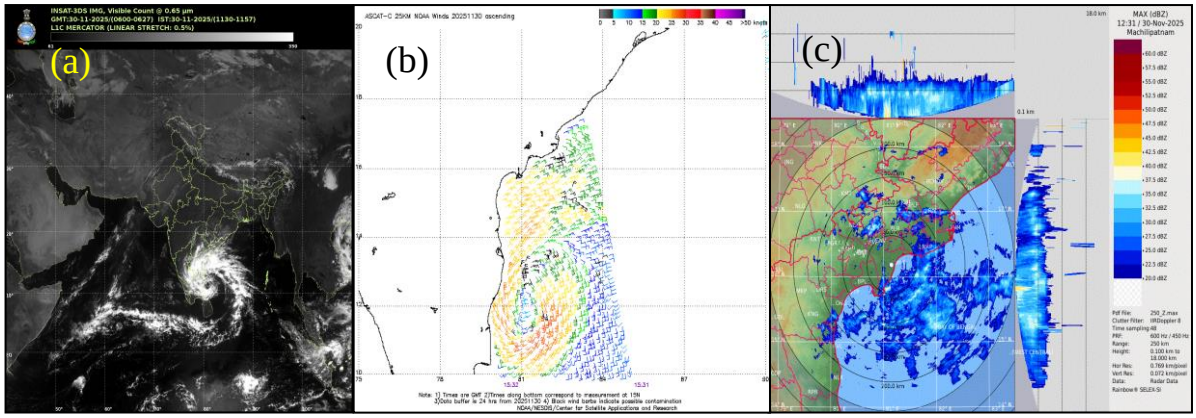


Fig.2.16.7: (a) INSAT 3DS image of 1130 hrs IST (0600 UTC) of 30th November of (b) ASCAT image at 2100 hrs IST (1530 UTC) of 29th Nov, 2025 of cyclonic storm "DITWAH" over Bay of Bengal and (c) Machilipatnam Radar image at 1800 hrs IST (1230 UTC) of 30th November of cyclonic storm "DITWAH" over Bay of Bengal

2.16.3.1 Features observed through satellite

Typical INSAT-3DS based visible/IR imageries, enhanced colored imageries, cloud top brightness temperature imageries and radar imageries from Doppler weather radar (DWR) Chennai & Karaikal are presented in Fig.2.16.8(a) – 8(e).

At 0000 UTC of 25th November, as per INSAT-3DS, persistent broad scale convection was seen over south BoB, southeast Arabian Sea and adjoining east Equatorial Indian Ocean. The low level cyclonic circulation (LLLC) lay over the Comorin area and adjoining regions of the southwest Bay of Bengal & Sri Lanka. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over the Comorin area, Gulf of

Mannar, Sri Lanka and the southwest Bay of Bengal with minimum cloud top temperature (CTT) of **–70 to –90°C**.

At 1200 UTC of 25th November, 2025, LLLC lay over the southwest Bay of Bengal and adjoining south Sri Lanka. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over the Comorin area, Gulf of Mannar, Sri Lanka, and the southwest Bay of Bengal with minimum CTT of minus 70 to 90°C.

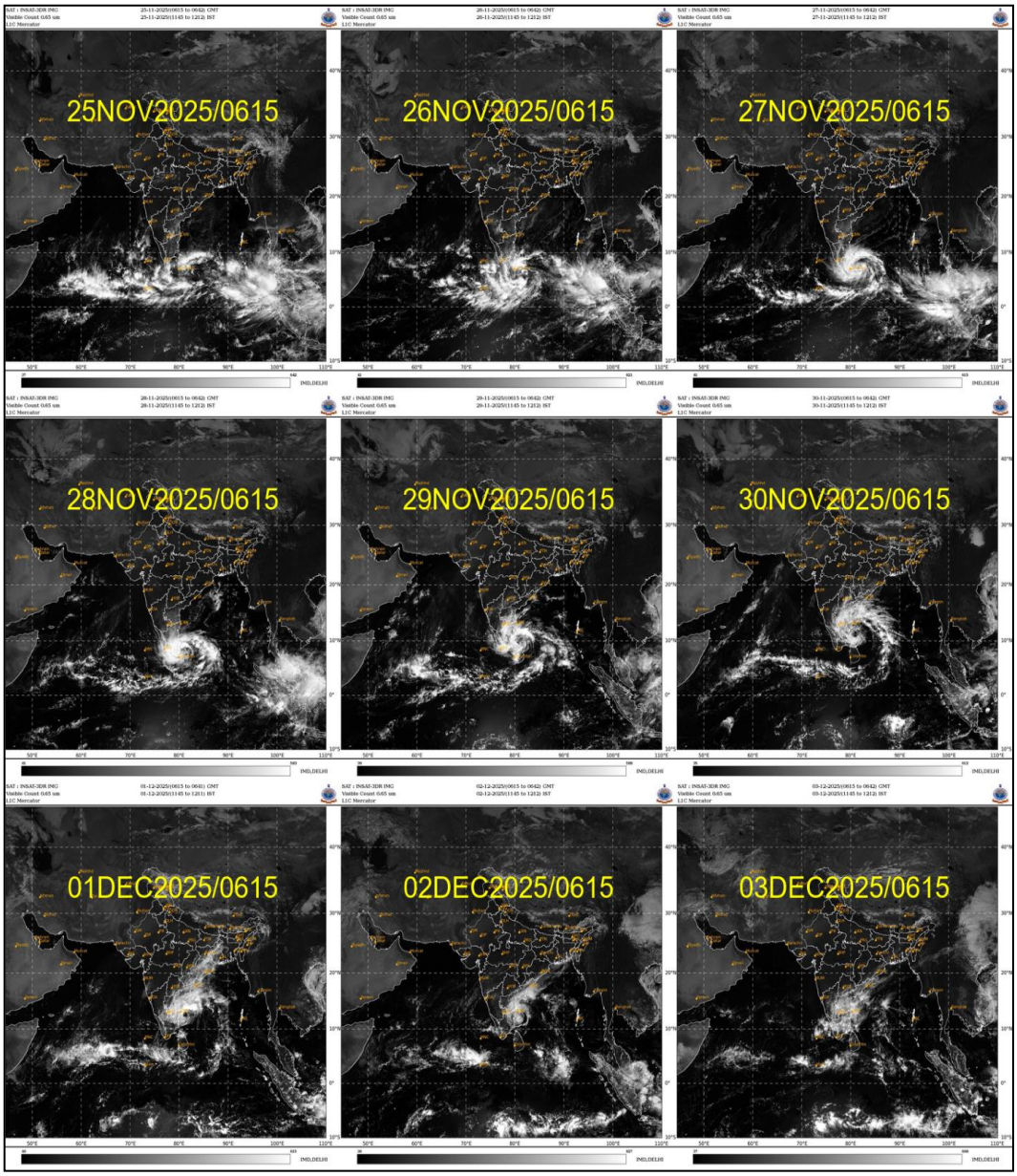


Fig.2.16.8(a): INSAT-3D visible imageries during life cycle of CS DITWAH (26 November- 03 December)

At 0000 UTC of 26th November, 2025, well-marked low-pressure area over southwest Bay of Bengal and adjoining areas of Southeast Sri Lanka & Equatorial Indian Ocean. As per INSAT-3DS, Low Level Circulation (LLC) lay over southwest Bay of Bengal, adjoining south

Sri Lanka and the equatorial Indian Ocean. The associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over the Comorin area, Gulf of Mannar, Sri Lanka and southwest Bay of Bengal with minimum CTT of minus 70 to 90°C.

At 1200 UTC of 26th November, as per INSAT-3DS, the convective clusters came closer and intensity was characterised as T1.0. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over southwest BoB & adjoining East EIO, Sri Lanka, Comorin area, Palk Strait and Gulf of Mannar with minimum CTT of minus 70 to 90°C.

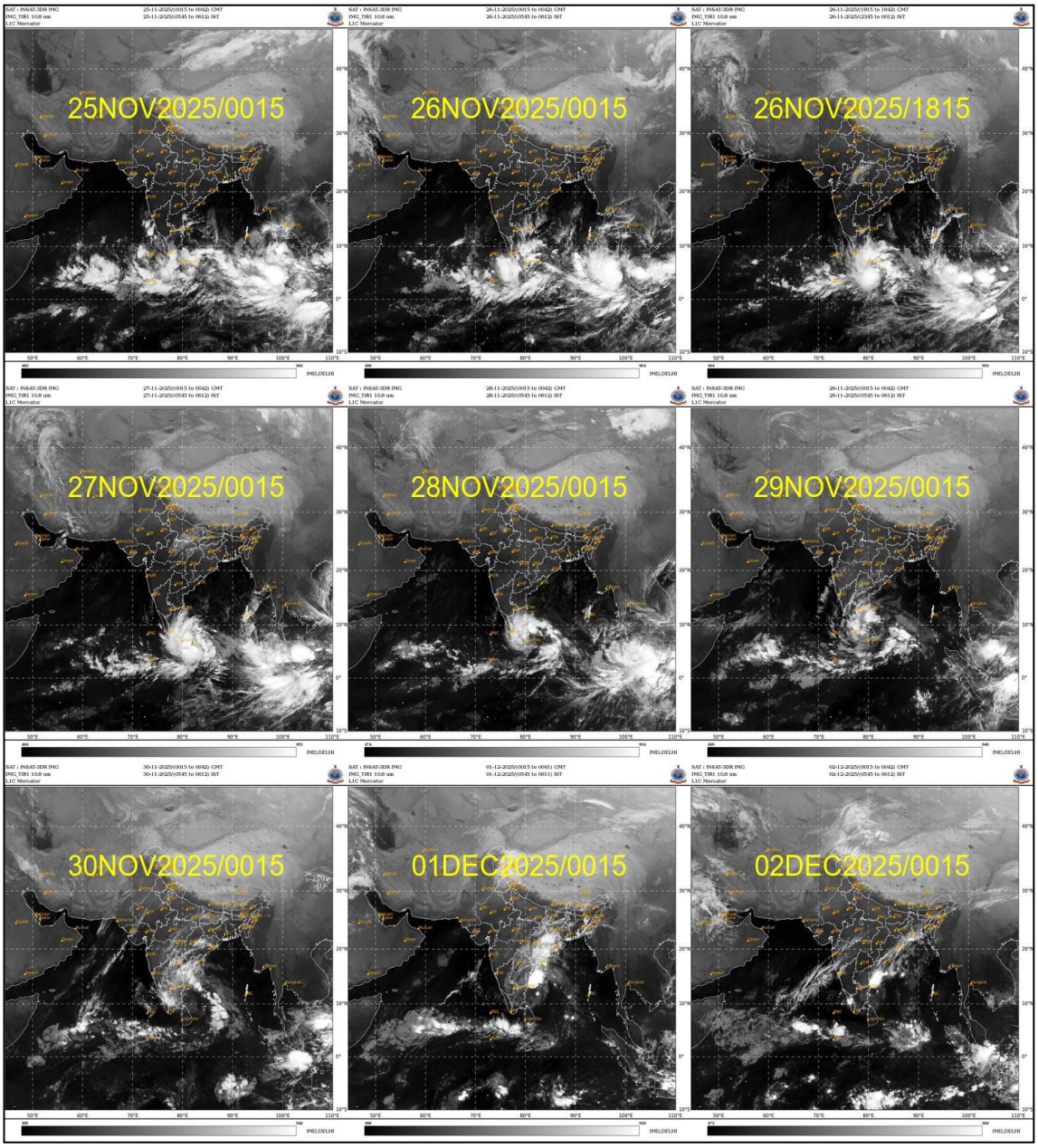


Fig.2.16.8(b): INSAT-3D IR imageries during life cycle of CS DITWAH (26 November- 02 December)

At 1800 UTC of 26th November, the convective clusters started organising. The intensity was characterised as T1.5. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over southwest BoB & adjoining East EIO, Sri Lanka, Comorin area, Palk Strait, and Gulf of Mannar with minimum CTT of minus 70 to 90 °C). **At 1800 UTC of 27th November**, the clouds were organized in curved band pattern. Intensity of the system was characterized as T2.5. Intense convection was seen over Southwest BoB and Sri Lanka. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over southwest BoB & adjoining Sri Lanka, Comorin area, Palk Strait & Gulf of Mannar with minimum CTT as minus 70 to 90 °C and moderate to intense convection lay over Kerala & Tamil Nadu, Comorin area with minimum CTT as minus 40 to 70 °C.

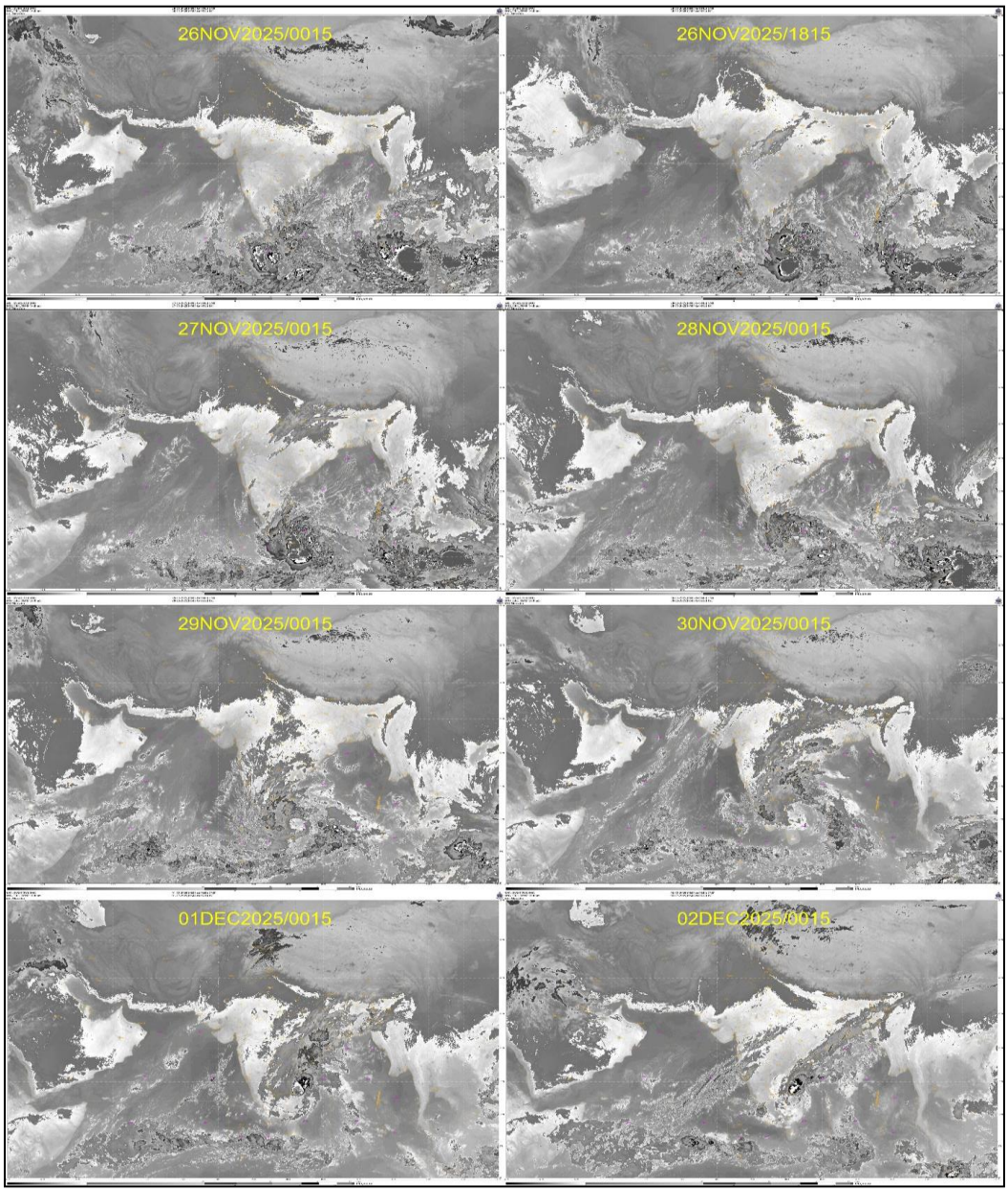


Fig.2.16.8(c): INSAT-3D BD imageries during life cycle of CS DITWAH (26 November- 02 December)

At 0300 UTC of 28th November, the clouds were organized in curved band pattern. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over southwest BoB, Sri Lanka, Comorin area, Palk Strait, Gulf of Mannar, Kerala and Tamil Nadu with minimum CTT as minus 70 to 90 °C. Multispectral winds indicated stronger winds in the northeast sector.

At 0600 UTC of 27th November, the clouds got organized in curved band pattern Intensity of the system was characterized as T2.5. Intense convection was seen over Southwest Sri Lanka. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over southwest BoB & adjoining EIO, Sri Lanka, Comorin area, Palk Strait & Gulf of Mannar, south Kerala & Tamil Nadu (minimum CTT minus 70 to 90°C.

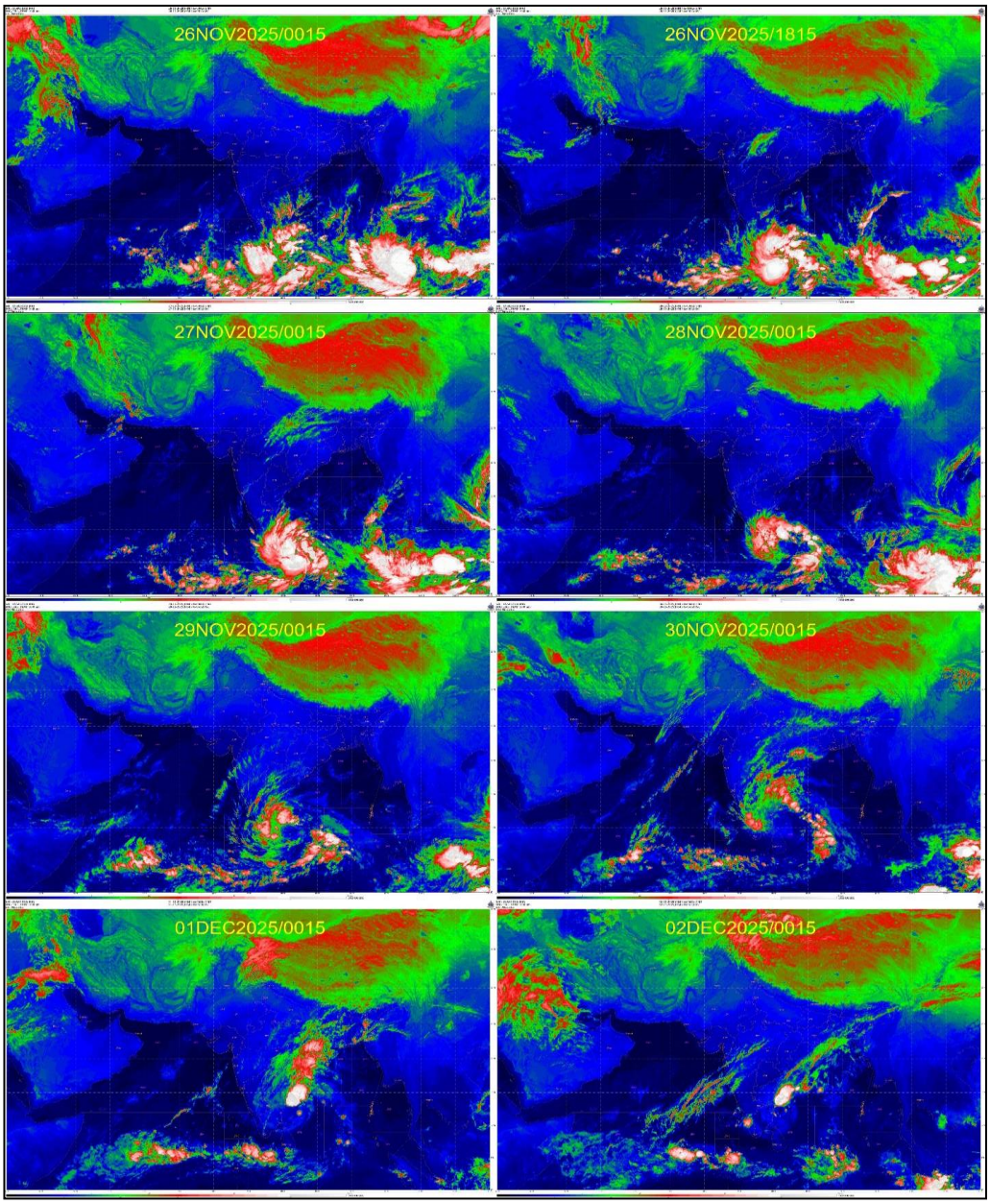


Fig.2.16.8(d): INSAT-3D enhanced colored imageries during life cycle of CS DITWAH (26 November- 02 December)

At 1200 UTC of 28th November, the clouds were organized in curved band pattern. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over southwest BoB, Sri Lanka, Comorin area, Palk Strait, Gulf of Mannar, Kerala and Tamil Nadu with minimum CTT as minus 70 to 90 °C. Cloud picture was indicating poleward and equatorward outflow.

At 0300 UTC of 29th November, intensity was characterised as T2.5. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over southwest BoB, Palk Strait, Gulf of Mannar and Tamil Nadu with minimum CTT as minus 70 to 90 °C. Moderate to intense convection also lay over Kerala, Rayalaseema, south Coastal Andhra Pradesh, Sri Lanka and Comorin Area with minimum CTT as minus 50 to 70 °C.

At 0300 UTC of 30th November, scattered to broken low and medium clouds with embedded intense to very intense convection lay over southwest adjoining westcentral BoB, Tamil Nadu, south Coastal Andhra Pradesh, Rayalaseema, South-interior Karnataka and Kerala with minimum CTT as minu 70 to 90 °C. Moderate to intense convection lay over Palk Strait, Gulf of Mannar, Sri Lanka and the rest of southwest BoB with minimum CTT as minus 40 to 60 °C.

At 1200 UTC of 30th November, the intensity of the system was characterized as T2.0/2.5. The clouds were organized in a curved band pattern. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over westcentral and adjoining coastal Andhra Pradesh, Tamil Nadu, Rayalaseema, South-interior Karnataka and Kerala with minimum CTT as minus 70 to 90 °C. Moderate to intense convection lay over southwest BoB, south Chhattisgarh, south Odisha, Telangana, Rayalaseema, Coastal Andhra Pradesh, South Interior Karnataka, North Tamil Nadu, Palk Strait, Gulf of Mannar, Sri Lanka and rest of southwest BoB with minimum CTT as minus 50 to 70 °C.

At 0300 UTC of 01st December, the intensity of the system was characterized as T2.0. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over westcentral BoB and adjoining north coastal Andhra Pradesh, Odisha, Jharkhand (minimum CTT was minus 70 to 90 °C).

At 1200 UTC of 01st December, the clouds are organized in shear pattern. The intensity was characterized as T2.0. Intense convection was seen in the northern sector. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over westcentral BoB and adjoining Coastal Andhra Pradesh, north Tamil Nadu, Odisha, Jharkhand, Gangetic West Bengal with minimum CTT as minus 70 to minus 90°C. Strong poleward outflow was seen reaching upto Bihar, Jharkhand area.

At 0000 UTC of 02nd December, the clouds were organized in shear pattern, and the system intensity was classified as T1.5/T2.0. Intense convection was observed in the northern sector. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over the westcentral BoB and adjoining coastal Andhra Pradesh and north Tamil Nadu, with minimum cloud top temperatures (CTT) of –70 to –90°C.

At 1200 UTC of 02nd December, 2025, the clouds are organized in a shear pattern, and the convective cloud mass associated with the LLCC were gradually decreasing, indicating weakening of the system. The current intensity was assessed as T1.5. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over the westcentral and adjoining southwest BoB, coastal Andhra Pradesh, and north

coastal Tamil Nadu. Minimum was very low minus 70 to 90°C. The areal extent of convection decreased further. Moderate to intense convection was observed over east Odisha with minimum CTT as minus 50 to 70°C.

At 0000 UTC of 03rd December, 2025, the vortex was centred near 11.9°N/79.7°E over the north Tamil Nadu–Puducherry coasts and the adjoining southwest Bay of Bengal. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over the southwest and westcentral BoB, north Tamil Nadu, and coastal Andhra Pradesh, with minimum CTT ranging from −70 to −90°C. Moderate to intense convection was also observed over Kerala and south Tamil Nadu, where the minimum CTT ranging from −50 to −70°C.

Doppler weather radar at Machilipatnam captured the system on 30th November. Major convective activitry was captured over southwest BoB. Rainbands were seen entering South Andhra Pradesh coast from 09 UTC of 30th onwards. Typical reflectivity imageries from DWR Machilipatnam are presented in Fig.2.16.8(e).

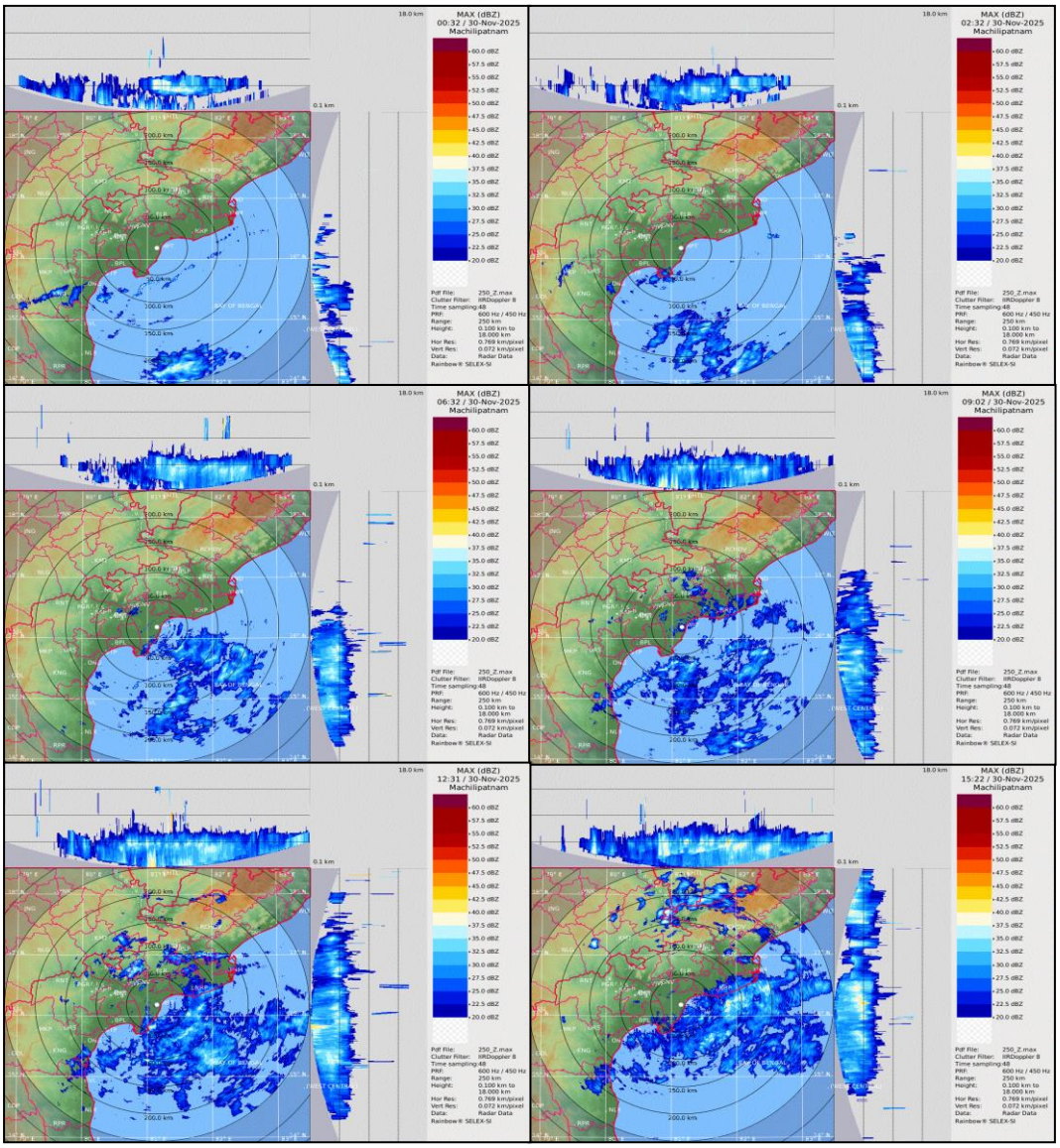


Fig.2.16.8(e): Typical Radar imagery from DWR Machilipatnam during life cycle of CS DITWAH (26 November- 02 December)

2.16.4 Dynamical features

IMD GFS (T1534) analysis field of mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels during 26th November – 02nd December are presented in **Fig.2.16.9(a)–9(g).**

At 0000 UTC of 26th November, the MSLP field indicated a deep depression over equatorial Indian Ocean (EIO) and adjoining southwest BoB to the south of Sri Lanka. Vertically the associated circulation extended upto 500 hPa. The upper tropospheric ridge lay near 12.0^{0}N. Actually, the system lay as Well marked low pressure area over southwest BoB and adjoining areas of southeast Sri Lanka and EIO. Thus, the model was overestimating the intensity of the system. However, location was correctly captured.

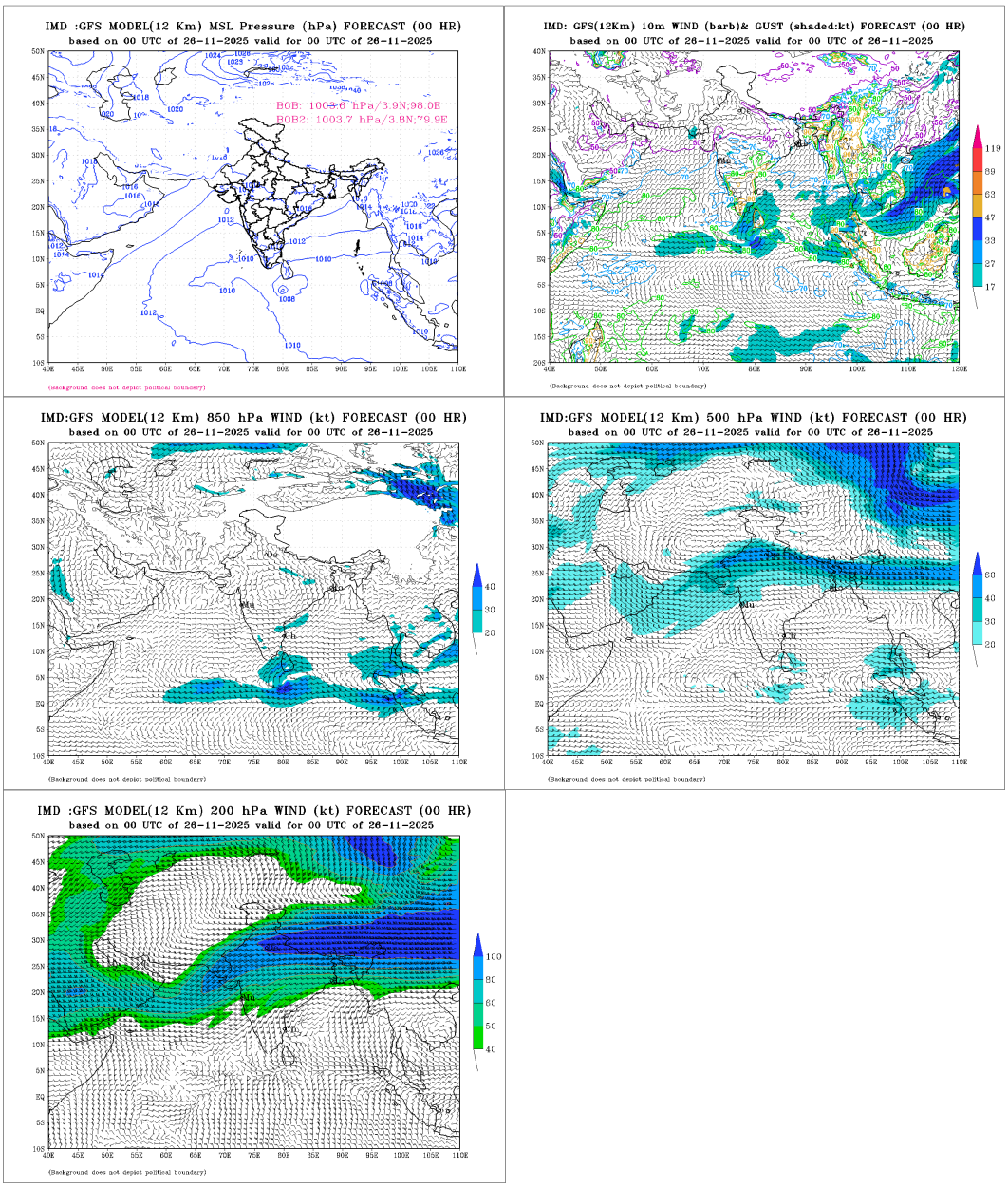


Fig.2.16.9(a): IMD GFS (T574) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 26th November, 2025

At 0000 UTC of 27th November, the MSLP field indicated rapid intensification and the system lay as a cyclonic storm near (6.2N81.6E) over southwest BoB and adjoining southeast Sri Lanka coast. The associated circulation extended upto 500 hPa. The upper tropospheric ridge lay near 15.0^{0}N. Actually, the system lay as deep depression over southwest BoB and adjoining areas of southeast Sri Lanka and EIO near (6.3N/82.4E). Thus, the model was overestimating the intensity of the system. However, location was correctly captured.

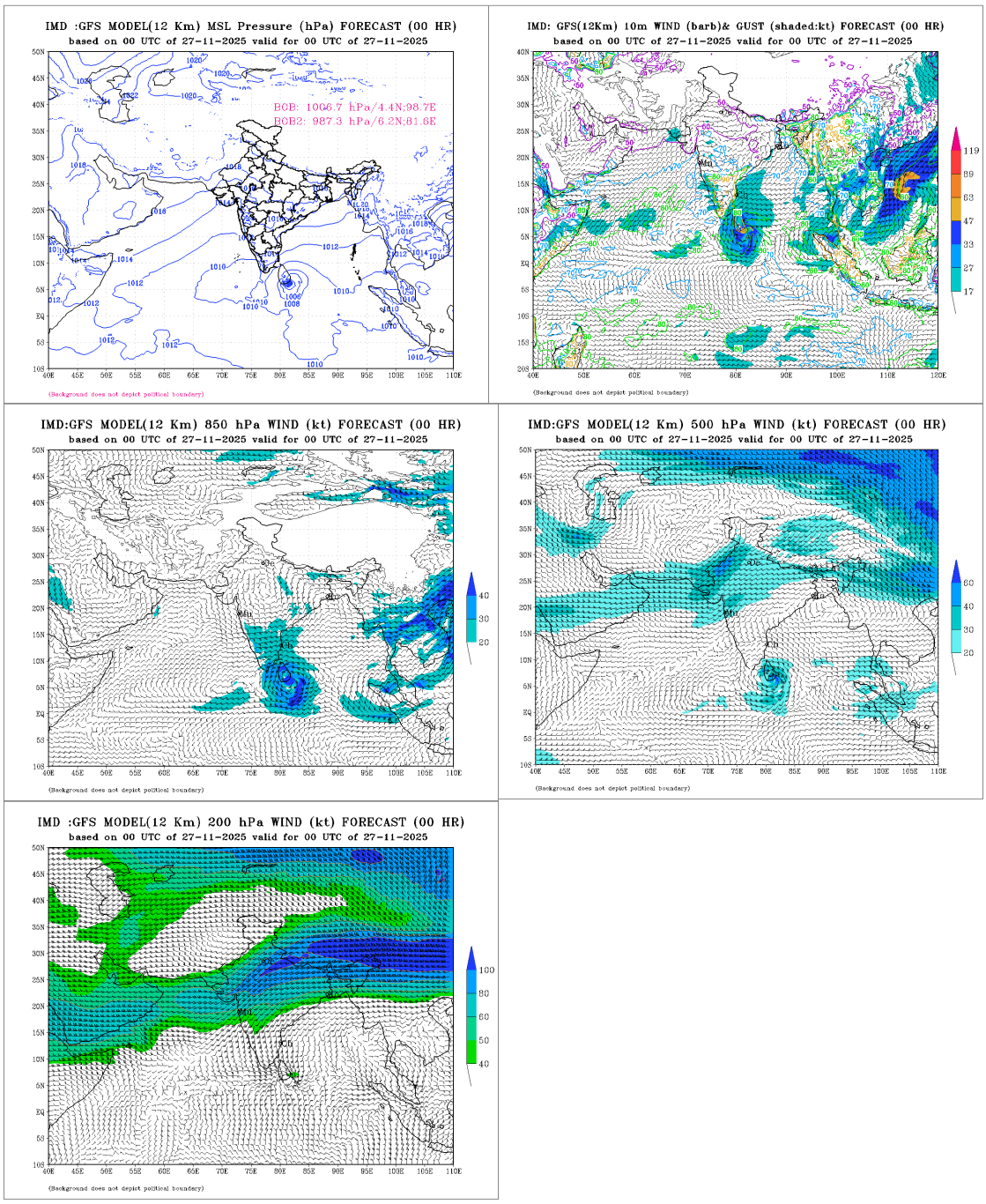


Fig.2.16.9(b): IMD GFS (T574) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 27th November, 2025

At 0000 UTC of 28th November, the MSLP field indicated a cyclonic storm over coastal Sri Lanka near (7.4N/81.3E). The associated circulation extended upto 500 hPa. The upper tropospheric ridge lay near 13.0^{0}N. System was steered north-northwestwards under the influence of south-southeasterly winds prevailing over the system area as indicated in the 200hpa wind field. Actually, the system lay as cyclonic storm with MSW of 35kts near (8.2N/81.1E). Thus on 28th, the model was correctly capturing the intensity and location of the system.

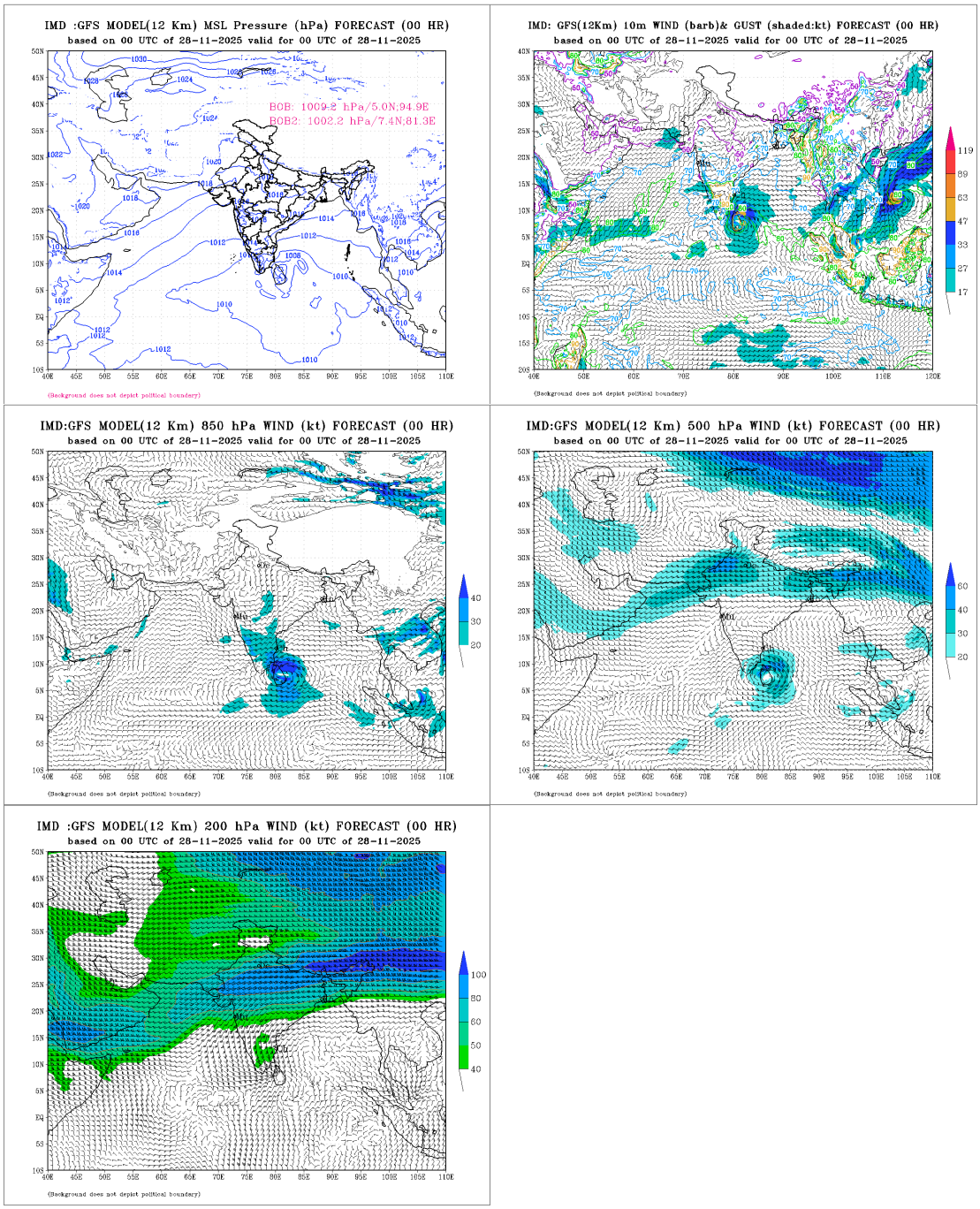


Fig.2.16.9(c): IMD GFS (T574) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 28th November.

At 0000 UTC of 29th November, the MSLP field indicated a deep depression over southwest BoB and adjoining northeast Sri Lanka near (9.4N/80.9E). The associated circulation extended upto 500 hPa. The upper tropospheric ridge lay near 13.0^{0}N. System was steered north-northwestwards under the influence of south-southeasterly winds prevailing over the system area as indicated in the 200hpa windfield. Actually, the system lay as cyclonic storm with MSW of 35kts near (9.4N/80.7E) over southwest BoB and adjoining northeast Sri Lanka. Thus on 29th, the model was correctly capturing the intensity and location of the system.

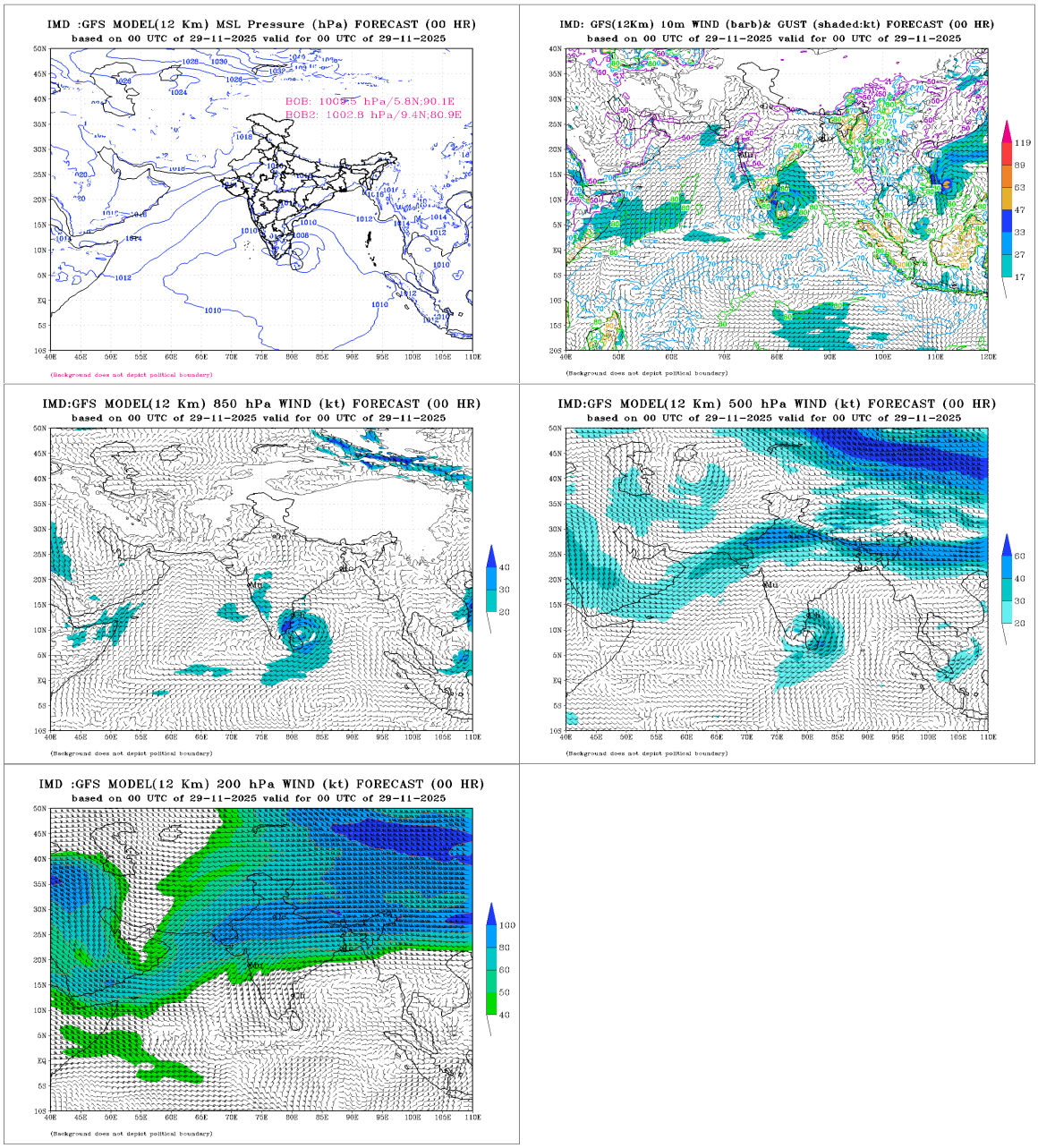


Fig.2.16.9(d): IMD GFS (T574) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 29th November, 2025.

At 0000 UTC of 30th November, the MSLP field indicated a cyclonic storm over southwest Bay off Tamil Nadu coast near (11.0N/80.7E). The associated circulation extended upto 500 hPa. The upper tropospheric ridge lay near 16-17^{0}N. However, south-southeasterly flow is seen over southwest BoB off Tami Nadu and north Sri Lanka coast indicating north-northwestwards movement. Actually, the system lay as cyclonic storm near (11.1N/80.6E) over southwest BoB off Tamil Nadu coast. Thus on 30th, the model was correctly capturing the intensity and location of the system.

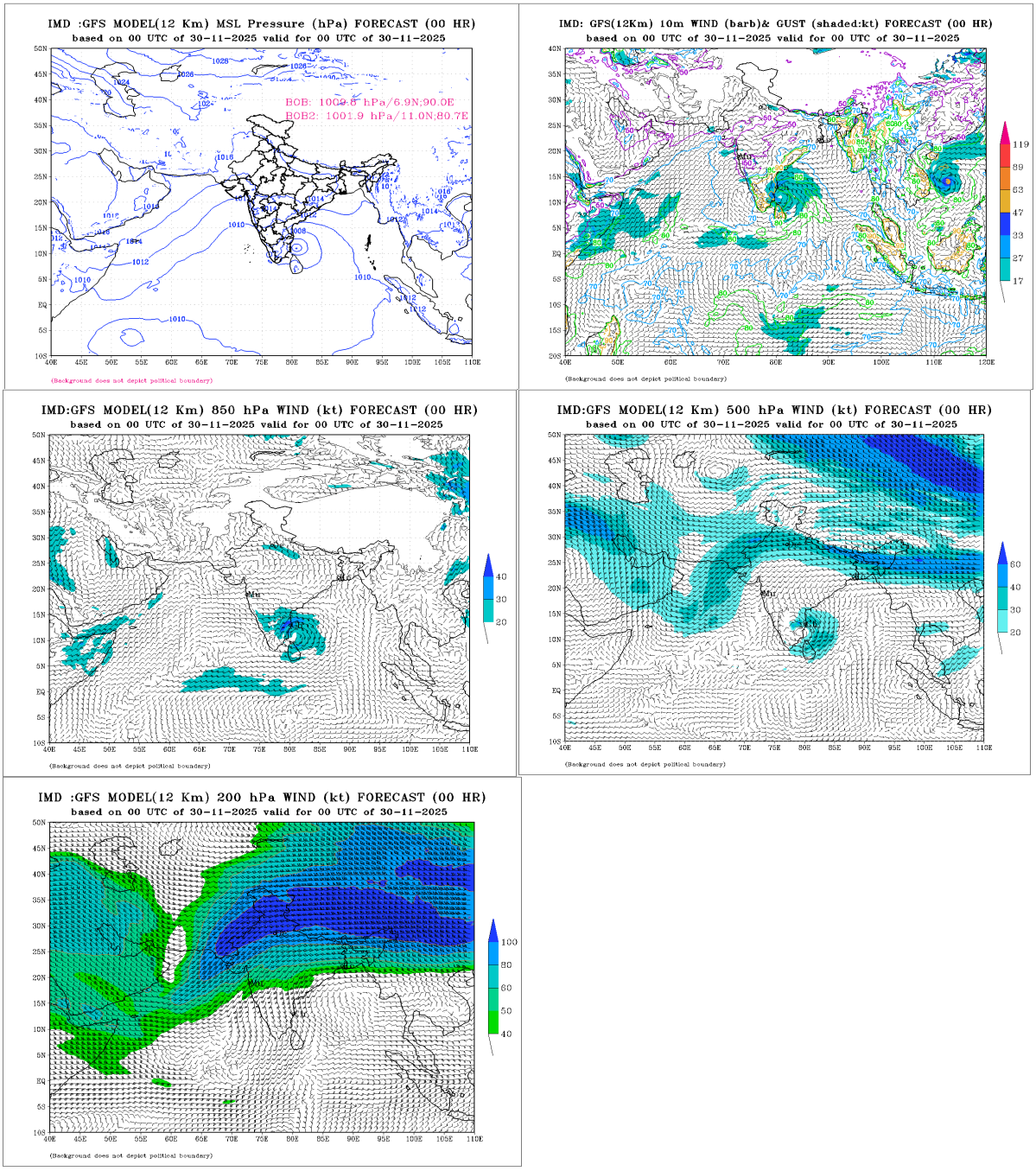


Fig.2.16.9(e): IMD GFS (T574) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 30th November, 2025

At 0000 UTC of 01st December, the MSLP field indicated a depression over southwest Bay and adjoining westcentral BoB off north Tamil Nadu and south Andhra Pradesh coast near (12.9N/81.1E). The associated circulation extended upto 850 hPa. The southerly wind prevails over the system region at 850 hpa was steering the system nearly northwards. Actually, the system lay as deep depression near (12.8N/80.6E) over southwest BoB adjoining westcentral BoB off north Tamil Nadu and south Andhra Pradesh coast. Thus, on 01st, December, the model was correctly capturing the location and intensity was slightly underestimated.

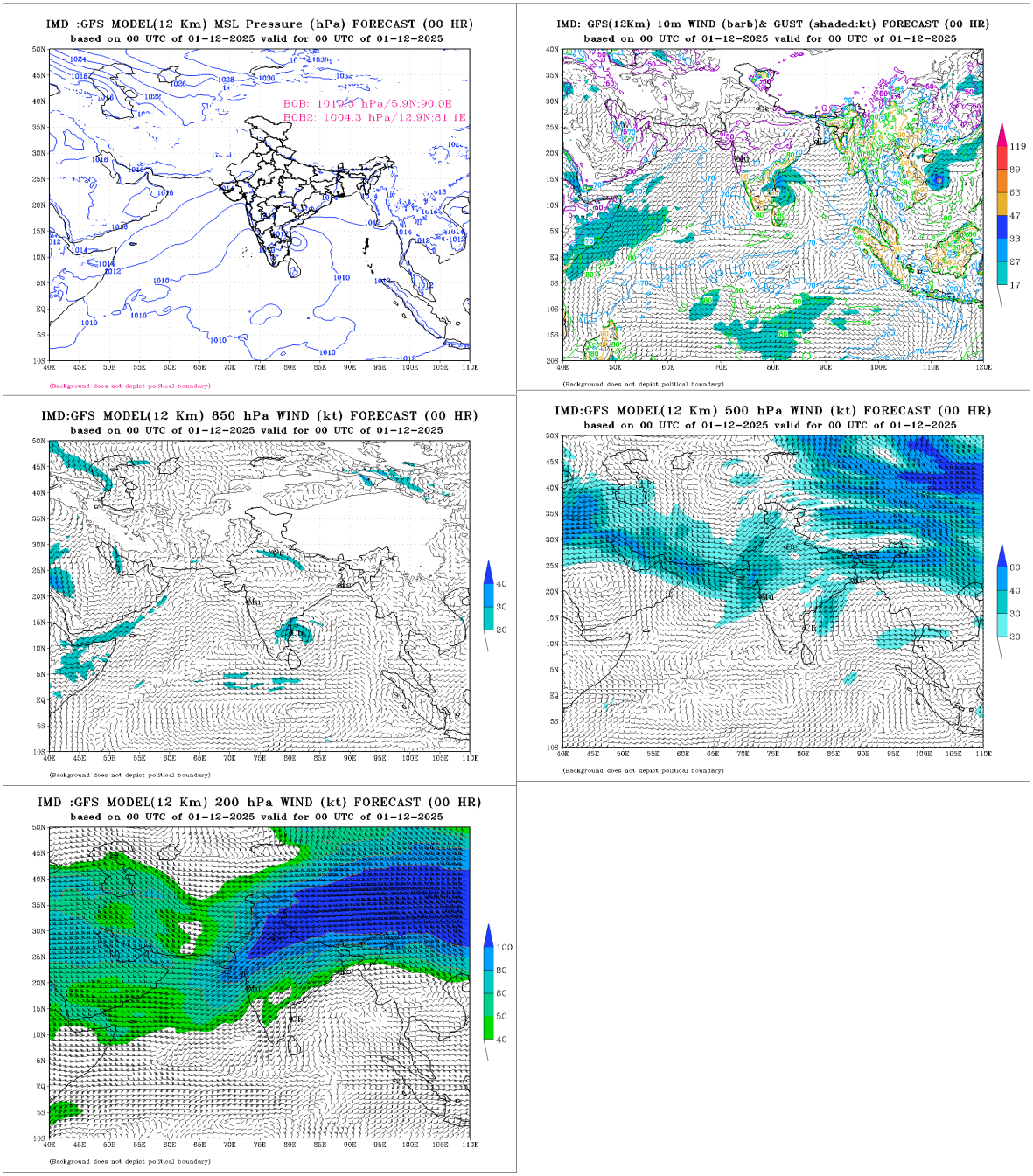


Fig.2.16.9(f): IMD GFS (T574) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 01st December, 2025

At 0000 UTC of 02nd December, the MSLP field indicated a depression over southwest Bay and adjoining westcentral BoB off north Tamil Nadu and south Andhra Pradesh coast near (12.4N/81.0E). The associated circulation extended upto 850 hPa. The southerly wind prevails over the system region at 850 hpa was steering the system nearly northwards. Actually, the system lay as depression near (12.9N/80.5E) over southwest BoB adjoining westcentral BoB off north Tamil Nadu and south Andhra Pradesh coast. However, it moved very slowly in past 24hrs which was not correctly captured by the models. Thus, on 02nd, December, the model was correctly capturing the intensity but movement was not captured well.

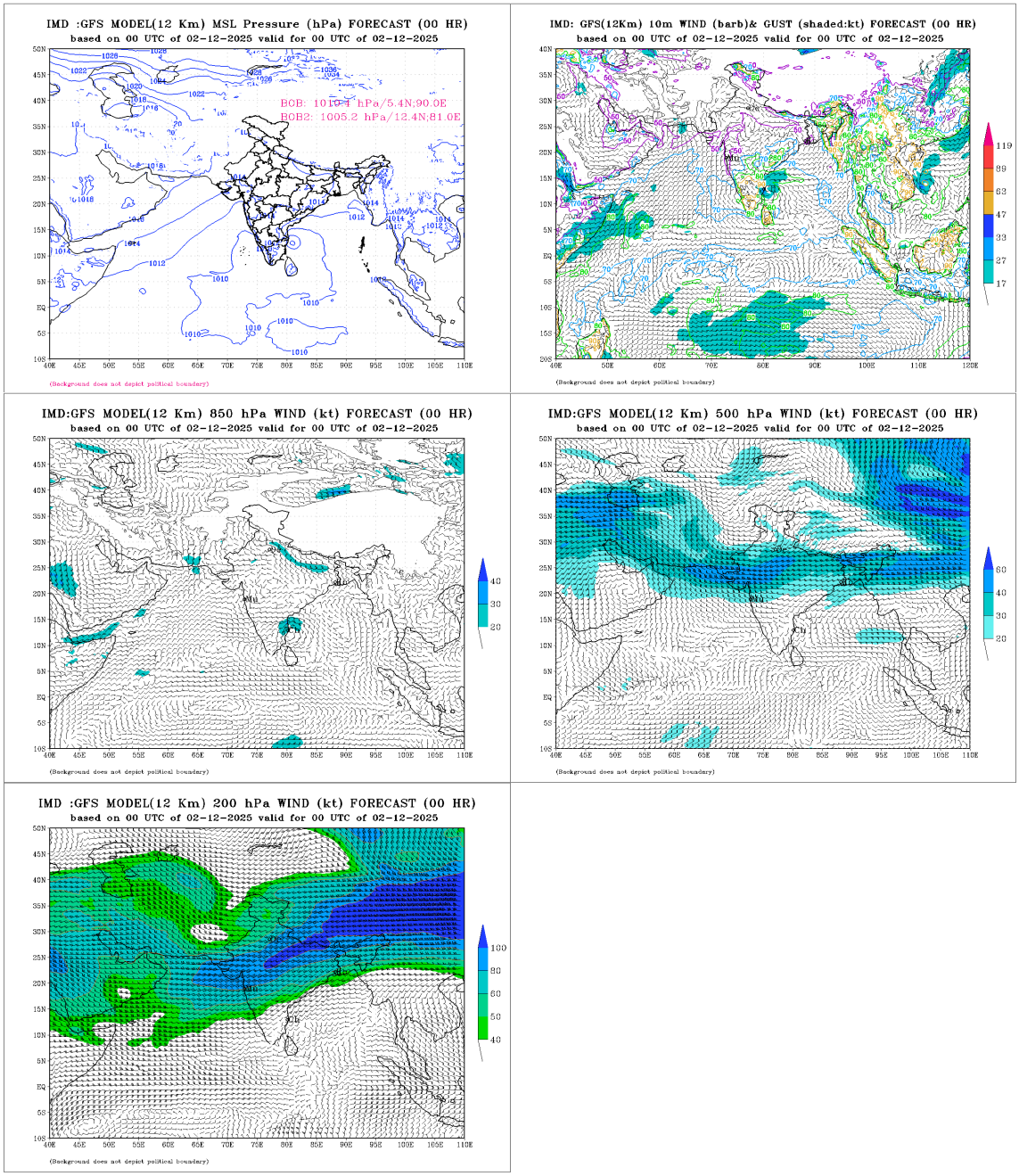


Fig.2.16.9(g): IMD GFS (T574) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 2nd December, 2025

2.16.5. Realised Weather:

2.16.5.1. Realised rainfall:

The system caused extremely heavy rains and landslides in Sri Lanka during 26th to 28th Nov. Over Tamil Nadu, heavy to very rainfall at some places and extremely heavy rainfall (≥ 20 cm) at isolated places was observed on 28th, 29th November & 1st December and heavy to very heavy rainfall at isolated places on 2nd December. Heavy to very heavy rainfall at some places with isolated extremely heavy rainfall occurred over Coastal Andhra Pradesh & Rayalaseema on 2nd December. Satellite-gauge merged rainfall plots showing realised winds during cyclone Ditwah is presented in **Fig.2.16.10**.

24 hours cumulative realised rainfall (≥ 7 cm) ending at 0830 hrs IST (0300 UTC) of date as recorded by various observatories in India is presented below:

29.11.2025:

Tamil Nadu, Puducherry & Karaikal: Kodiayakarai 25; Vedaranyam) 18; Velankanni 13; Nagapattinam, Tirupoondi 12 Each; Thalaignayer 11; Karaikal, Pamban 10 Each; Rameswaram Illayangudi Mandapam Kayalpattinam, Thirukuvalai, Thangachimadam 7 each.

30.11.2025:

Tamil Nadu, Puducherry & Karaikal: Karaikal 19; Sembanarkoil 17; Mayiladuthurai, Nagapattinam 15 each; Mayiladuthurai, Sirkali, Tiruvarur 14 Each; Tondi, Tirupoondi, Thangachimadam 13 Each; Sethiathope, Vedaranyam, Nannilam, Velankanni, Kodiayakarai, Kurungulam 12 each; Srimushnam, Thiruthuraipoondi, Tiruvarur AWS, Thalaignayer, Thirukuvalai, Neivasal Thenpathi, Echanviduthi 11 each; Cuddalore, Parangipettai, Kollidam, Tiruvadanai, Orthanad, Mannargudi, Mimisal, Collectorate, Theerthandathanam 10 each; Chidambaram, Rameswaram, Pattukottai, Peravurani, Thiruvidaimaruthur, Needamangalam, Valangaiman, Manalmedu, Avudayarkoil, Vattanam, Ayyampettai, Budalur, Vadakuthu, Ayinkudi, Nagudi, Vettikadu 9 Each; Arantangi, Pamban, Madukkur, Thanjavur, Tiruvaiyaru, Sivakasi, Aduthurai AWS, Thanjavur, Bhuvanagiri, Mandapam, Manjalaru, Annamalai Nagar, Lalpet, Nandhiyar Head 8 each; K.M.Koil, Mahabalipuram, Tarangambadi, Puducherry, Alangudi, Pudukottai, Devakottai, Adirampatnam, Vallam, Muthupet, Pandavaiyar Head, Kodavasal, Kothavacherry, Lower Anaicut 7 each.

01.12.2025: Coastal Andhra Pradesh & Yanam: Kavali 11

02.12.2025:

Tamil Nadu, Puducherry & Karaikal:

Ennore Zone1 26, Parrys 25, Ice House 22, Ponneri 21; Manali New Town 21, EnnorE, Perambur, Chennai Collectorate BU 20 each; DGP Office, Chennai (n), Red Hills 18 each; Gummidipoondi, Ayanavaram Taluk Office, CD Hospital Tondaipet 17 each; Puzhal 16; Cholavaram, MGR Nagar 14 Each; Anna University 13; Anna Uty, Sholinganallur 11 each; Chennai AP, Sivakasi, Hindusthan University, Alandur, Avadi 9 each; Taramani 8; Kolapakkam, Ambathur 7 each.

03.12.2025:

Rayalaseema: Chittamur 27, Kota 23, Gudur, Satyavedu, Tada 9 each; Sullurpeta 7;

Tamil Nadu, Puducherry & Karaikal: Hindusthan University 15; Chetpet 13; Tirumayam, Thamaraipakkam 12 each; Tiruvarur, Satyabama Uty, Thirukalukundram, Kudimiyanmalai 11 each; Kelambakkam, Mahabalipuram, Illuppur, Red Hills, Ulundurpet, Vadakuthu 10 Each; Pollachi, Tondi, Cholavaram, Ponneri, Tiruvarur, Gummidipoondi, Ambathur, Perambur, Neivasal Thenpathi 9 Each; Needamangalam, Uthukottai, RSCL Vallam 8 each; Virudachalam, Karaikal, Mannargudi, Sholinganallur, DSCL Eraiyur, Avadi, Ranipet 7 each;

Coastal Andhra Pradesh & Yanam: Edagali 24, Nellore 9;

Kerala & Mahe: Vannamada 7.

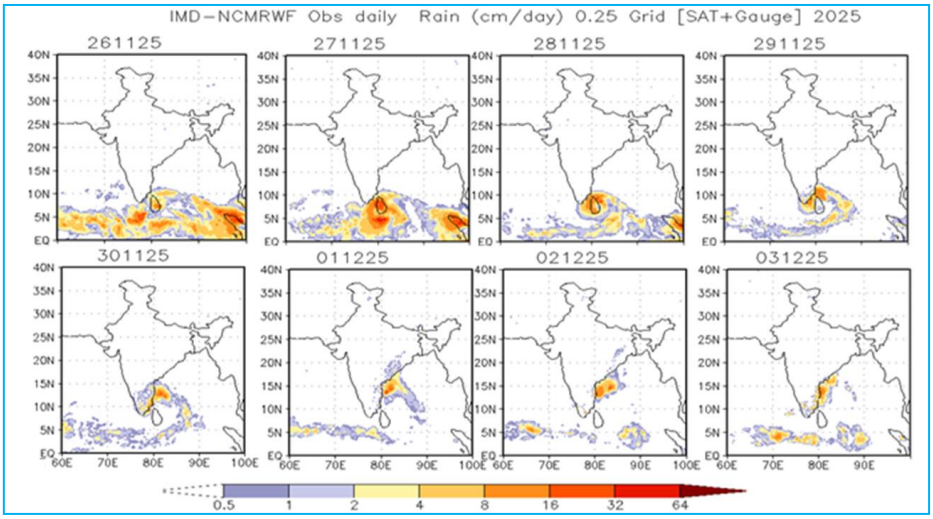


Fig.2.16.10: IMD-NCMRWF satellite-gauge merged rainfall plots during 26th Nov. to 3 Dec., 2025.

2.16.5.2 Realised wind:

Gale wind speed reaching 60 to 70 kmph gusting to 80 kmph was observed over south Sri Lanka on 27th Nov. and 65 to 75 gusting to 85 kmph was observed over central & north Sri Lanka during 27th to 28th Nov. Gale wind speed reaching 70-80 gusting to 90 kmph prevailed over southwest Bay of Bengal and south Tamil Nadu and adjoining north Tamil Nadu-Puducherry & north Sri Lanka during 29th morning to 30th morning. The realised wind during CS Ditwah is presented in **Fig.2.16.11.**

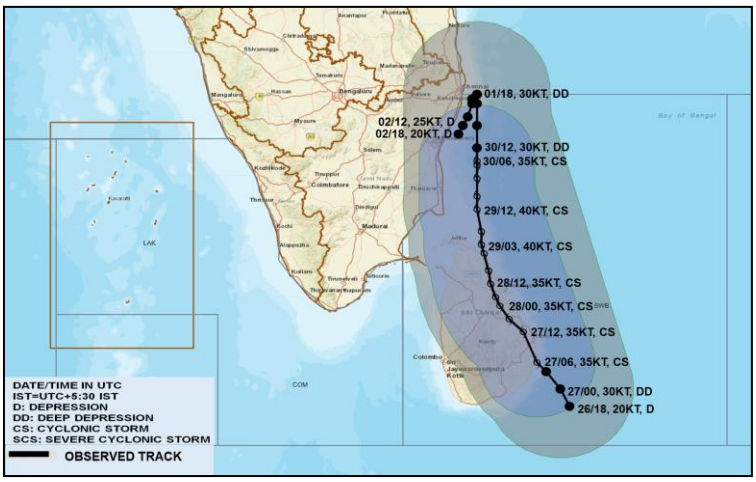


Fig.2.16.11: Realised maximum sustained wind during CS Ditwah

2.16.5.3 Realised storm surge:

Storm surge of height about 1.0 to 1.5 m above the astronomical tide inundated the low-lying coastal areas of north Sri Lanka during 27th morning till 29th evening. Storm surge of height 0.5 m – 1.0 m above astronomical tide inundated low lying areas of coastal Tamil Nadu – Puducherry on 29th November. Significant wave height of 1.8 m was observed near Pamban Bridge on 29th Nov.

2.16.6 Damage Report:

Sri Lanka:

Heavy rains and landslides in Sri Lanka caused at least 643 deaths, 183 people missing, and 18 injuries, making it the deadliest disaster since the 2004 tsunami. Over 6,200 homes were destroyed, and nearly 100,000 others were damaged. The storm caused flooding in several regions, with train services suspended and evacuations near reservoirs. Power outages affected 30% of the country, and around 1.46 million people were impacted. A helicopter crash during relief efforts killed one and injured four. Economic losses ranged from $1.6 billion to $7 billion. The country faced widespread damage and displacement.

Tamil Nadu:

Cyclone Ditwah killed three people and 149 cattle. Two deaths occurred due to wall collapse, and one person died from electrocution. The heavy rains damaged around 57,000 hectares of farmland and 234 huts.

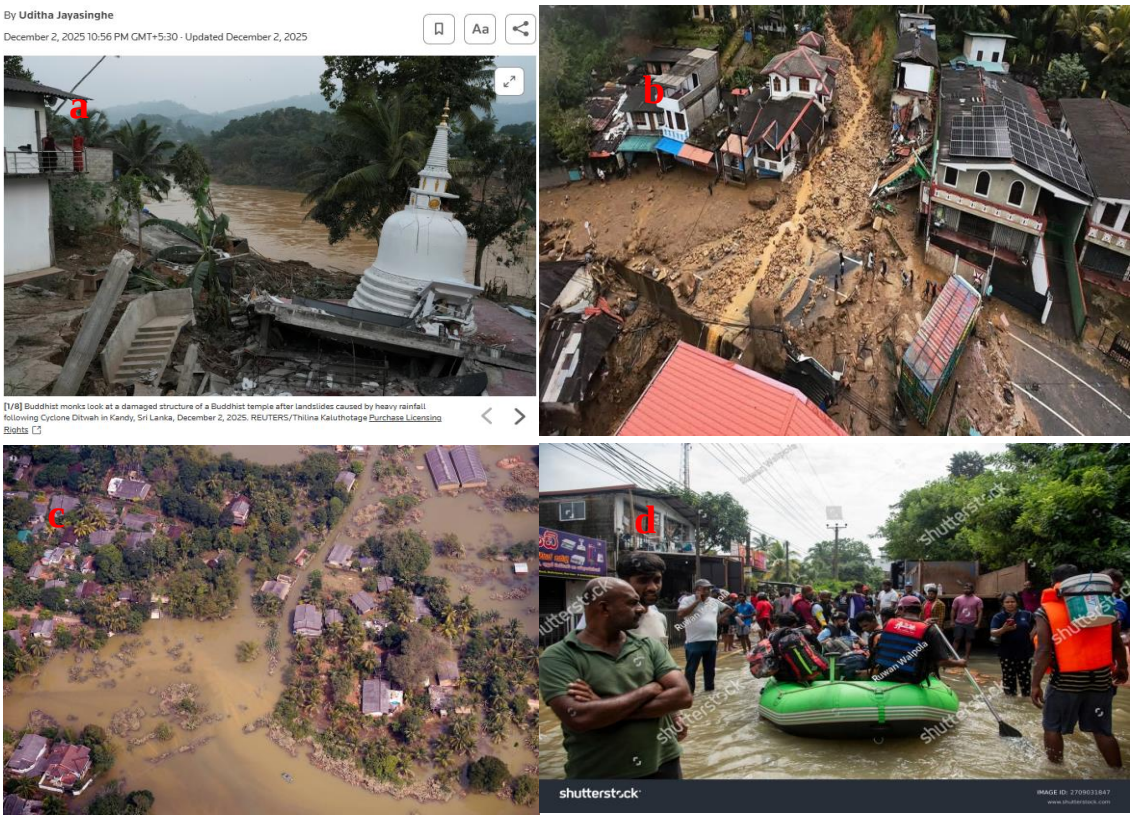


Fig.2.16.12: Damage in Sri Lanka due to cyclone Ditwah. Image Sources: (a) Reuters, (b) News.un.org, (c): Reuters, and (d) shutterstock.com.

CHAPTER-III

3.1. NWP Models in operational use during the year 2025

For predicting cyclogenesis, track, intensity, landfall point & time and associated adverse weather including rainfall, wind & storm surge, RSMC New Delhi utilizes an array of models including various global and regional in various scales from extended range to short to medium range. The forecast is based on consensus derived from various models which is further modulated utilizing observations and forecasters experience & expertise. Details of these models are discussed in Chapter-1.

3.2. Forecast performance of NWP models during severe cyclonic storm Shakhti

The forecasts issued by various NWP models and utilized during operational weather forecasting of IMD are described and analysed against best track location & intensity of the cyclonic storm during 2025 storms. All the model forecasts are not considered for the discussion as they were not available and didn't contribute to any guidance during real time forecasting of the tropical cyclone Shakhti. The analytical descriptions of the track forecast from various NWP models are given sequencially with time in the following sub-section below.

3.2.1 Verification of Track forecasts:

The Fig. 3.2.1(a) describes the track forecasts of GEFS model based on 0000 UTC of 01st October. The left panel represents the accumulated probability (%) of the system passing within 120 Km from the ensembled mean forecast locations at different forecast hours. The right panel displayed the track forecast from the control run of the GEFS model along with ensembled mean track forecast. Both the control and ensembled mean forecast indicated initial southwestwards movement of the storm for about 6 hours. Thereafter, the storm was likely to move northwestwards for subsequent 6 hour before it starts moving southwestward thereafter. The ensemble members of the model furnished consensus amongst them up to 48 hours as the accumulated probability was more than 70% and thereafter the spread among them increased. However, a large number of members are showing anti-clockwise recurving loop back towards Gujarat coast after 48 to 72 hrs of forecast, a few members were furnishing the same after longer forecast hours.

The track forecast of NEPS model based on 00 UTC of 01st October is shown in Fig. 3.2.1(b). The left panel represents the forecast tracks of ensemble members of NEPS model at various forecast range, denoted by different colours. The right panel displayed the accumulated probability (%) of the system passing within 120 Km from the ensemble mean forecast locations at different forecast hours. The ensemble members show a clustering of tracks with nearly westward movement. The spread amongst the members was very high even after 24 hrs. A group of ensemble members showing initial west-northwestwards movement over the northeast Arabian Sea and thereafter west-southwestward movement over the northwest Arabian Sea. Another set of members was quickly taking the storm directly west-southwestwards towards Oman coast. A few members were also showing anti-clockwise recurvature after 72 hrs of forecast. The fact was clarified in the right panel, where the highest probability can be seen within 72 hrs spread in the cumulative probability diagram. It can be seen that there is about a 40 % probability that the tracks of the members could reach up to the Oman coast. However, the deterministic run illustrated anti-clockwise recurvature after 72 hours. Therefore, the results in Fig 3.2.1(a) & (b) indicated that both the

ensemble models GEFS and NEPS could predict the initial west-northwestwards movement with higher probability. However, in the case of both models, many members indicated anti-clockwise recurvature after 72 hrs, which was not realised as the storm continued west-southwestwards movement for 120 hrs before it showed anti-clockwise loop.

The figures 3.2.1(c)-3.2.1(e) displaying the forecast track information of IMD MME, along with individual members, GEFS and NEPS models track forecasts issued based on 00 UTC of 03rd-06th October, 2025 respectively.

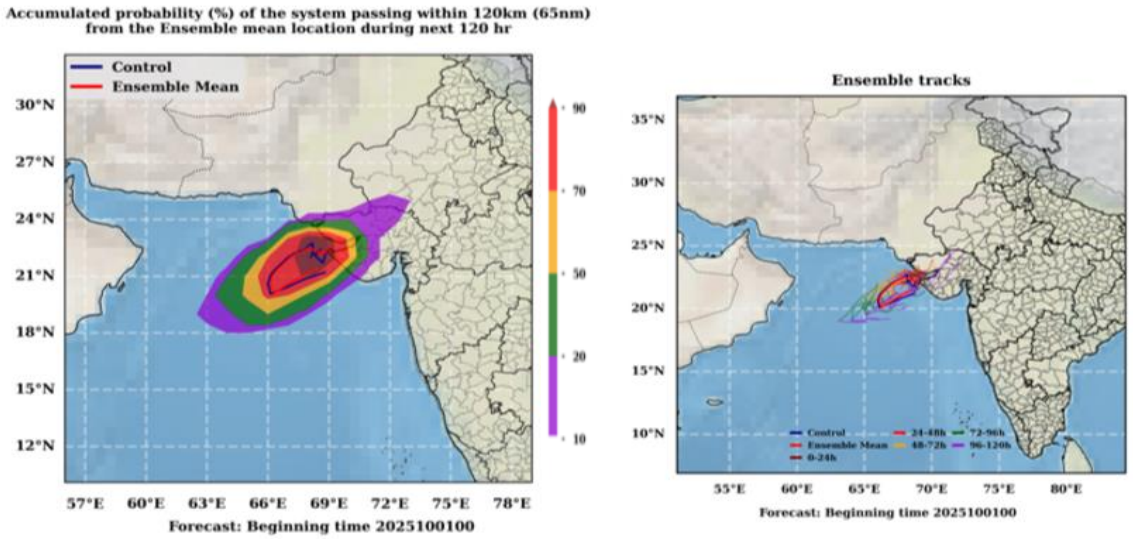


Fig. 3.2.1(a). Accumulated probability (in %) of the system passing within 120 km from the ensemble mean forecast locations at different forecast hours issued by the GEFS model at 0000 UTC of 01 October, 2025.

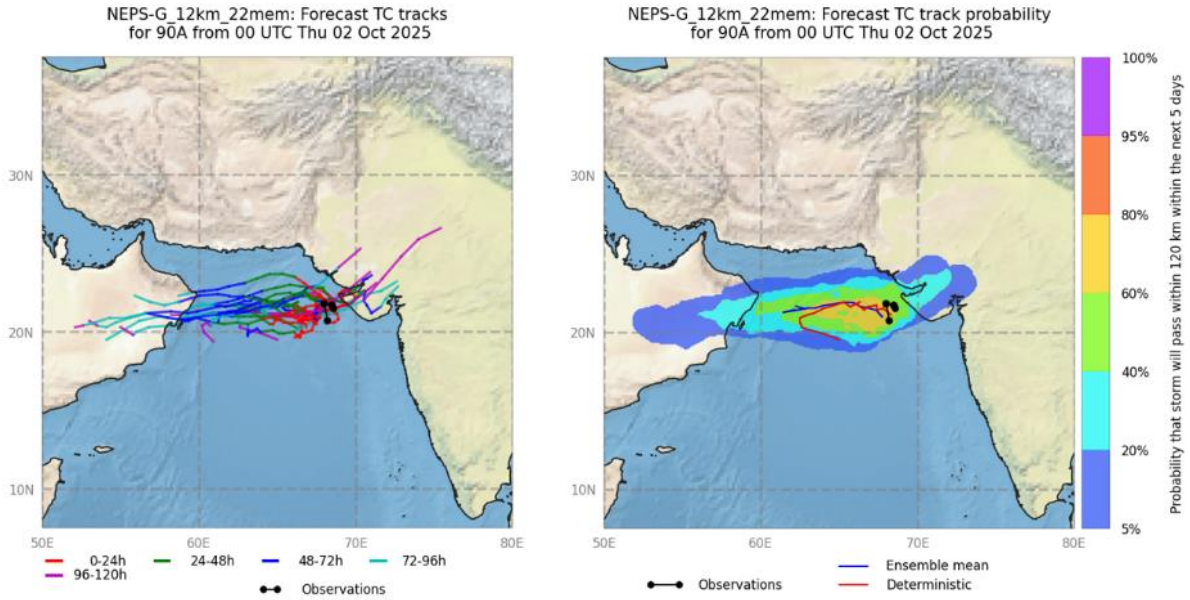


Fig. 3.2.1(b). Accumulated probability (in %) of the system passing within 120 km from the ensemble mean forecast locations at different forecast hours issued by the NEPS model at 0000 UTC of 02 October, 2025.

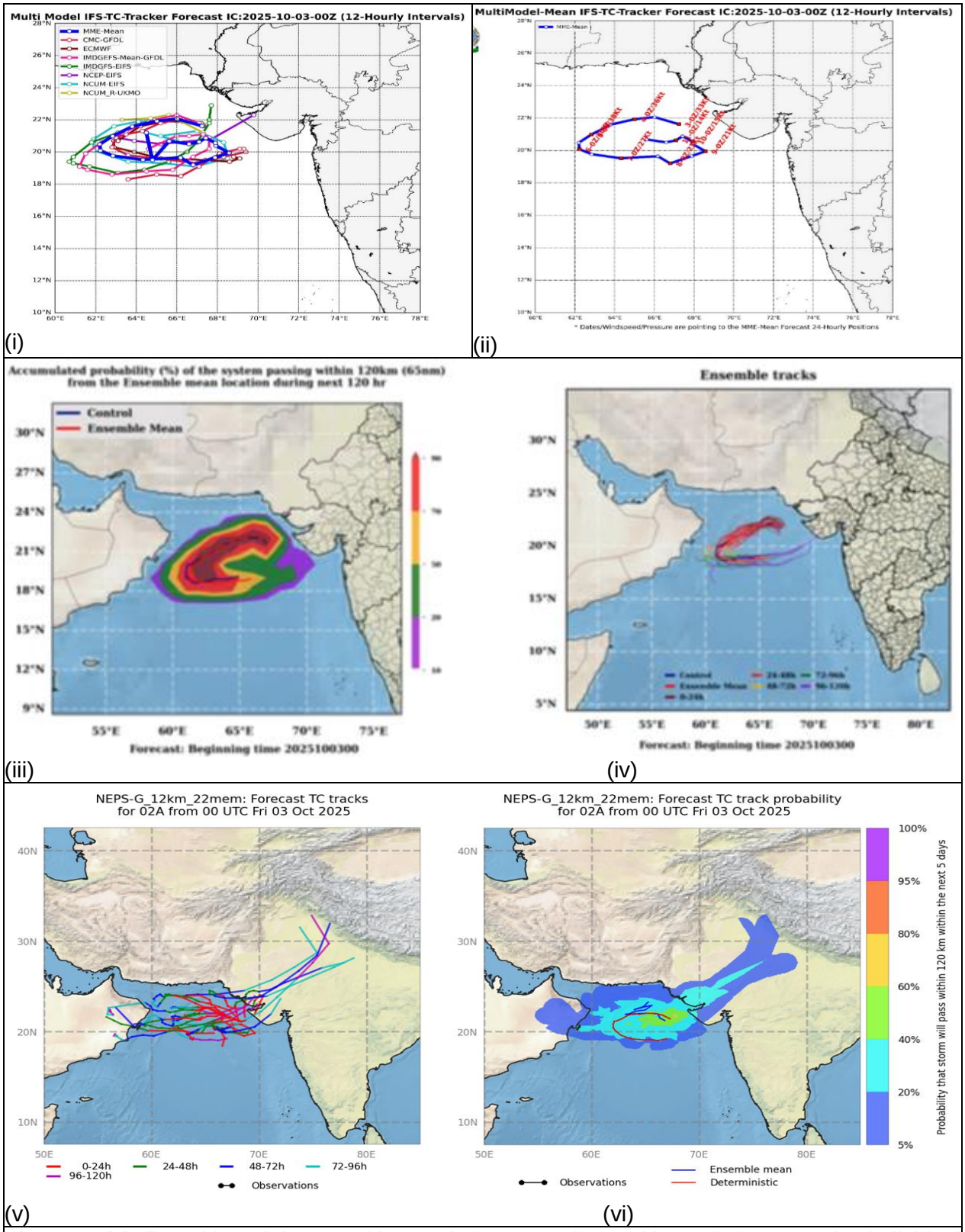


Fig. 3.2.1(c) (i) Multi-Model Ensemble Track forecast along with track forecasts by individual member models, (ii) MME track, accumulated probability (in %) of the system passing within 120 km from the ensemble mean forecast locations at different forecast hours issued by the (iii) & (iv) GEFS model and (v) & (vi) NEPS model based on 0000 UTC of 03rd October, 2025.

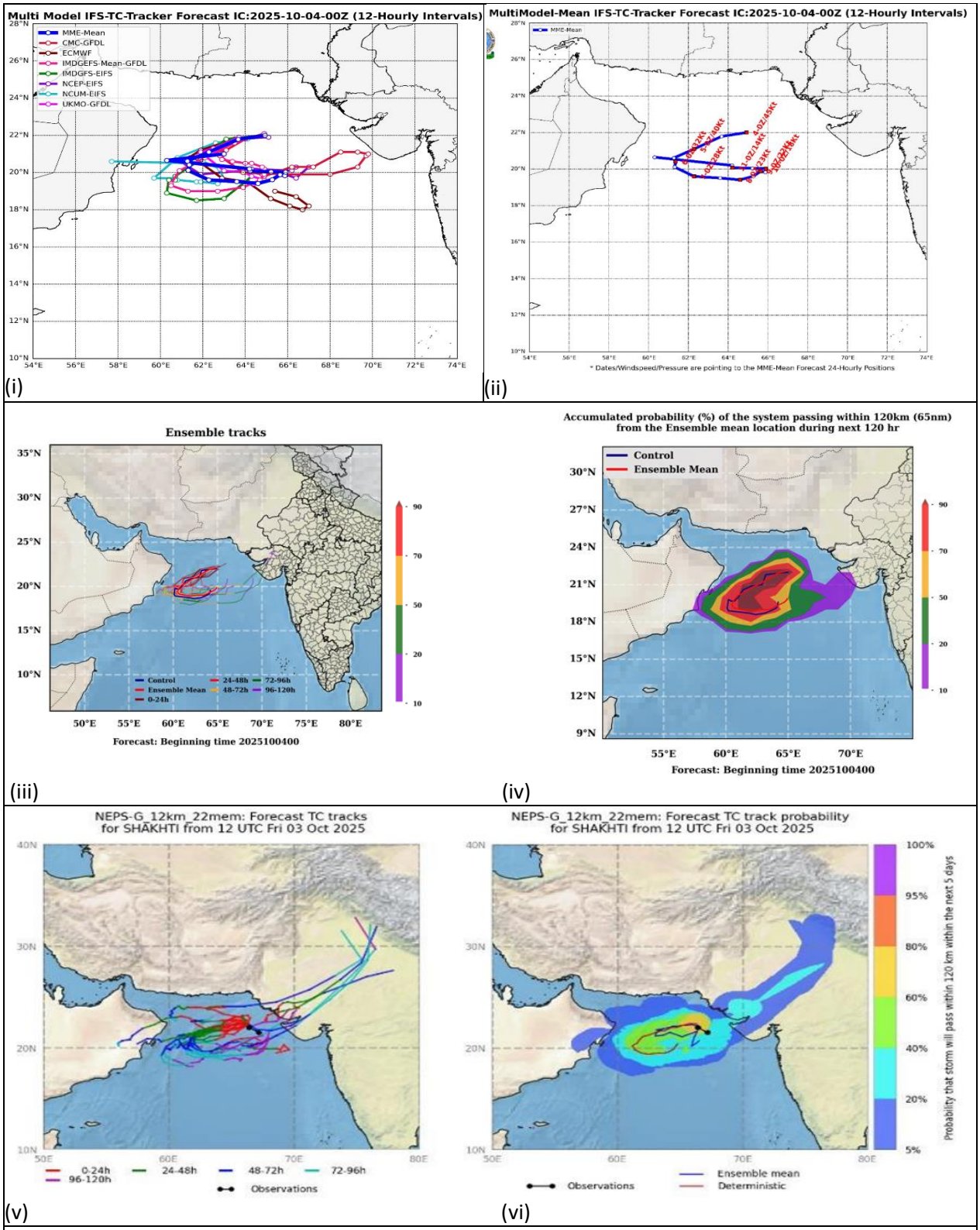


Fig. 3.2.1(d) (i) Multi-Model Ensemble Track forecast along with track forecasts by individual members, (ii) MME track, accumulated probability (in %) of the system passing within 120 km from the ensemble mean forecast locations at different forecast hours issued by the (iii) & (iv) GEFS model and (v) & (vi) NEPS model based on 0000 UTC of 4th October, 2025.

The MME track forecast [Fig 3.2.1(c)(i) & (ii)] based on 00 UTC of 03rd October was indicating initial nearly westward movement for 24 hrs thereafter west-southwestward

movement till 00 UTC of 06th October. Then there is an anti-clockwise recurvature at latitude 20.3° N & longitude 62.1° E towards southwest direction reaching over the northwest Arabian Sea on 06th October. Whereas as per best track, the Severe Cyclonic storm "SHAKHTI" continued west-southwestwards movement till 00 UTC of 07th October before it recurved anti-clockwise at latitude 19.5° N & longitude 60.1° E towards southeastwards over westcentral Arabian Sea. Thereafter, the MME forecast was predicting eastward movement across westcentral and eastcentral Arabian Sea towards Indian Coast for subsequent 3 days. Amongst individual members [in Fig. 3.2.1(c)(ii)], IMD GFS, NCUM and GEFS nearly followed the MME track except the point of recurvature was reached on 08th October which is delayed compared to MME. IMD GFS and GEFS tracks extended more towards southwest over westcentral Arabian sea before it started recurving towards southeastwards. Whereas NCUM followed a zigzag path while moving westwards and started anti-clockwise recurvature on 08th October. The ECMWF and CMC models also showed west-southwestward movement of the storm before its anti-clockwise recurvature at latitude 20.5° N & longitude 63.0° E, i.e. the point of recurvature in the model forecasts were northeast of the actual location of recurvature. However, the time of recurvature was close to observation. Comparing all the models, IMD GFS was showing comparatively better forecast track in terms of location and time of the anti-clockwise recurvature towards southeast direction. The deviation of forecast tracks of NCEP GFS, NCUM-G and UKMO were more compared to the best-track.

The track forecasts by the GEFS model [Fig. 3.2.1(c) (iii)-(iv)], indicated initial west-northwestwards movement followed by west-southwestward movement upto 96 hrs before it recurved anti-clockwise direction towards southeast over westcentral Arabian Sea. The accumulated probability of the ensembled tracks illustrating that most of the members have consensus for a recurving track. However, the zone of higher TC track probability has an eastward bias compared with the best track. On the other hand, the track forecasts of NEPS model ([Fig. 3.2.1(c) (v)-(vi)]) were showing randomness in the forecast of various members. There was only 40%-60% probability upto 24 hrs forecast. This implies that the NEPS model could not capture the recurving track of the cyclone, as it shows only 20%-40% TC track probability near the actual zone of recurvature.

Fig. 3.2.1(d) & 3.2.1(e) are representing the track forecast of various models issued based on the initial conditions of 00 UTC of 04th & 05th October respectively. Comparing MME forecasts in both the pictures it is clear that as the lead period reduced to predict the anti-clockwise recurvature and weakening of the storm around early morning of 07th October, the forecast accuracy increased with lead time. The consensus amongst the individual member models also increased from 04th to 05th October. However, still there are variations in space and time with respect to the occurrence of recurvature as well as weakening of the storm. Amongst all NCUM-G and UKMO models was the outlier on 04th October. the most of the models as well as IMD MME produced sharp recurvature towards east-southeast direction whereas in reality the Cyclone recurved slowly initially southward then southeastward direction. On 05th October the track forecast of NCUM-G was closer to the best track. The GEFS forecast [Fig. 3.2.1(e) (iii)-(iv)] was showing very high probability in terms of anti-clockwise recurvature but after recurvature the eastward component was stronger compared to southward component of the storm movement. Looking at the [Fig 3.2.1(e) (v)-(vi)], it is inferred that the model showed more than 60% probability towards continued southwestward

movement of the storm reaching near Oman coast. However, the ensembled mean forecast was closer to observed track with 60% TC track probability.

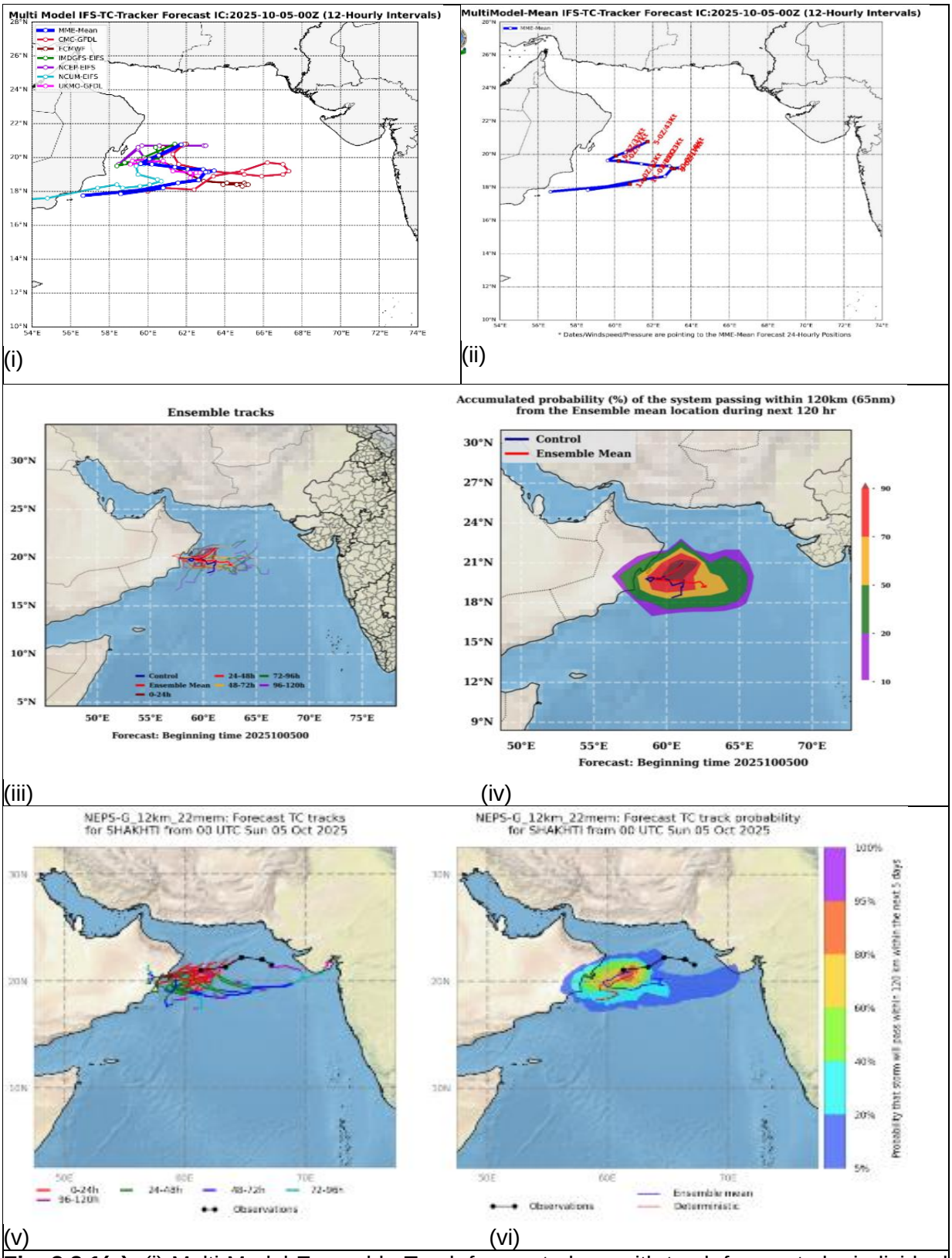


Fig. 3.2.1(e) (i) Multi-Model Ensemble Track forecast along with track forecasts by individual member models, (ii) MME track, accumulated probability (in %) of the system passing within 120 km from the ensemble mean forecast locations at different forecast hours issued by the (iii) & (iv) GEFS model and (v) & (vi) NEPS model based on 0000 UTC of 5th October, 2025.

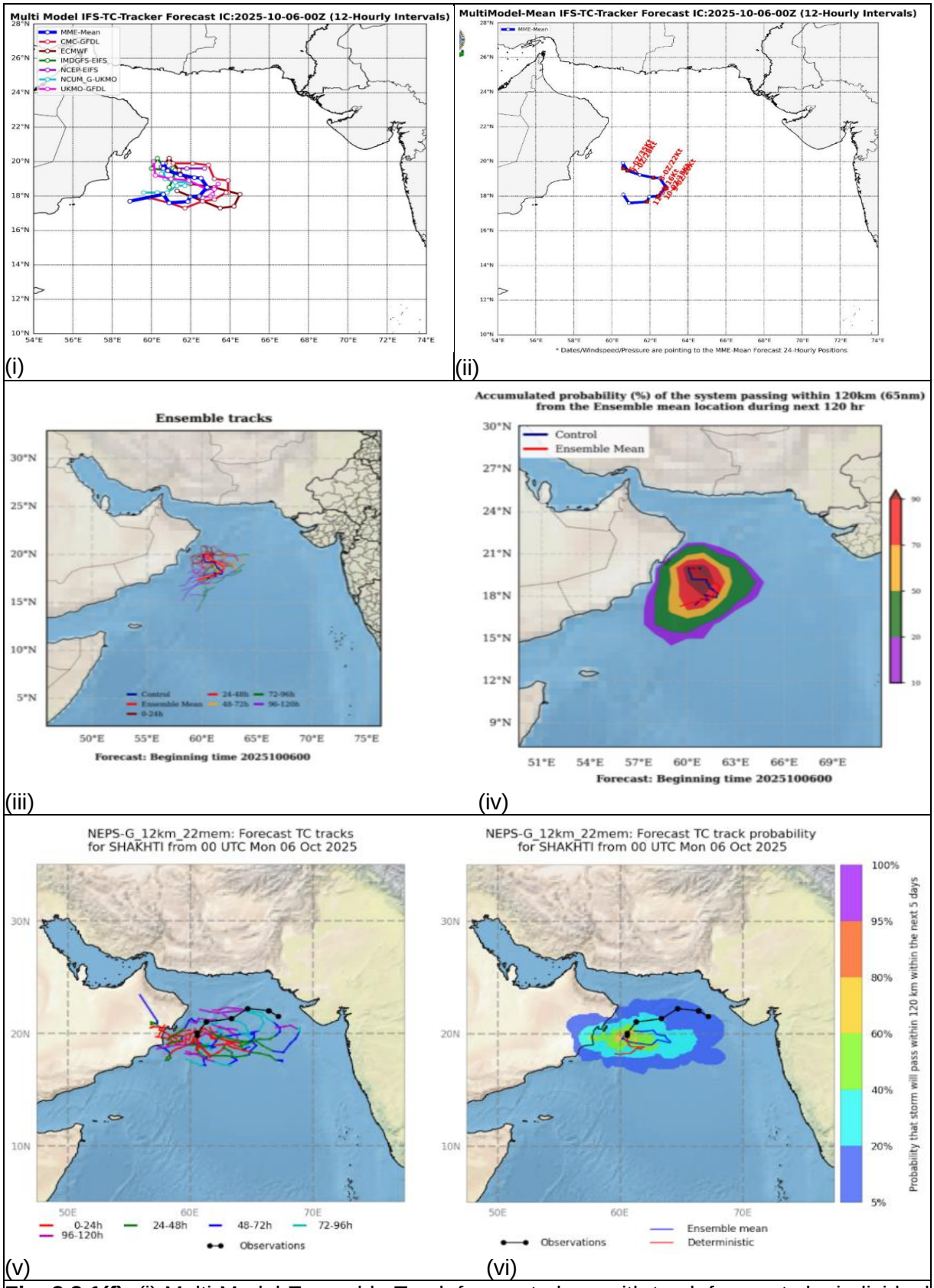


Fig. 3.2.1(f) (i) Multi-Model Ensemble Track forecast along with track forecasts by individual member models, (ii) MME track, accumulated probability (in %) of the system passing within 120 km from the ensemble mean forecast locations at different forecast hours issued by the (iii) & (iv) GEFS model and (v) & (vi) NEPS model based on 0000 UTC of 6th October, 2025.

The MME forecast [Fig 3.2.1(f) (i)-(ii)] along with the individual member forecast clearly depicted initial south-southeastwards recurvature followed by a southeastward movement of the storm for upto 48 hrs. The forecast tracks after 48 hrs were not considered for the discussion as the accuracy in detecting the centre of the low pressure system with intensity weaker than a depression, by the tracker software, faltered due to inadequacies in the tracking algorithm. MME track forecast furnished a northward bias compared to the best track, which increased along with forecast hours. starting from the initial position of the storm upto 48 hrs forecast, all individual models indicated a large variation. CMC and NCEP GFS models were among the outliers. UKMO and NCUM-G were close to the best track. The forecast of the GEFS model is shown in [Fig 3.2.1(f) (iii)-(iv)]. The accumulated probability is more than 90% for the forecast track upto 48 hrs. Mean track of the GEFS model was in agreement with the best track. However, there were still several members scattered from the central cluster. The [Fig 3.2.1(f) (v) & (vi)] indicate the clustering of tracks by NEPS members and TC track probability of the model, respectively. It is obvious that the members lacked consensus as the tracks were spreading in every direction from the initial location. However, the ensemble mean track with 40% to 60% probability lay along the best track.

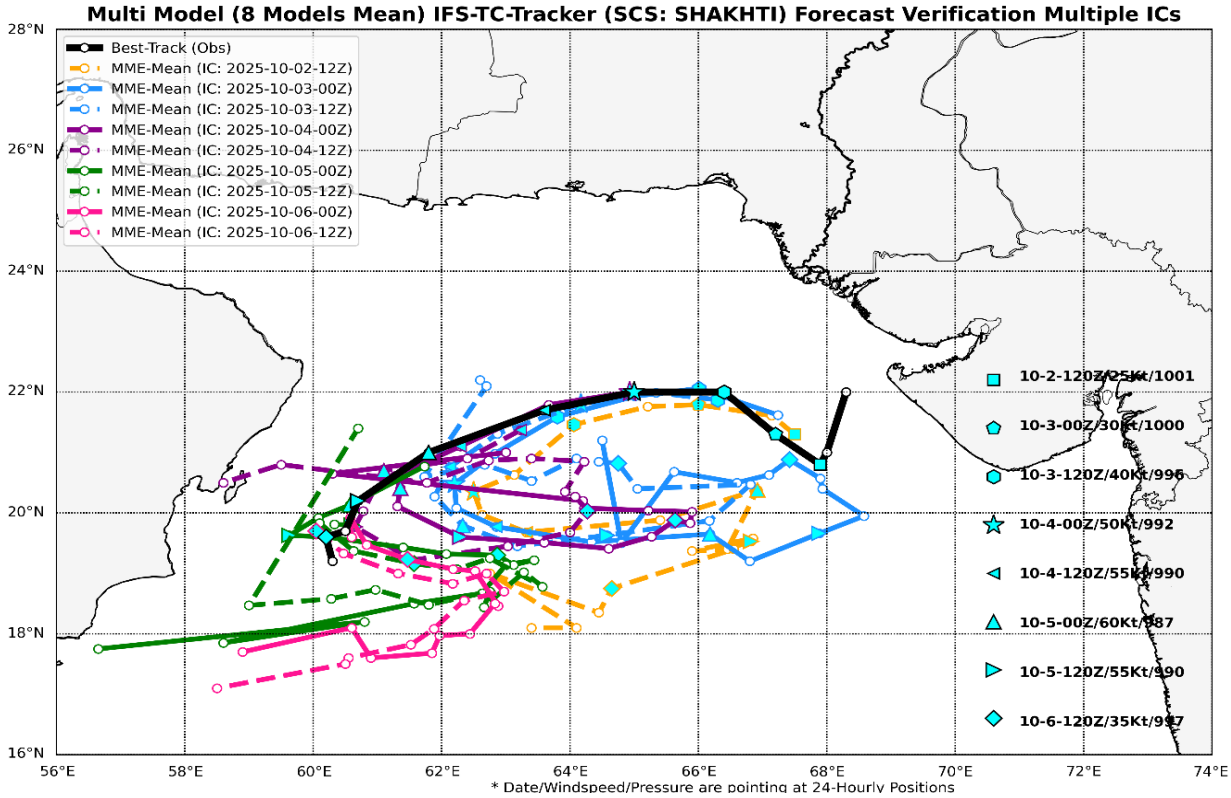


Fig. 3.2.2 Comparative forecast track cluster from different initial times during the life of the severe cyclonic storm Shakhti

The Fig 3.2.2 displayed the cluster of forecast tracks from different initial condition issued during the lifetime of Severe Cyclonic Storm “SHAKHTI”. It is observed that MME could capture initial west-northwestward movement of the storm followed by nearly westward movement for some time and west-southwestward movement before the storm took anti-clockwise turn towards south-southeastward. However, if we compare the location of the point of recurvature in the MME forecasts, the forecast issued during initial stage of the cyclonic storm portrayed early anti-clockwise turn around the location nearly 2.5o northeast

of observed location. The forecasts during 04th October to 05th October generated more accurate track forecast in terms of time and location of the recurvature over westcentral and adjoining northwest Arabian Sea. The segment of the tracks provided by the models after the storm weakened into a well marked low pressure area is not considered for discussion.

Track and Intensity Errors

In the **Fig 3.2.3,** all forecast track errors in terms of mean direct position error are described.

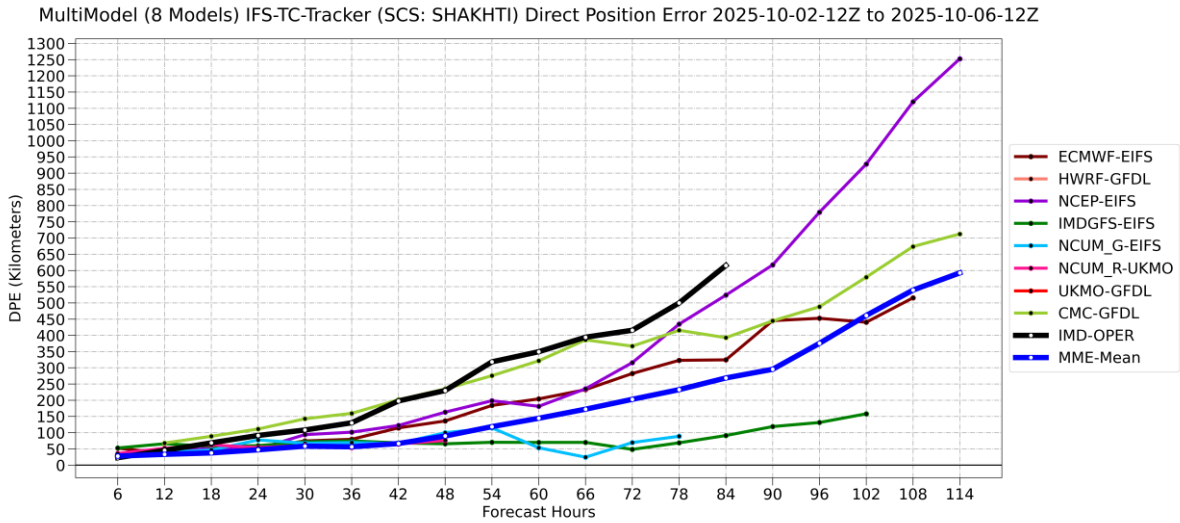


Fig. 3.2.3 Comparative analysis of forecast track errors in terms of mean Direct Position error (DPE) during Shakhti

The errors (in km) of the IMD MME forecast, along with other individual member models in predicting the track of the severe cyclonic storm Shakhti up to 114 hours are plotted in **Fig. 3.2.3**. It is clear that the track errors for all model forecasts are increasing uniformly with increasing forecast hours. The direct position errors for all forecasts are less than 100 km up to 24 hours. In this particular cyclonic storm, the operational forecast errors are higher than the errors of the model after 48 hours. Amongst all models, the IMD MME delivered the lowest error compared to other forecasts up to 42 hours. The combinations of IMD-GFS and NCUM-G models with EIFS tracker produced smaller errors (less than 100 km) compared against other forecasts up to a lead time of 78 hours. The IMD-GFS had track errors of less than 150 km, even up to 108 hours. The CMC model produced forecasts with the largest error amongst all NWP models, followed by NCEP-GFS up to 3 days.

The mean absolute errors in the intensity forecasts by various models, along with IMD MME and IMD operational forecasts, are plotted in Fig. 3.2.4. It is noticed that the operational forecasts invariably had the least error (less than 5 knots) compared to other forecasts up to 60 hours. However, operational forecast errors increased beyond that point. The model errors in predicting intensity show a wide variation with errors ranging between 5-15 kts, 9-23 knots and 4-15 knots for the lead time of 24, 48 and 72 hours. The decreasing trend of errors by the models in forecasting the intensity after 66 hours is an evident fact that came out after the analysis. A few individual models (e.g., NCUM-G-EIFS and NCEP-EIFS) had smaller values of errors compared to MME for nearly all forecast hours. Still MME produced consistent intensity forecast errors, which show an initial increasing trend up to 36 hours and then again a decreasing trend after 66 hours.

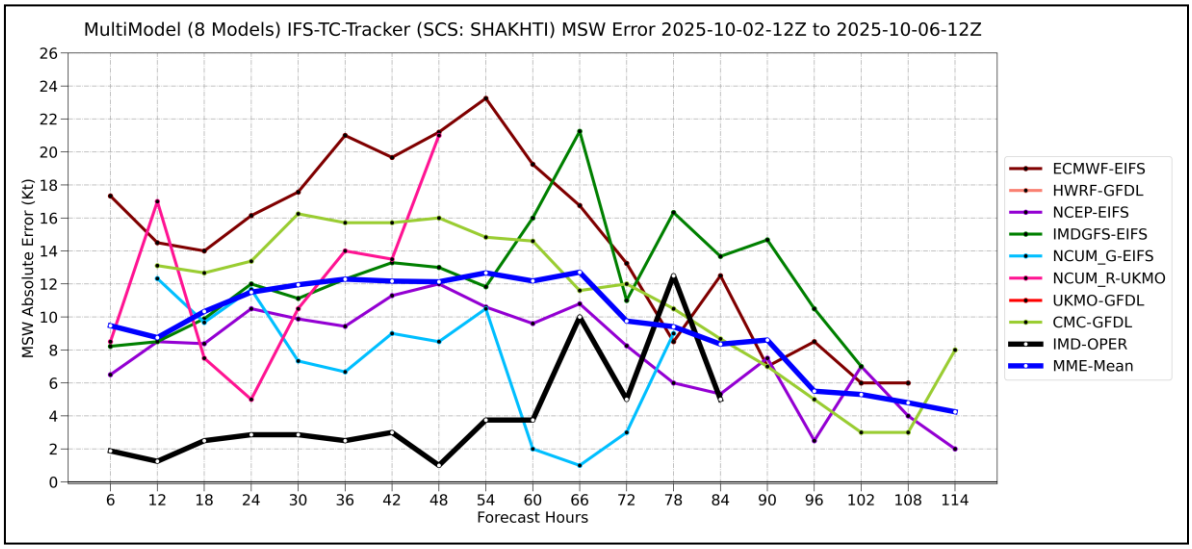


Fig. 3.2.4 Comparative analysis of intensity forecast errors in terms of mean absolute errors during Shakhti

The average track forecast errors by various models compared to operational forecast errors which are described in **Fig. 3.2.3** are also presented in **Table 3.2.1**. The model errors in forecasting the track of the severe cyclonic storm Shakhti are compared from 12 hour up to 108 hours.

The IMD MMEM had least error for 24 hrs lead period. The errors were the least from IMD-GEFS mean forecast for 48 hours and IMD-GFS for both 72 and 96 hours. Up to 48 hours all models except ECMWF and NCEP-GFS had track error less than 100 km.

Table 3.2.1 Average track forecast errors (Direct Position Error (DPE)) in km

Model	12	24	36	48	60	72	84	96	108
NCUM_R-UKMO	52.04 (2)	54.22 (2)	54.17 (2)	76.22 (1)	NaN (0)	NaN (0)	NaN (0)	NaN (0)	NaN (0)
ECMWF-EIFS	36.77 (8)	52.58 (7)	79.63 (6)	136.19 (5)	204.16 (4)	282.52 (4)	324.53 (2)	452.63 (2)	515.68 (1)
IMDGFS-EIFS	65.98 (8)	60.03 (8)	74.82 (7)	65.79 (6)	70.02 (5)	48.56 (4)	91.27 (3)	131.43 (2)	NaN (0)
IMDGEFS_mean_GFDL	47.62 (6)	49.25 (6)	52.15 (6)	57.95 (5)	83.82 (5)	115.52 (4)	165.16 (3)	254.74 (2)	300.55 (1)
NCEP-EIFS	37.48 (8)	49.95 (8)	101.61 (7)	163.36 (6)	181.32 (5)	316.00 (4)	524.01 (3)	779.56 (2)	1119.83 (1)
NCUM_G-EIFS	39.95 (3)	77.64 (3)	69.55 (3)	100.04 (2)	53.53 (1)	69.64 (1)	NaN (0)	NaN (0)	NaN (0)
NCUM_G-UKMO	27.24 (2)	47.55 (1)	NaN (0)	NaN (0)	NaN (0)	NaN (0)	NaN (0)	NaN (0)	NaN (0)
CMC_GFDL	68.05 (9)	111.39 (8)	159.61 (7)	234.80 (6)	321.66 (5)	366.75 (4)	392.87 (3)	488.26 (2)	673.78 (1)
MMEM	33.34 (9)	47.23 (8)	56.53 (7)	89.76 (6)	144.53 (5)	202.90 (4)	268.76 (3)	375.50 (2)	539.57 (1)
IMDOPER	45.43 (8)	91.50 (7)	130.52 (6)	229.99 (5)	349.64 (4)	415.79 (3)	615.67 (1)	NaN (0)	NaN (0)

(Number of forecasts verified is given in the parentheses)

Similar to Table 3.2.2, the average errors in the intensity forecasts by various models, along with IMD MME and operational forecasts, are described in **Table -3.2.2** up to 108 hours. All error values are positive, indicating the overestimation by every model. As plotted in Fig. 3.2.4, the values of the errors in **Table 3.2.2** show that the operational forecasts had the least errors up to 60 hours.

Table 3.2.2 Average Intensity Forecast Errors of maximum sustained wind in knots Negative sign indicates underestimation of intensity and vice versa

Model	12	24	36	48	60	72	84	96	108
NCUM_R-UKMO	17.0 (2)	5.0 (2)	14.0 (2)	21.0 (1)	NaN (0)	NaN (0)	NaN (0)	NaN (0)	NaN (0)
ECMWF-EIFS	14.5 (8)	16.14 (7)	21.0 (6)	21.2 (5)	19.25 (4)	13.25 (4)	12.5 (2)	8.5 (2)	6.0 (1)
IMDGFS-EIFS	8.5 (8)	12.0 (8)	12.29 (7)	13.0 (6)	16.0 (5)	11.0 (4)	13.67 (3)	10.5 (2)	NaN (0)
IMDGEFS_mean_GFDL	7.83 (6)	11.17 (6)	12.83 (6)	12.4 (5)	11.8 (5)	11.75 (4)	10.67 (3)	7.5 (2)	9.0 (1)
NCEP-EIFS	8.5 (8)	10.5 (8)	9.43 (7)	12.0 (6)	9.6 (5)	8.25 (4)	5.33 (3)	2.5 (2)	4.0 (1)
NCUM_G-EIFS	12.33 (3)	11.67 (3)	6.67 (3)	8.5 (2)	2.0 (1)	3.0 (1)	NaN (0)	NaN (0)	NaN (0)
NCUM_G-UKMO	4.5 (2)	11.0 (1)	NaN (0)	NaN (0)	NaN (0)	NaN (0)	NaN (0)	NaN (0)	NaN (0)
CMC_GFDL	13.11 (9)	13.38 (8)	15.71 (7)	16.0 (6)	14.6 (5)	12.0 (4)	8.67 (3)	5.0 (2)	3.0 (1)
MMEM	8.75 (9)	11.5 (8)	12.29 (7)	12.13 (6)	12.18 (5)	9.75 (4)	8.35 (3)	5.5 (2)	4.8 (1)
IMDOPER	1.25 (8)	2.86 (7)	2.5 (6)	1.0 (5)	3.75 (4)	5.0 (3)	5.0 (1)	NaN (0)	NaN (0)

(Number of forecasts verified is given in parentheses).

3.3. Performance of NWP models during severe cyclonic storm Montha:

The forecasts issued by various NWP models and utilised during operational weather forecasting of IMD are described and analysed against the best track location & intensity of the severe cyclonic storm during 25th to 29th October, 2025. Not all the model forecast products are considered for the discussion in this report, as they were not available and didn't contribute to any guidance during real-time forecasting of the tropical cyclone Montha. The analytical descriptions of the track forecast from various NWP models are given sequentially with time in the following sub-section below.

3.3.1. Prediction of Cyclogenesis for severe cyclonic storm Montha:

The Grid point analysis and forecast of Genesis Potential Parameter (GPP) is utilised to identify the potential zone of cyclogenesis based on 0000 UTC 20th October, 5 days ahead of the genesis of cyclonic storm Montha. Along with computed GPP from the IMD GFS model analysis, the GPP forecasts valid for different forecast hours are also displayed in the various panels of Fig. 3.3.1.

The GPP parameter derived from model analyses and forecasts based on 0000 UTC of 20th October is plotted in Fig. 3.3.1. indicating a zone with a significant value of GPP over the southeast and adjoining southwest Bay of Bengal during 22-23 October. The zone gradually moved northwestwards initially along & off the North Tamil Nadu and south Andhra Pradesh coasts in the forecasts for subsequent days. The zone of prominent GPP reached up to the westcentral BoB off north Andhra Pradesh-south Odisha coasts on 25th October. The zone with a significantly high value of GPP was moving nearly northwestwards over westecentral BoB. Thereafter, the GPP zone moved adjacent to south Odisha coast and gradually further northwards along the east coast-line, even up to the West Bengal coastline on 26th October. Compared with the best track of the severe cyclonic storm Montha, it is noted that the cyclogenesis over southeast BoB was earlier by the GPP guidance as compared to actual occurrence. Although the possible swath with northwestward movement towards the north Andhra Pradesh-south Odisha coasts was brought out well by the GPP plots, the timing was earlier than actual, similar to genesis.

3.3.2. Verification of track forecast:

The track forecast of IMD MME along with individual members NCUM and Bharat Forecast System (BFS) from 25th October to 28th October, 2025 during the Severe Cyclonic Storm "MONTHA" are plotted in [Fig. 3.3.2 (a)-(d)]. The top left panel represented the tracks of all individual member models along with MME in each figure. Top right panel displayed only the MME track with suitable combination of models. Then bottom left & right panels of each figure displayed the predicted tracks of NCUM & BFS models.

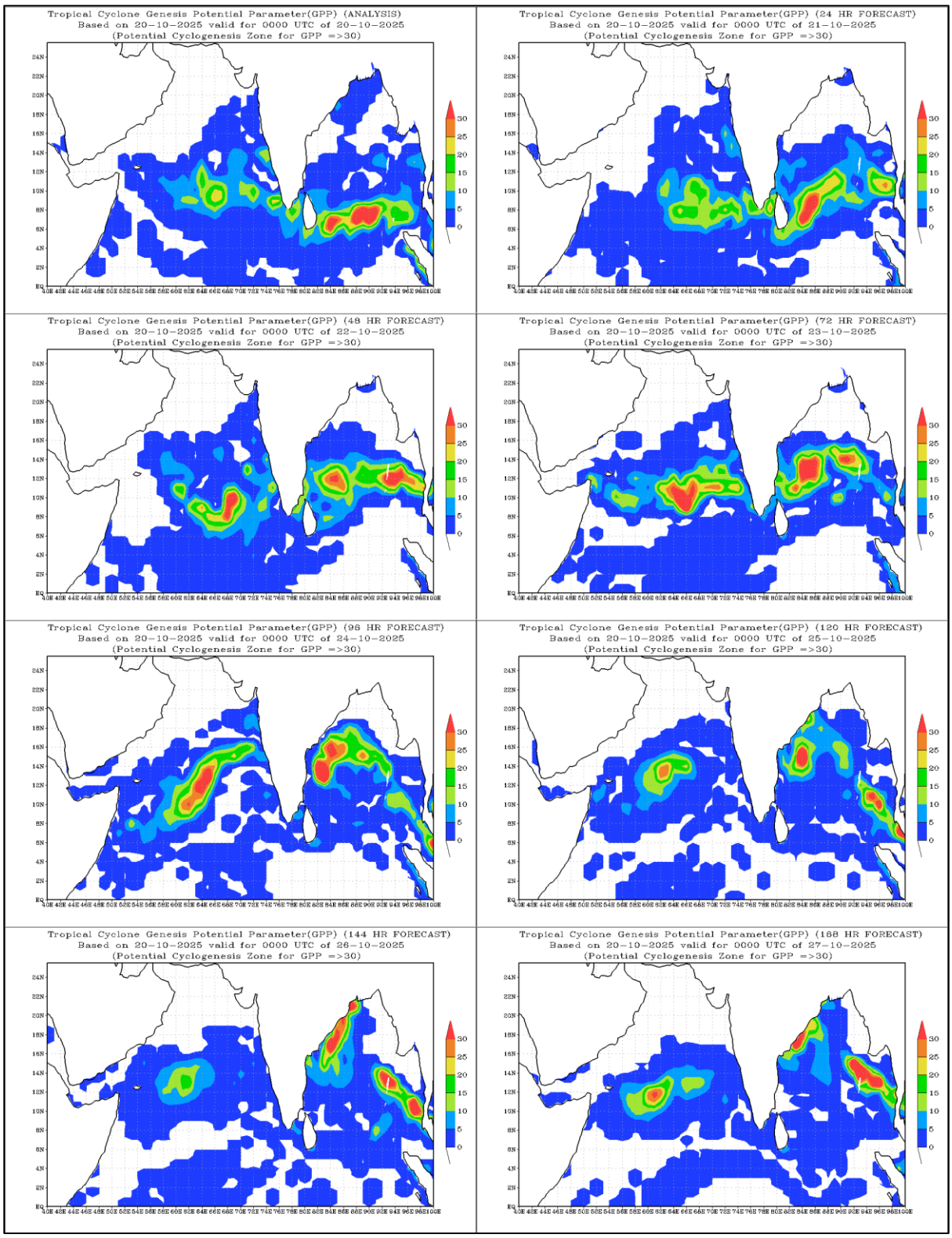


Fig. 3.3.1 The Genesis Potential Parameter (GPP) analysis and forecasts for 7 days based on 0000 UTC of 20th October, 2025.

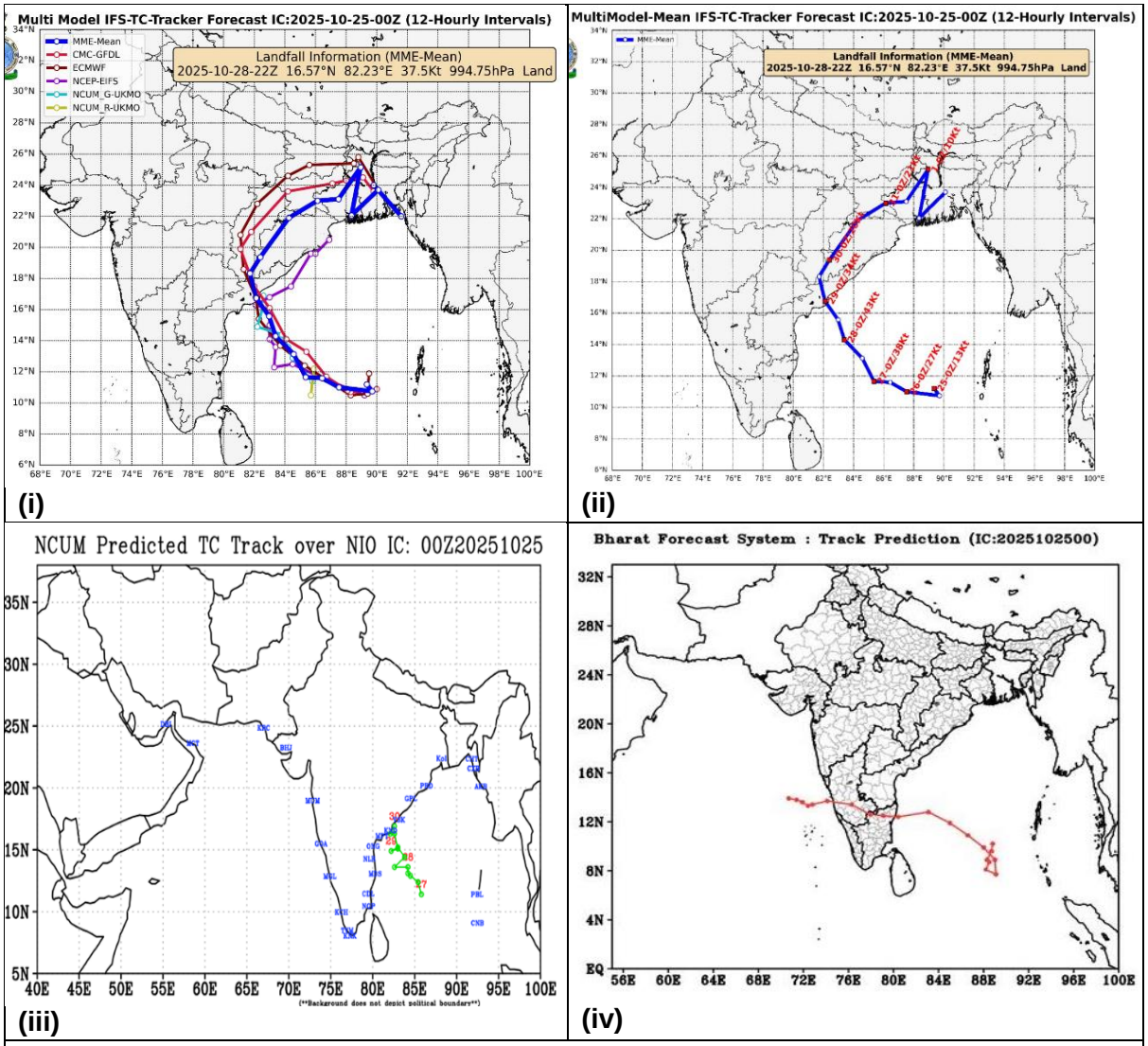


Fig. 3.3.2 (a) (i) Multi-Model Ensemble Track forecast along with track forecasts by individual member models, (ii) MME track, (iii) NCUM track, (iv) BFS track based on 0000 UTC of 25th October, 2025.

In general, there was a consensus amongst individual member models in their track forecast based 00 UTC of 25th October (Fig. 3.3.2 (a)). Accordingly, all the model tracks are clustered around the MME track. All the forecast tracks are very close to each other during first 2 days till 00 UTC of 27th October. While the storm was moving initial nearly westwards and west-northwestwards thereafter. The NCEP GFS model produced a zigzag forecast track after 48 hrs and indicated a northeastward recurvature after reaching near North Andhra Pradesh coast over westcentral Bay of Bengal (BoB) on 30th October without making any landfall. The storm as per NCUM-G predicted track [Fig. 3.3.2 (a)(i)&(iii)] was moving very slowly northwestwards and reached over westcentral Bay of Bengal (BoB) off North Andhra Pradesh coast in on 30th October (Day 6 forecast). The predicted tracks of ECMWF and CMC were close to MME as well as best track. The time of landfall was also well captured by the MME with a lead time of nearly 96 hrs. However, the landfall point predicted by MME was shifted northeastward from the actual landfall point. Looking at the forecast track of BFS system based on 00 UTC of 25th October, it is clear that the prediction of the model grossly missed captured the initial movement of the cyclone as well as subsequent northwestward movement towards Indian coast.

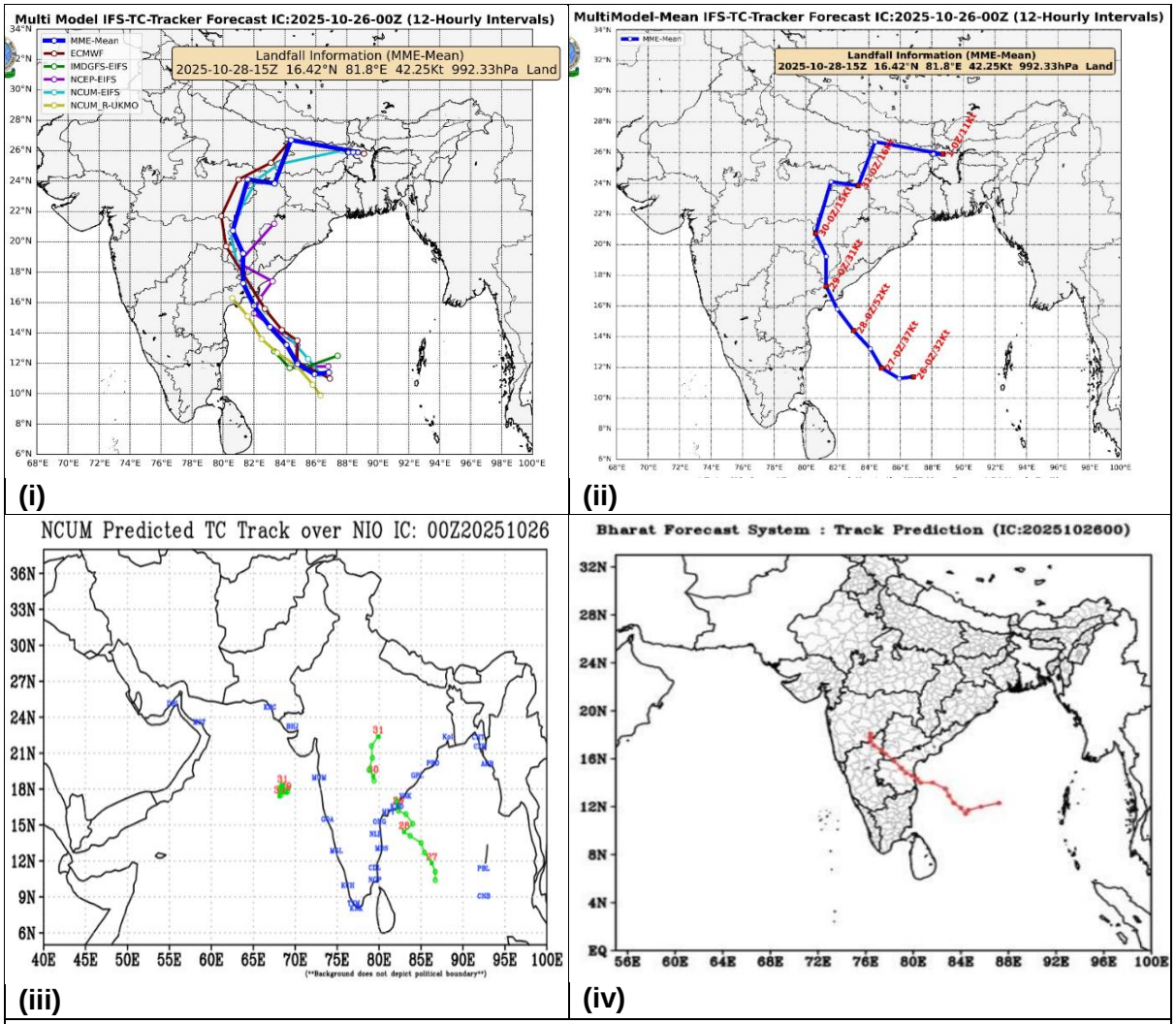


Fig. 3.3.2 (b) (i) Multi-Model Ensemble Track forecast along with track forecasts by individual member models, (ii) MME track, (iii) NCUM track, (iv) BFS track based on 0000 UTC of 26th October, 2025.

The plots in [Fig (b)(i)&(ii)] indicated that MME track forecast based on 00 UTC 26th October, 2025 remained consistent and agreed well with the best track of the Severe Cyclonic Storm "MONTHA". However, the landfall location and time changed from the earlier forecast of 25th October. In the MME forecast the landfall time was early compared to the best track. Amongst individual models NCUM-R and GFS were the outlier as they deviated from the best track. NCEP GFS again produced zigzag track towards Indian coast and making delayed landfall over North Andhra Pradesh coast. NCUM-G and ECMWF forecast were closer to the MME as well as best track. However, due to a zigzag motion on 28th October over westcentral Bay of Bengal NCUM-G [Fig. 3.3.2 (b)(iii)] predicted delayed landfall. Again, the forecast track of BFS model [Fig. 3.3.2 (b)(iv)] based on 00 UTC of 26th October deviated greatly from the best track of the storm making landfall over South Andhra Pradesh and adjoining North Tamil Nadu coasts.

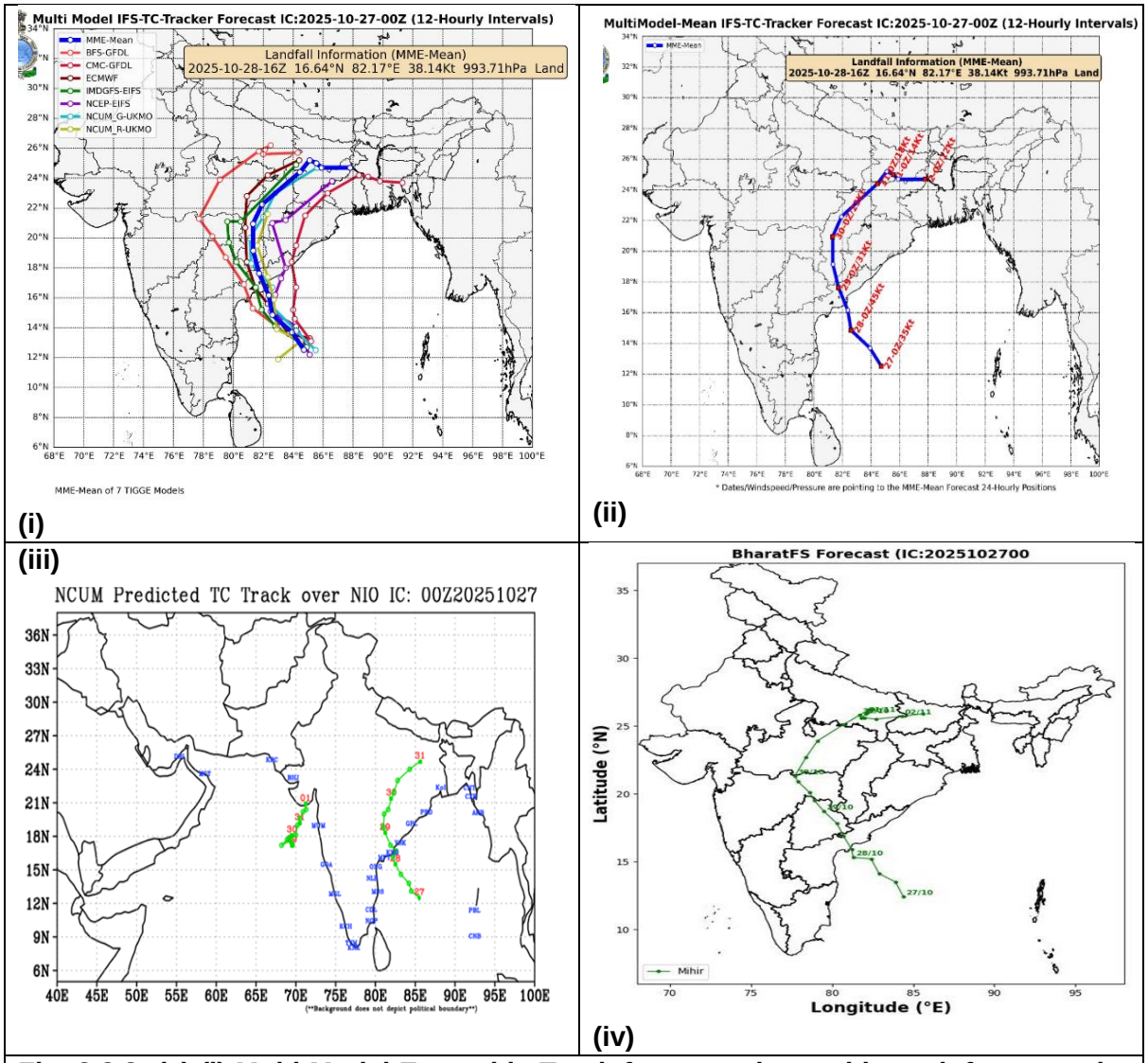


Fig. 3.3.2 (c) (i) Multi-Model Ensemble Track forecast along with track forecasts by individual member models, (ii) MME track, (iii) NCUM(G) track respectively, (iv) BFS track based on 0000 UTC of 27th October, 2025.

The MME forecast and the forecasts of individual member models in the Fig. 3.3.2 (c)(i) &(ii) based on 00 UTC of 27th October, 2025 indicated that the MME forecast still managed to capture the northwestward movement of the storm as observed in the best track, although individual member models produced a comparatively large spread after 24 hours. similar to the previous day's forecast the landfall time of the MME forecast is few hours early than the actual landfall time. The larger deviation is produced by the CMC and BFS model compare to others. Even the IMD GFS model which could not capture the northwest movement of the storm in the earlier cycles, started to follow the best track based on this initial condition. The ECMWF was providing consistently better forecast closer to MME as well as best track. The forecast track of NCUM-G model [Fig. 3.3.2 (c)(i)&(iii)] could capture the northwestwards movement of the storm over westcentral Bay of Bengal, but the landfall over north Andhra Pradesh coast was very much early compared to the best track. Although the deviation of the forecast track of the BFS model from the best track reduced considerably in this cycle still southward shifting from the best track was very much visible. Accordingly the landfall point also shifted southwards from the actual landfall point.

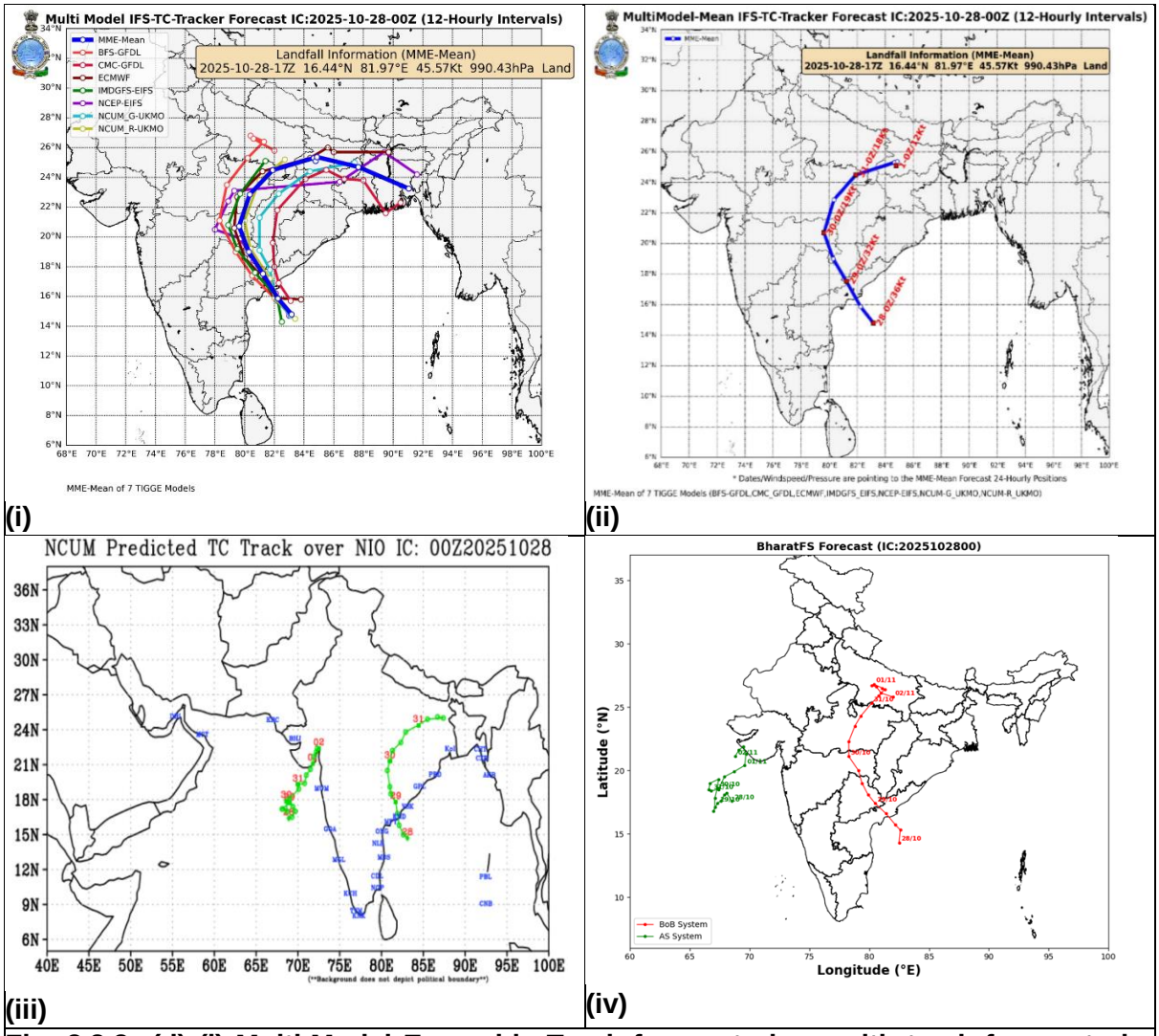


Fig. 3.3.2 (d) (i) Multi-Model Ensemble Track forecast along with track forecasts by individual member models, (ii) MME track, (iii) NCUM track, (iv) BFS track based on 0000 UTC of 28th October, 2025.

The model forecast based on 00 UTC of 28th October, 2025 nearly 1 day ahead of the landfall were plotted in Fig. 3.3.2 (d). The MME as well as other member models except BFS [Fig. 3.3.2 (d)(i)-(ii)] produced more accurate track forecast with northwesterly movement of the storm before its landfall. However, there was still variations amongst member models in terms of their landfall location and time. Following the trend of earlier cycles, MME predicted early landfall compared to the best track. As no model could bring out a unusual westward movement just before the landfall, the MME also failed to bring out this specific feature. Consequently, MME predicted regular northwestwards movement with early landfall and crossing point of the storm over North Andhra Pradesh coast shifted slightly northeastwards compared to actual landfall location. NCUM-G model [Fig. 3.3.2 (d)(iii)] also produced northwestward movement before landfall over North Andhra Pradesh coast but the forecast track displayed a north eastward curvature after the landfall before continued inland northwestward movement. Similar to previous cycle the NCUM-G model predicted early landfall. The BFS model track [Fig. 3.3.2 (d)(iv)] was displaying initial northerly movement for 6 hours before the usual northwesterly movement to cross the North Andhra Pradesh coast

earlier than the actual landfall time. Overall the BFS track was shifted southward compare to the best track.

The Fig 3.3.3 displayed the cluster of forecast tracks from different initial condition issued during the lifetime of Severe Cyclonic Storm “Montha”. It is observed that MME could capture initial nearly westward movement of the storm followed by nearly northwestward movement before the landfall. However, if we compare the location of the point of landfall, the MME forecasts issued in later stage of the cyclonic storm portrayed early landfall with the landfall point shifted nearly 0.5° sifted northeastwards from the observed location. There was a little segment of the best track before landfall where the storm moved westwards for some time and weakened could not be captured by the MME at any point of time.

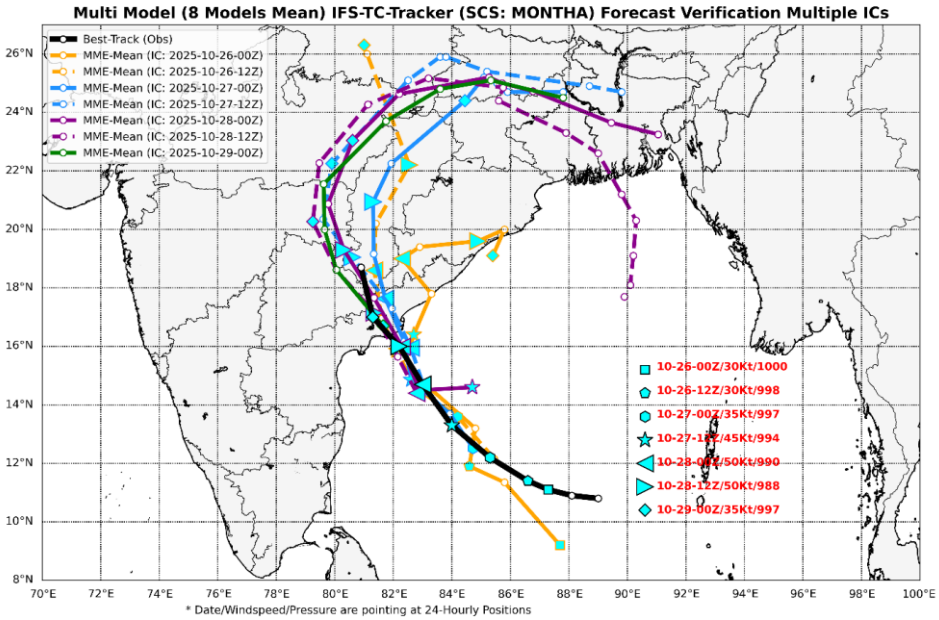


Fig. 3.3.3 Comparative forecast track cluster based on different initial times during the life of the severe cyclonic storm Montha

3.3.3 Track and Intensity Errors

In the **Fig 3.3.4,** all forecast track errors in terms of mean direct position error are described.

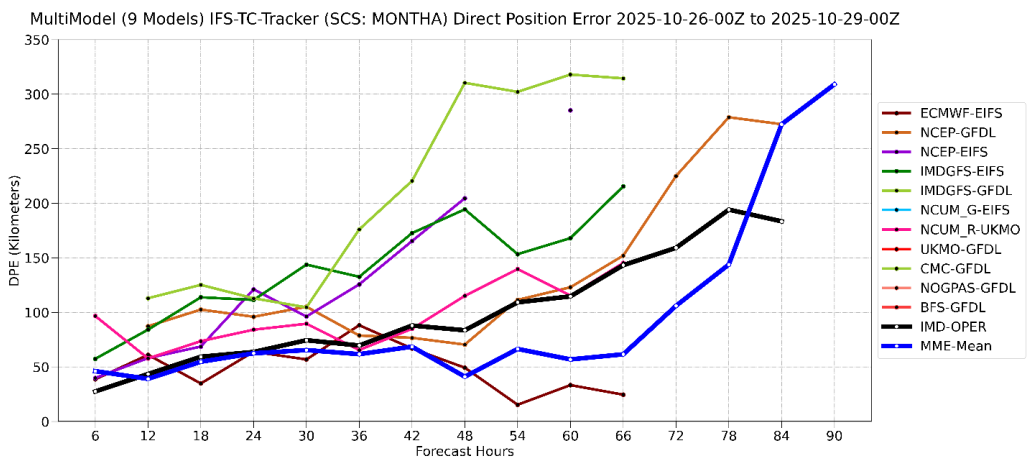


Fig. 3.3.4 Comparative analysis of forecast track errors in terms of mean Direct Position error (DPE) during Montha

The errors (in km) of the IMD MME forecast, along with other individual member models in predicting the track of the severe cyclonic storm Montha up to 90 hours are plotted in **Fig. 3.3.4**. It is clear that the track errors for all model forecasts are increasing uniformly with increasing forecast hours. The direct position errors for all forecasts are less than 120 km up to 24 hours. The operational forecast errors are comparable with MME up to 48 hours and thereafter MME performance is better than operational forecasts for all forecast hours. Amongst all models, the ECMWF delivered the lowest error compared to other forecasts up to 66 hours leaving apart first 12 hours. CMC model produced the largest track error (more than 100 Km at 12 hours) compared to all member models followed by IMD GFS and NCEP GFS. Although BFS track forecasts errors were higher than operational forecast. They became comparable with the operational forecast after 36 hours.

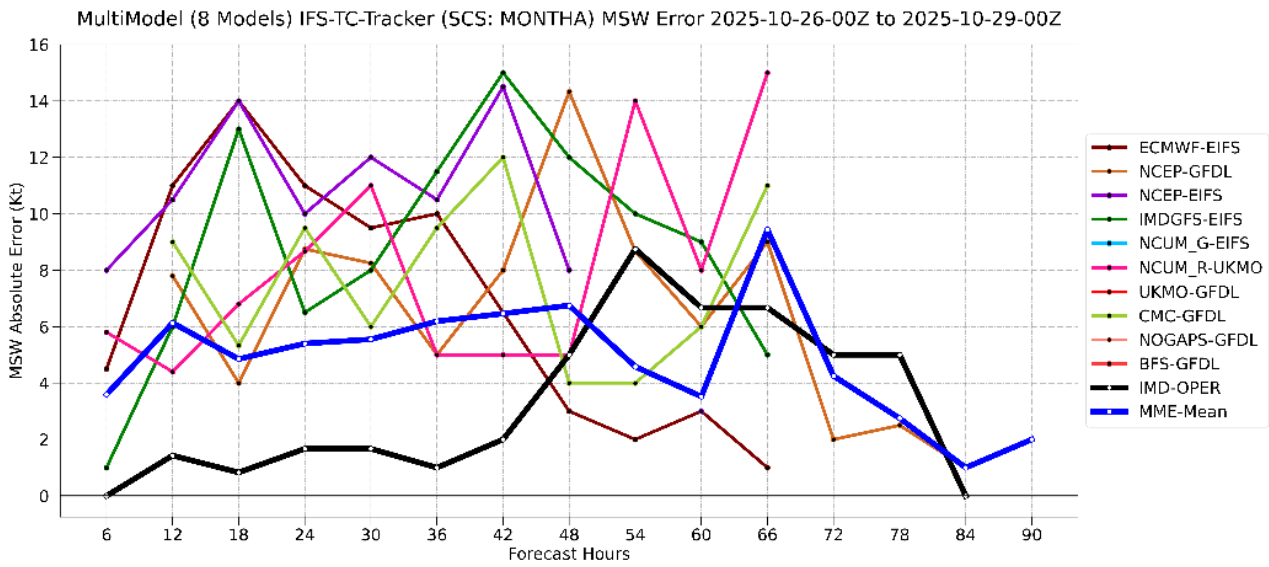


Fig. 3.3.5 Comparative analysis of the errors in intensity forecasts in terms of mean Direct Position error (DPE) during Montha

The mean absolute errors in the intensity forecasts by various models, along with IMD MME and IMD operational forecasts, are plotted in Fig. 3.3.5. It is noticed that the operational forecasts invariably had the least error (~ 2 knots) compared to other forecasts up to 42 hours. However, operational forecast errors increased beyond that point and reached upto more than 8 Knots for 54 hours forecast. The forecast error decreased drastically after that. The MME had consistent eror around 5 Knots upto 72 hours before and show a decreasing trend after that. However, there is a error spike (~ 9 knots) at 66 hours. On an average most of the member models had forecast error more than 5 knots for all forecast hours predicting the intensity of the storm. However, ECMWF model had lesser error after 48 hours. GFS series of models had larger errors (reaching upto 15 knots) compared to other models.

3.3.4. Landfall point and time errors

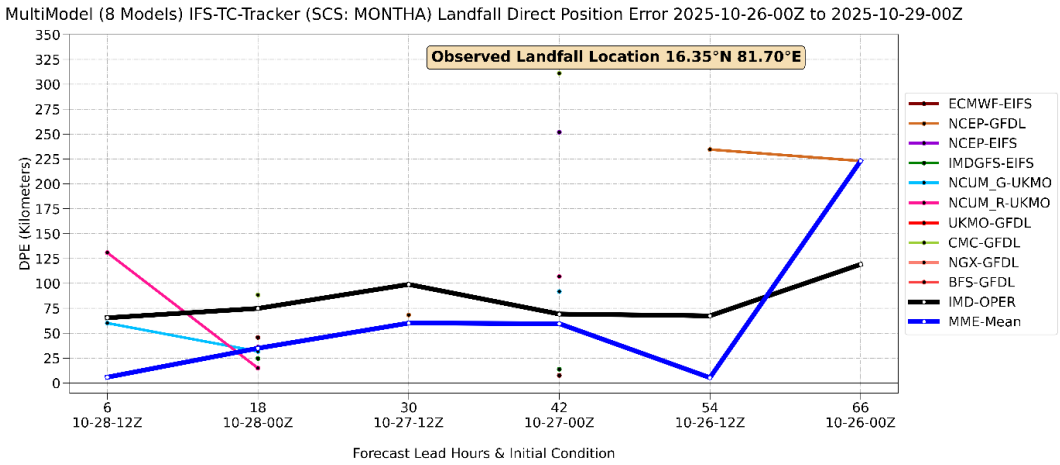


Fig. 3.3.6 Comparative analysis of the landfall point errors of model forecasts in terms of mean Direct Position error (DPE) during severe cyclonic storm Montha

Direct position errors in the position of landfall point are positioned in Fig 3.3.6. For a few orecast hours some of the models didn't show any landfall. Therefore, representation points for those models in the plots are missing in the line graphs. Overall. the MME Mean shows the best forecast for the location of the landfall point with the lowest and consistent landfall position errors. Hence, MME was the most reliable guidance. Among individual models, ECMWF had least landfall point error followed by NCUM. However, NCUM was not showing any landfall during for the forecast with lead time greater than 42 hours. From the fig 3.3.6 it is also clear that the landfall point error was ~100 Km upto a lead time 66 hours. Whereas, landfall point error for MME was less than 60 Km upto 54 hours.

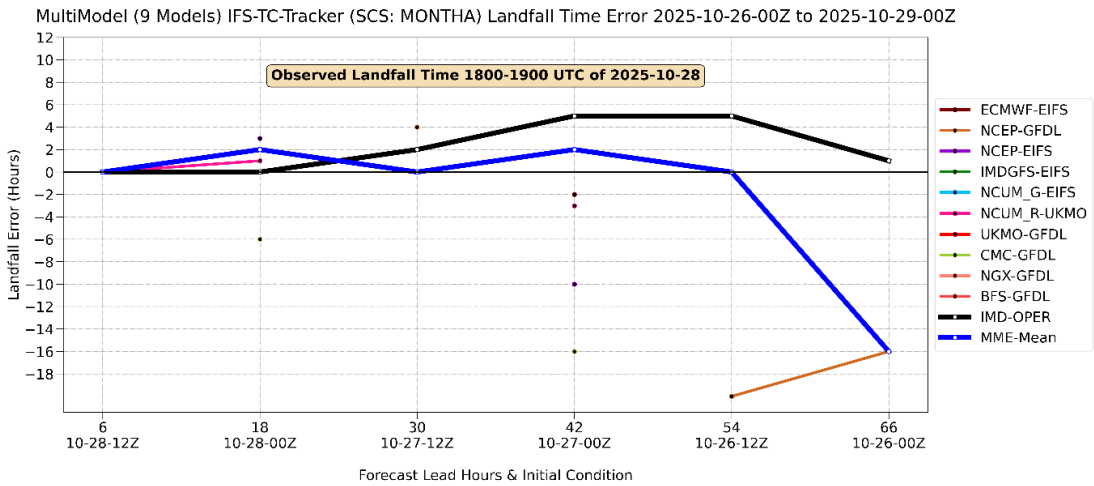


Fig. 3.3.7 Comparative analysis of the landfall time errors of model forecasts during severe cyclonic storm Montha

The Fig. 3.3.7 illustrates the comparison of errors of different mosdels in predicting landfall time in the similar way as earlier Fig.3.3.7 for landfall point error during Severe Cyclonic Storm "MONTHA".

The Graphs in the plot shows that the landfall prediction by the MME model was earlier than the actual landfall time error for the MME was less than equal to 2 hours upto 54 hours lead time compared to 5 hours by the operational forecast. Beyond 54 hours lead time the MME forecasts produced delayed landfall. However, upto 36 hours MME and operational forecasts were comparable. Beyond the lead time of 30 hours most of the individual models produced delayed landfall ranging from 2 hours to 16 hours.

The average track forecast errors by various models compared to operational forecast errors which are described in **Fig. 3.3.5** are also represented in **Table 3.3.1** with their numerical values. The model errors in forecasting the track of the severe cyclonic storm “MONTHA” are compared from 12 hour up to 84 hours.

The IMD MME had least error for up to 48 hrs lead period. Even the error of the MME was the least even at lead time of 84 hours amongst available models. CMC produced consistentlky larger errors whereas ECMWF predicted consistently with lower errors. The performance of GFS group of models was not moderate considering all forecast hours.

Table 3.3.1. Average track forecast errors (Direct Position Error (DPE)) in km

Model	12	24	36	48	60	72	84
NCUM_R-UKMO	57.82 (5)	84.14 (3)	65.56 (2)	115.16 (1)	115.42 (1)	NaN (0)	NaN (0)
NCEP-GFDL	87.31 (5)	95.99 (4)	78.80 (3)	70.48 (3)	123.04 (2)	224.97 (2)	272.46 (1)
ECMWF-EIFS	61.08 (2)	63.94 (2)	88.21 (2)	49.31 (1)	33.36 (1)	NaN (0)	NaN (0)
IMDGFS-EIFS	84.17 (2)	111.42 (2)	132.62 (2)	194.44 (1)	168.05 (1)	NaN (0)	NaN (0)
NCEP-EIFS	58.10 (2)	121.08 (2)	125.66 (2)	204.60 (1)	285.20 (1)	NaN (0)	NaN (0)
NCUM_G-UKMO	41.33 (4)	81.53 (3)	67.24 (2)	144.94 (1)	146.07 (1)	NaN (0)	NaN (0)
CMC_GFDL	113.00 (3)	112.90 (2)	176.04 (2)	310.38 (1)	317.97 (1)	NaN (0)	NaN (0)
MMEM	39.08 (7)	62.51 (6)	61.71 (5)	41.07 (4)	56.91 (3)	106.02 (2)	272.46 (1)
IMDOPER	43.51 (7)	63.72 (6)	69.62 (5)	83.61 (4)	114.68 (3)	159.17 (2)	183.47 (1)

Similar to Table 3.3.1, the average errors in the intensity (in terms of MSW) forecasts by various models, along with IMD MME and operational forecasts, are described in **Table -3.3.2** up to 84 hours. As plotted in Fig. 3.3.6, the values of the errors in **Table 3.3.2** show that the operational forecasts had the least errors for all forecast lead times except 60th hour. From the table it is noticed that the models were inconsistent for predicting the MSW of the cyclone “MONTHA”. NCUM-G amongst all models produced less error up to 60 hours next to operational models.

Table 3.3.2. Average Intensity Forecast Errors of maximum sustained wind in knots Negative sign indicates underestimation of intensity and vice versa

Model	12	24	36	48	60	72	84
NCUM_R-UKMO	4.4 (5)	8.67 (3)	5.0 (2)	5.0 (1)	8.0 (1)	NaN (0)	NaN (0)
NCEP-GFDL	7.8 (5)	8.75 (4)	5.0 (3)	14.33 (3)	6.0 (2)	2.0 (2)	1.0 (1)
ECMWF-EIFS	11.0 (2)	11.0 (2)	10.0 (2)	3.0 (1)	3.0 (1)	NaN (0)	NaN (0)
IMDGFS-EIFS	6.0 (2)	6.5 (2)	11.5 (2)	12.0 (1)	9.0 (1)	NaN (0)	NaN (0)
NCEP-EIFS	10.5 (2)	10.0 (2)	10.5 (2)	8.0 (1)	3.0 (1)	NaN (0)	NaN (0)
NCUM_G-UKMO	4.0 (4)	3.33 (3)	6.5 (2)	2.0 (1)	2.0 (1)	NaN (0)	NaN (0)
CMC_GFDL	9.0 (3)	9.5 (2)	9.5 (2)	4.0 (1)	6.0 (1)	NaN (0)	NaN (0)
MMEM	6.13 (7)	5.40 (6)	6.19 (5)	6.75 (4)	3.52 (3)	4.25 (2)	1.0 (1)
IMDOPER	1.43 (7)	1.67 (6)	1.0 (5)	5.0 (4)	6.67 (3)	5.0 (2)	0.0 (1)

Landfall point errors of model forecasts in terms of DPE are given in Table 3.3.3 which was already described graphically in Fig. 3.3.7. Numerical values of landfall time errors as per the prediction by all models during SCS MONTHA is given in Table 3.3.4.

Table 3.3.3 Landfall point errors of model forecasts in terms of mean Direct Position Error (DPE) during severe cyclonic storm Montha

Model	6	18	30	42	54	66
NCUM_R-UKMO	130.93	14.94	NaN	107.03	NaN	NaN
NCEP-GFDL	NaN	NaN	68.31	NaN	234.51	223.01
ECMWF-EIFS	NaN	45.81	NaN	7.7	NaN	NaN
IMDGFS-EIFS	NaN	24.64	NaN	13.89	NaN	NaN
NCEP-EIFS	NaN	36.08	NaN	252.03	NaN	NaN
NCUM_G-UKMO	60.13	31.74	NaN	91.87	NaN	NaN
CMC_GFDL	NaN	88.44	NaN	311.22	NaN	NaN
MMEM	5.78	34.89	60.13	59.59	5.33	223.01
IMDOPER	65.47	74.87	99	69.24	67.46	119.12

Table 3.3.4 Landfall time errors of model forecasts during severe cyclonic storm Montha

Model	6	18	30	42	54	66
NCUM_R-UKMO	0	1	NaN	−3	NaN	NaN
NCEP-GFDL	NaN	NaN	4	NaN	−20	−16
HWRF-GFDL	NaN	NaN	NaN	NaN	NaN	NaN
ECMWF-EIFS	NaN	0	NaN	−2	N	

3.4 Performance of NWP models during Cyclonic Storm Senyar

The forecast issued by various NWP models were considered during the real time forecasting of Cyclonic Storm “SENYAR”. After the event all model forecast were analysed against observed and best track location and intensity of the storm. A few model forecasts are not considered for the discussion as they were not available and guidance from those models were absent during the real time forecast. The analytical description of track forecasts from different NWP models are given below.

3.4.1 Verification of track forecast

The MME forecasts along with other member models based 00 UTC of 22nd November, 2025 are plotted in the two panels of the Fig. 3.4.1 (a). all the forecasts indicated a quick westward movement of the storm from Gulf of Malacca to southeast Bay of Bengal across south Andaman Sea. According to the best track analysis of the storm, the initial westward movement was realised but continued movement across south Andaman Sea predicted wrongly by all the models. It is also obvious from the figure that there was a large spread among the member models in their track forecasts.

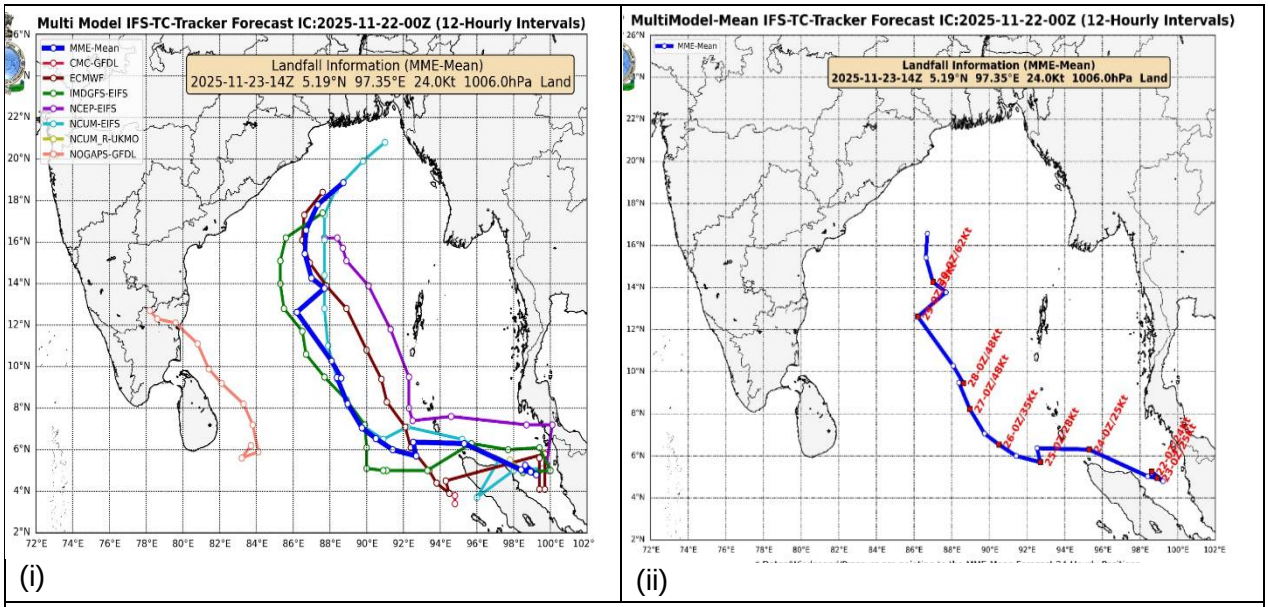


Fig. 3.4.1(a) (i) Multi-Model Ensemble Track forecast along with track forecasts by individual member models and (ii) MME track on 0000 UTC of 22nd November, 2025.

The top two panels in the Fig. 3.4.1(b) are similar to the two panels of the Fig. 3.4.1(a) except based on 00 UTC of 23rd November. The bottom two panels illustrated accumulated probability in percentage of the storm passing within 120 km from the ensemble mean forecast location at different forecast hours issued by Mithuna model [Fig. 3.4.1(b)(iii)] and the forecast of Mithuna model [Fig. 3.4.1(b)(iv)] based on same initial time. The forecast of all models could not capture the anti-clockwise backward looping movement of the storm. Hence, MME forecast also produced inaccurate forecast. The similar inaccurate forecast was noticed from both Mithuna and its ensembled prediction system.

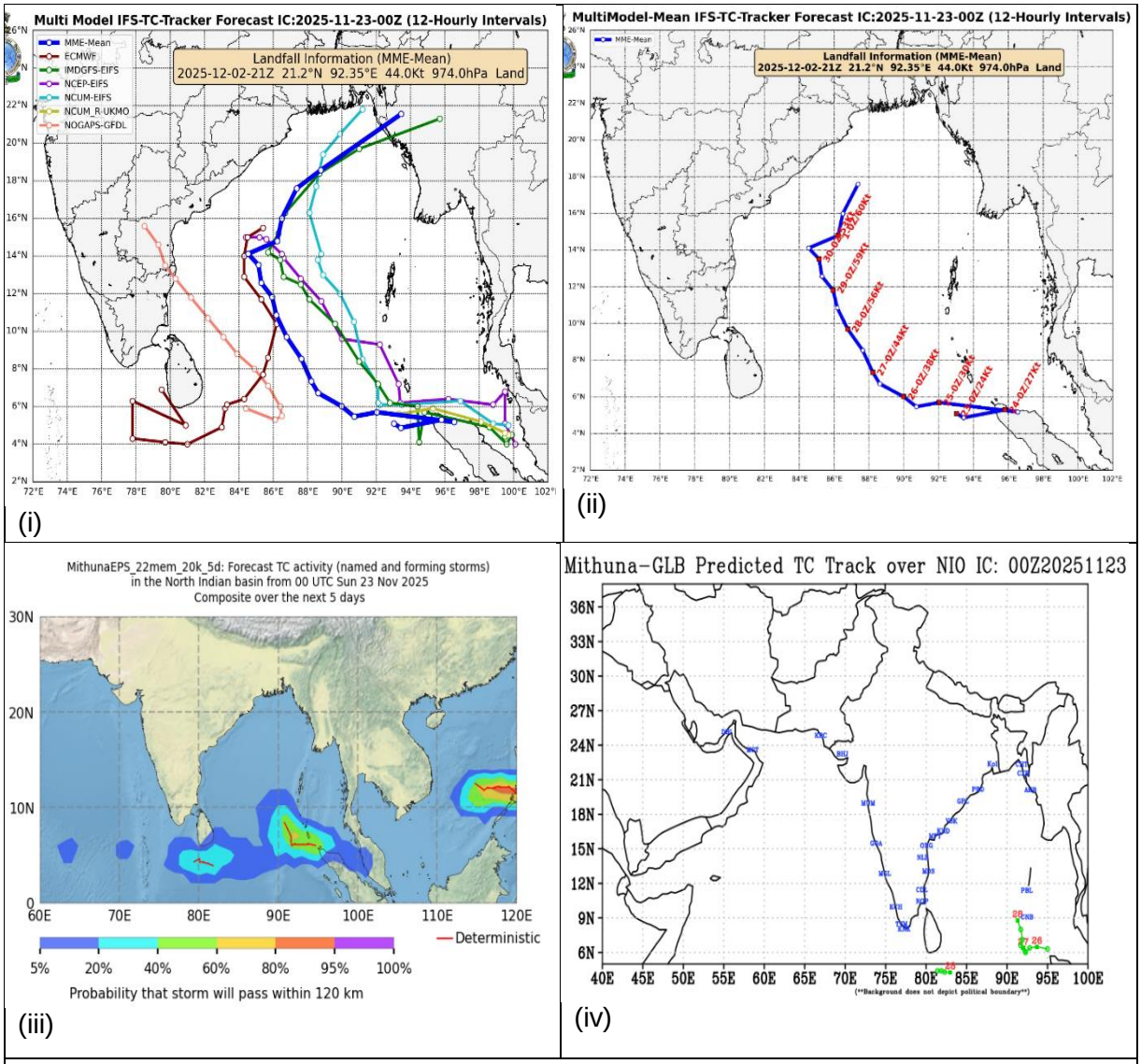


Fig. 3.4.1(b) (i) Multi-Model Ensemble Track forecast along with track forecasts by individual member models, (ii) MME track, accumulated probability (in %) of the system passing within 120 km from the ensemble mean forecast locations at different forecast hours issued by the (iii) MithunaEPS model and (iv) Mithuna model based on 0000 UTC of 23rd November, 2025.

The MME forecast based on 00 UTC of 24th November as shown in [Fig. 3.4.1(c)(i) &(ii)]. Illustrated that movement of the storm was ambiguous with looping during initial 2-3 days as various model tracks showed random spread from the initial position. However, MithunaEPS was showing a zone with TC track probability of 60-80% over Malacca Strait which in turn indicated that there was a possibility for the anti-clockwise backward looping movement. The deterministic model could not capture the looping movement of the storm.

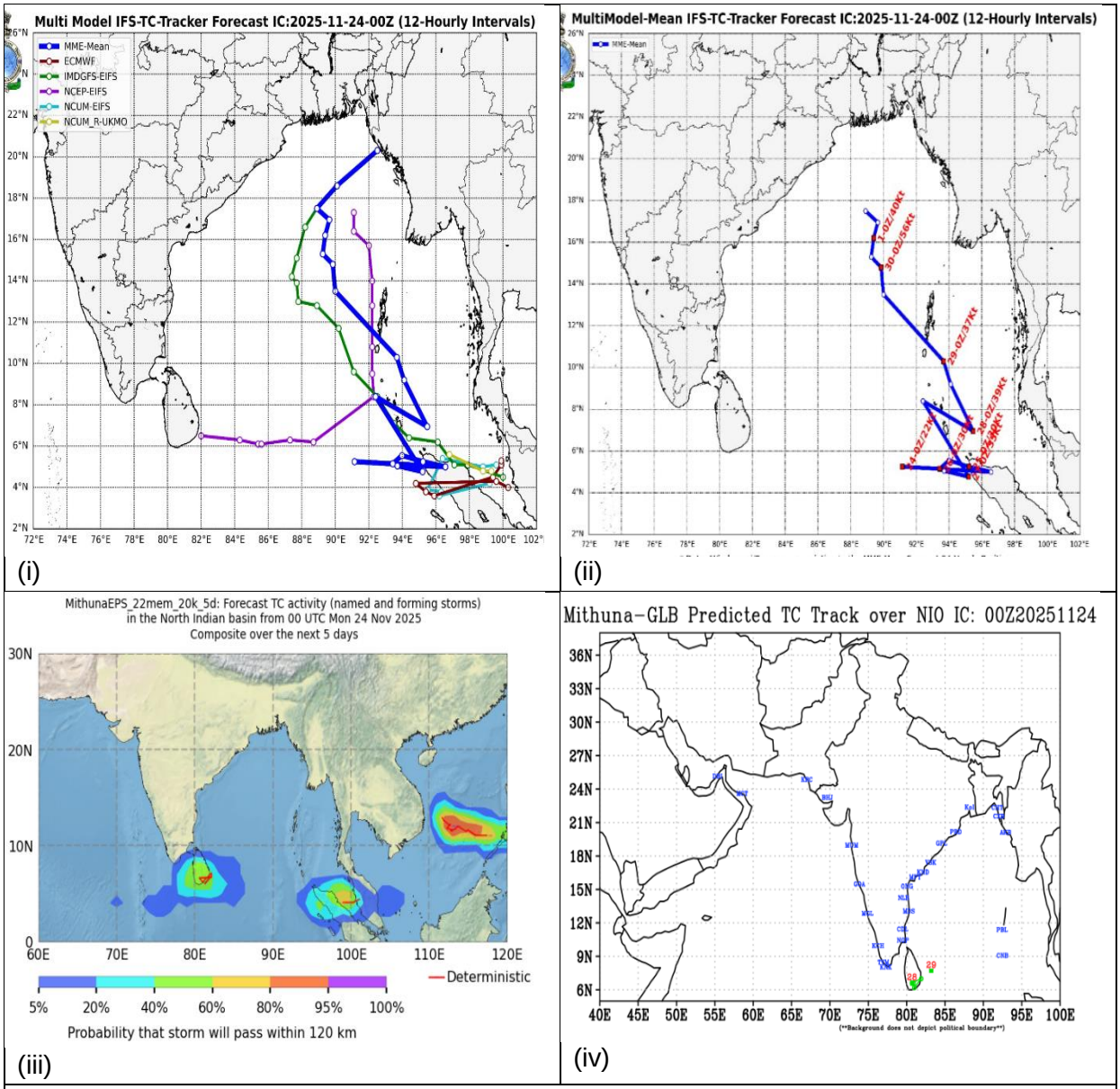
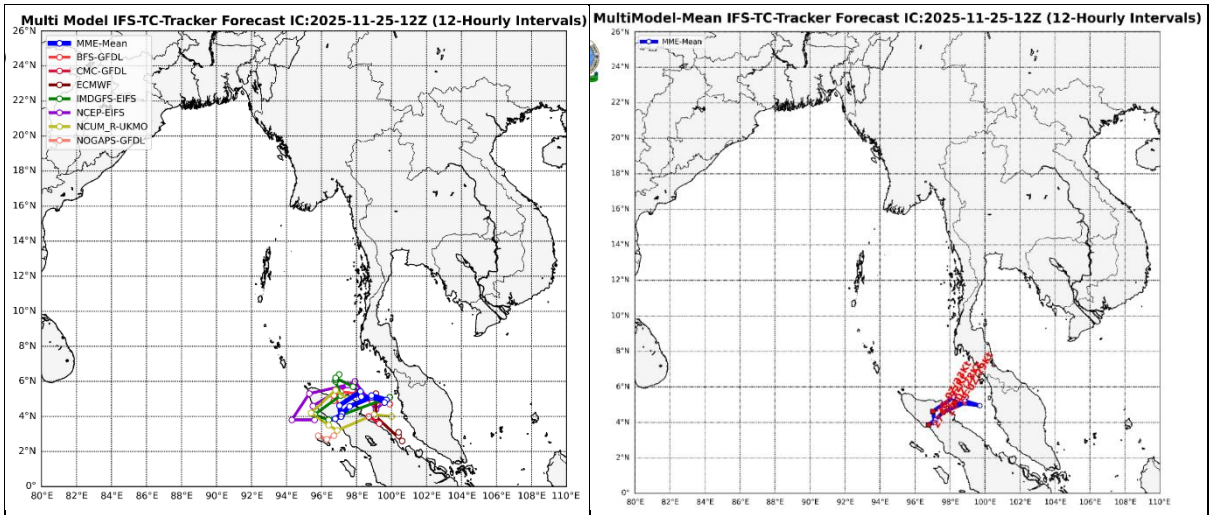


Fig. 3.4.1(c) (i) Multi-Model Ensemble Track forecast along with track forecasts by individual member models, (ii) MME track, accumulated probability (in %) of the system passing within 120 km from the ensemble mean forecast locations at different forecast hours issued by the (iii) MithunaEPS model and (iv) Mithuna model based on 0000 UTC of 24th November, 2025.

The MME model along with other model forecasts based on 00 UTC of 25th November in [Fig. 3.4.1(d)(i) &(ii)] were able to capture the anti-clockwise backward looping movement of the cyclone. Accordingly, MME was also indicating the same. However, there was variations amongst individual member models.



(i) (ii)

Fig. 3.4.1(d) (i) Multi-Model Ensemble Track forecast along with track forecasts by individual member models and (ii) MME track based on 0000 UTC of 25th November, 2025.

The Fig 3.4.2 represents the comparative track cluster of MME forecasts based on different initial times during the life of the cyclonic storm Senyar. Only a few tracks based on initial conditions from 12 UTC of 25th upto 00 27th November were able to capture anti-clockwise backward looping of the storm.

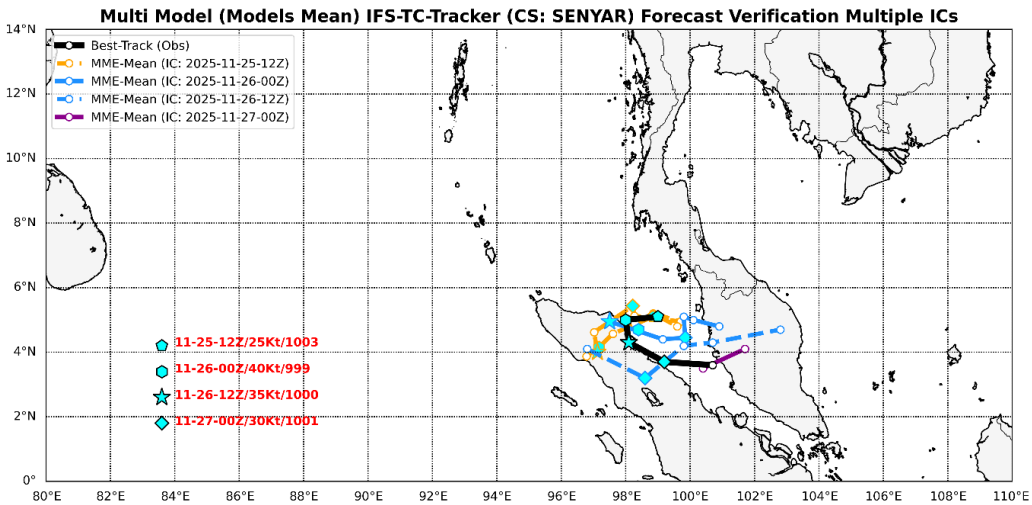


Fig. 3.4.2 Comparative track cluster of MME forecasts based on different initial times during the life of the cyclonic storm Senyar

The comparison of forecast track errors of different NWP models in terms of DPE is plotted in Fig. 3.4.3 & Table 3.4.1. In the figure it is noticed that the errors of operational forecast and MME were comparable upto a lead time of 24 hours only and track errors of the MME were lesser than operational forecast for all forecast hours beyond 24 hours. The forecast of all Individual models were higher than both MME and operational forecasts.

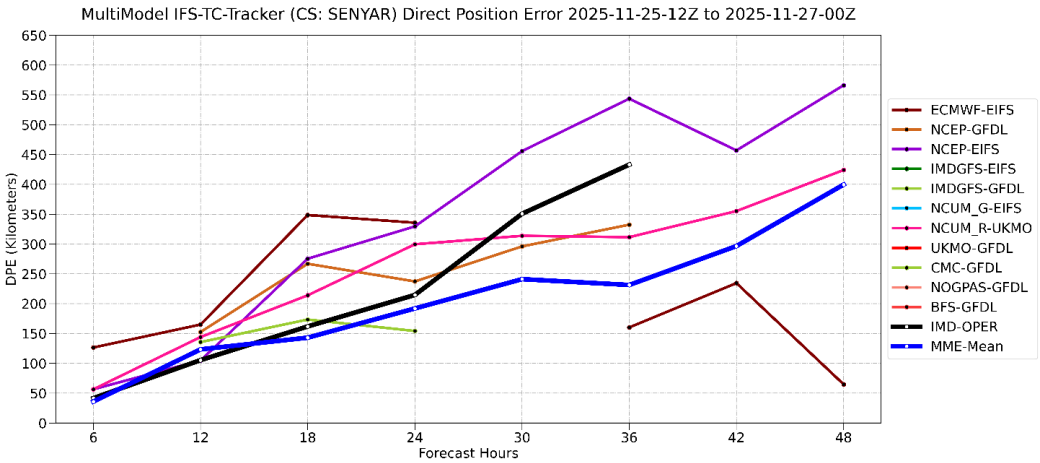


Fig. 3.4.3 Comparative analysis of forecast track errors in terms of mean Direct Position error (DPE) during Senyar

NCEP performed better than all models for all lead periods are shown in Fig. 3.4.4 & Table 3.4.2. Even ECMWF could not predict the intensity correctly. The operational intensity forecast errors were less than MME up to 18 hours lead period and more than MME beyond that.

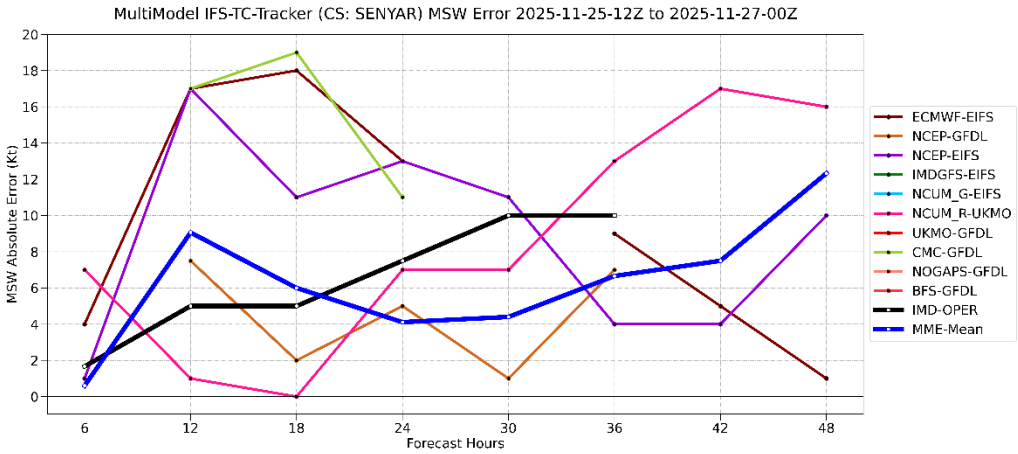


Fig. 3.4.4 Comparative analysis of intensity forecast errors in terms of absolute errors during Senyar

Table 3.4.1 Comparative analysis of forecast track errors in terms of mean Direct Position error (DPE) during

Model	12	24	36	48
NCUM_R-UKMO	144.03 (1)	299.58 (1)	311.49 (1)	424.06 (1)
NCEP-GFDL	152.51 (2)	237.29 (1)	332.43 (1)	NaN (0)
ECMWF-EIFS	165.02 (1)	335.71 (1)	160.18 (1)	64.81 (1)
NCEP-EIFS	104.77 (1)	329.54 (1)	543.64 (1)	566.16 (1)
CMC_GFDL	135.59 (1)	154.20 (1)	NaN (0)	NaN (0)
MMEM	123.41 (3)	191.98 (3)	231.36 (2)	399.62 (1)
IMDOPER	105.36 (3)	214.64 (2)	433.12 (1)	NaN (0)

Table 3.4.2 Comparative analysis of intensity forecast errors in terms of absolute errors during Senyar

Model	12	24	36	48
NCUM_R-UKMO	1.0 (1)	7.0 (1)	13.0 (1)	16.0 (1)
NCEP-GFDL	7.5 (2)	5.0 (1)	7.0 (1)	NaN (0)
ECMWF-EIFS	17.0 (1)	13.0 (1)	9.0 (1)	1.0 (1)
NCEP-EIFS	17.0 (1)	13.0 (1)	4.0 (1)	10.0 (1)
CMC_GFDL	17.0 (1)	11.0 (1)	NaN (0)	NaN (0)
MMEM	9.06 (3)	4.11 (3)	6.66 (2)	12.33 (1)
IMDOPER	5.0 (3)	7.5 (2)	10.0 (1)	NaN (0)

3.5 Performance of NWP models during CS Ditwah

Various global models and dynamical-statistical models run by Ministry of Earth Sciences (MoES) institutions including IMD, NCMRWF, IITM & INCOIS and guidance from models from various international agencies under bilateral arrangement. IMD operationally runs Global and regional models short-range (3- days) to medium-range (10 days) prediction of tropical cyclones over North Indian Ocean region. The IMD Global Forecast System (IMD-GFS-T1534L64) at the resolution of 12 km with 6 hourly assimilation cycle with Global Data Assimilation System (GDAS) was utilized for medium range prediction (10 days). The WRF-VAR model was run at the horizontal resolution of 3 km to produce forecasts for 3 days over a domain covering the area of responsibility for RSMC, New Delhi. Initial and boundary conditions were obtained from the IMD Global Forecast System (IMDGFS). The boundary conditions are updated at every six hours interval. Global model is also run at NCMRWF. This unified model (NCUM) is adapted from UK Meteorological Office.

The forecasts were mainly based on multi-model ensemble technique developed by IMD. which was further value added to arrive at consensus forecast by considering various prognostic & diagnostic features, observational features, initial conditions and consistency of individual models etc. A digitized forecasting system of IMD was utilized for analysis and comparison of various observations and numerical weather prediction models guidance, decision making process and warning products generation. The guidance based on 0000 UTC of various models is presented in **Fig.3.5.1.**

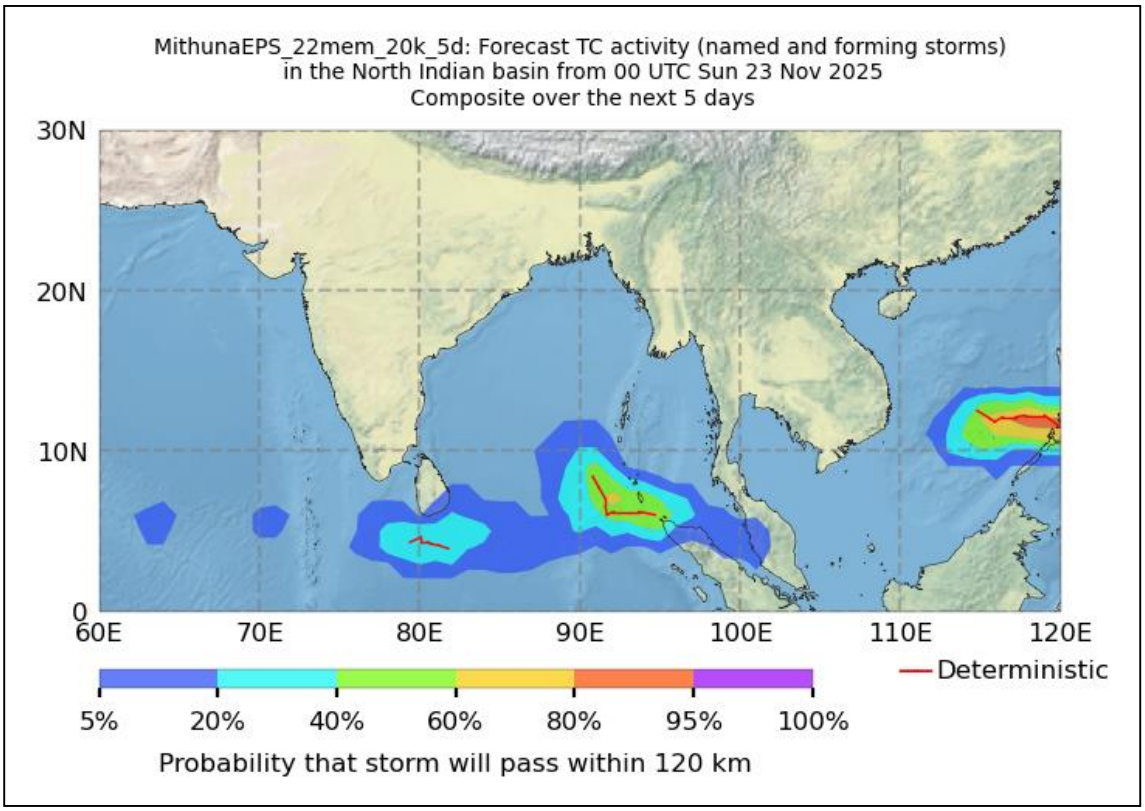


Fig. 3.5.1(i) : NWP model track forecast based on 0000 UTC of 26.11.2025

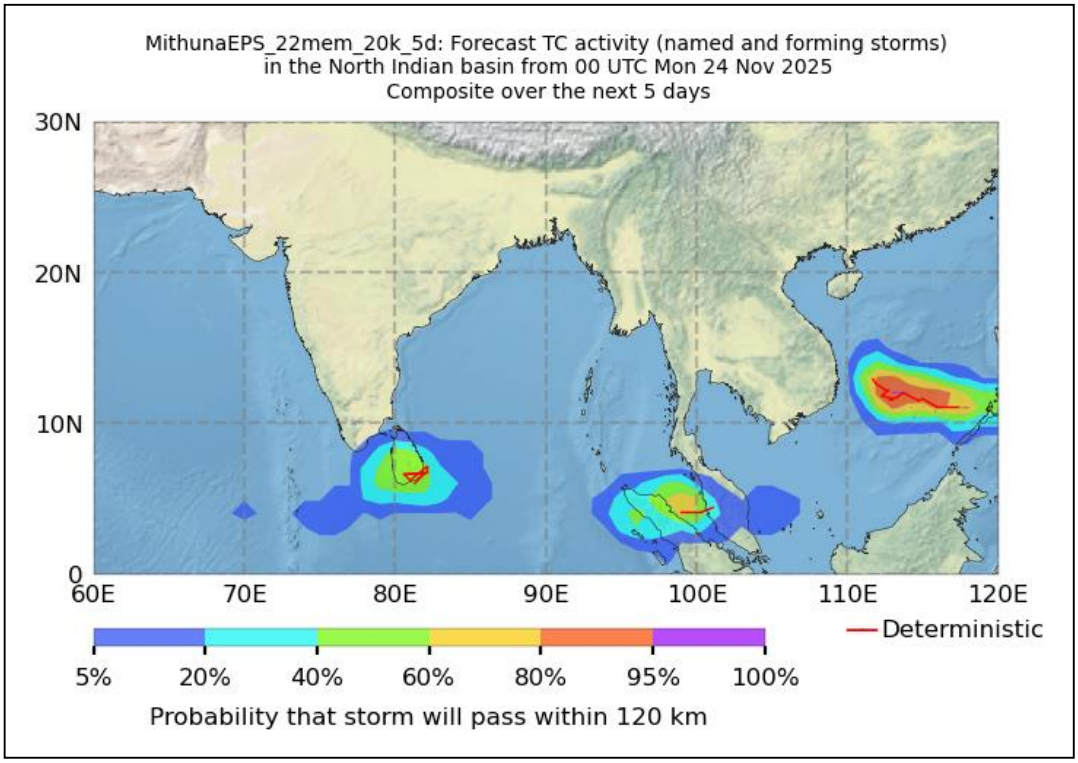


Fig.3.5.1. (ii) : NWP model track forecast based on 0000 UTC of 26.11.2025

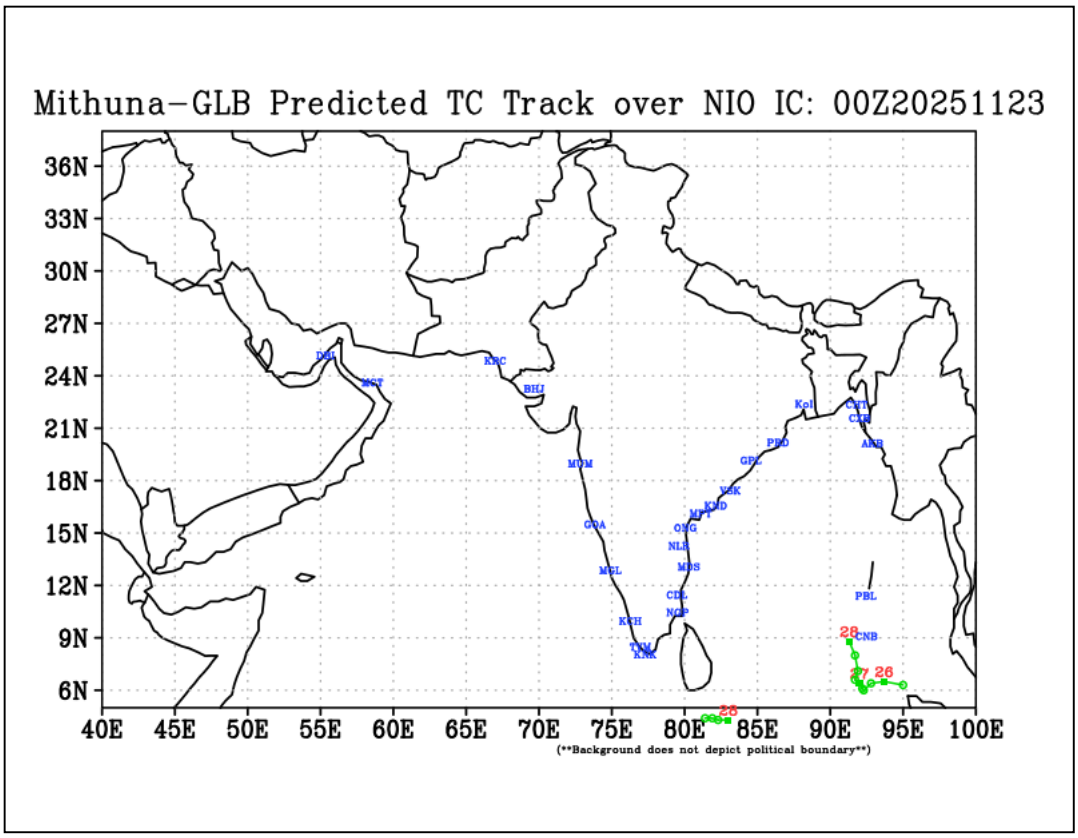


Fig.3.5.1. (iii) : NWP model track forecast based on 0000 UTC of 26.11.2025

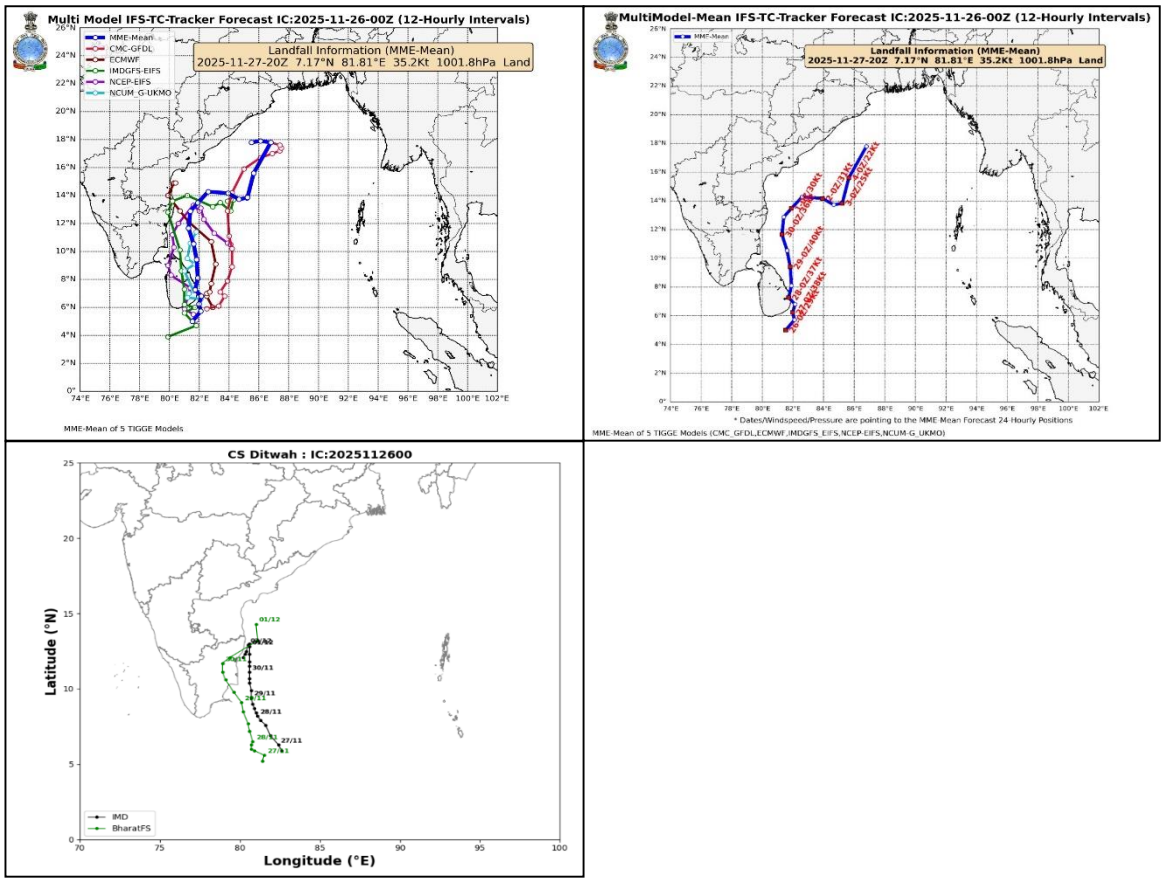


Fig.3.5.1. (iv) : NWP model track forecast based on 0000 UTC of 26.11.2025

The model runs at 0000 UTC of 26th November indicated the system over southwest BoB & adjoining southeast Sri Lanka. IMD GFS, NCEP GFS and NCUM indicated the system to move south to north across Sri Lanka and then emerge into sea. After emergence, ECMWF indicated the system to move across southwest and westcentral BoB, touch cross south Andhra Pradesh coast, recurve north-northeastwards and weaken over westcentral BoB. IMD GFS was indicating the system to cross North Tamil Nadu coast, re-emerge into sea & move nearly eastwards and weaken over westcentral BoB. CMC indicated the system to move northwards without hitting any coast and weaken over westcentral BoB. IMD MME indicated the system to intensify a cyclonic storm on 27th November near southeast Sri Lanka, touch Sri Lanka coast on 28/00, move northwards & then northeastwards and weaken over westcentral BoB by 4th Dec. /0000 UTC.

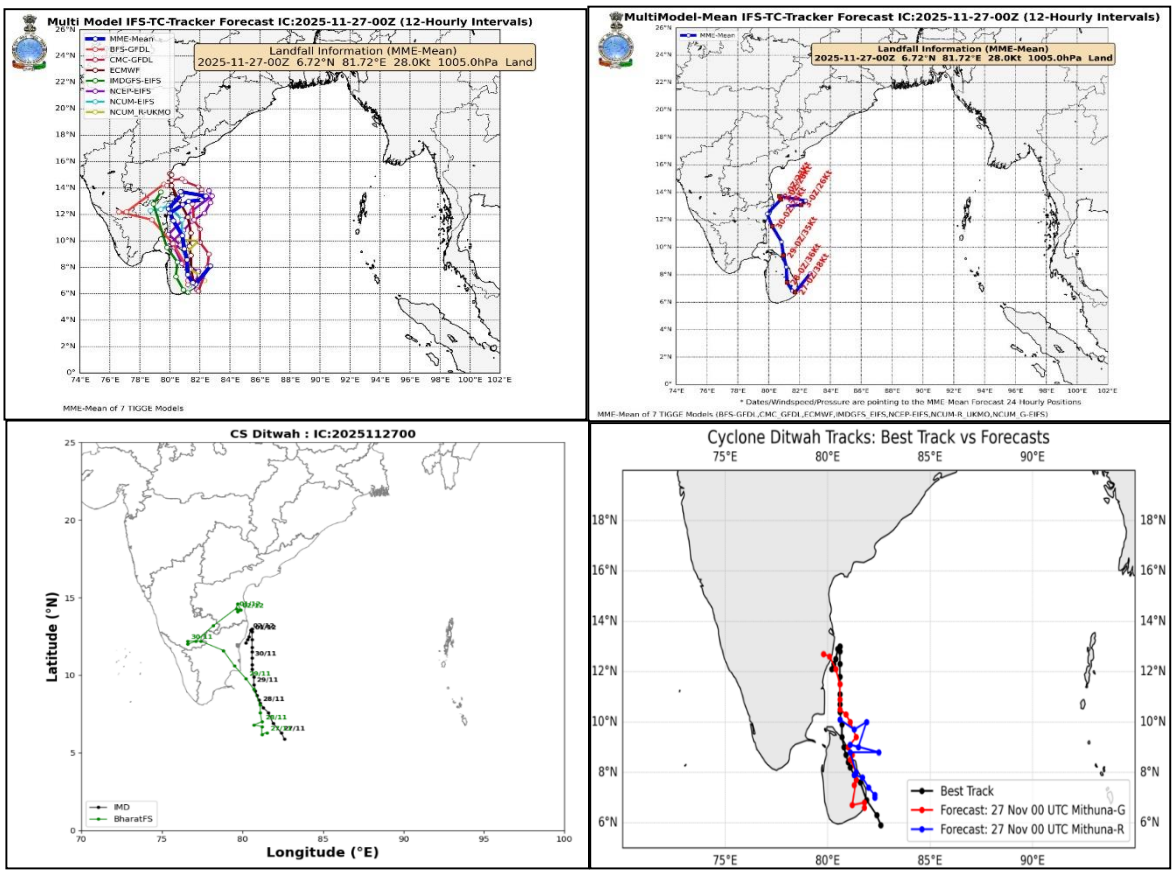


Fig.3.5.1. (v) : NWP model track forecast based on 0000 UTC of 27.11.2025

The model runs at 0000 UTC of 27th November indicated the system over southeast Sri Lanka & adjoining southwest BoB. IMD GFS indicated the system to move across Sri Lanka, emerge into Palk Strait cross south Tamil Nadu coast. BFS also indicated similar features. However, NCEP GFS indicated the system to move across southwest BoB and adjoining Sri Lanka, reach near south Tamil Nadu coast and recurve northeastwards and weaken over westcentral BoB. ECMWF model did not indicate any crossing. It indicated the system to move close to Sri Lanka coast and then northwards towards south Andhra Pradesh coast. CMC model did not indicate the movement close to coast rather it indicated the system to move south to north across southwest and westcentral BoB and weaken over westcentral BoB. IMD MME indicated the system to touch Southeast Sri Lanka coast and then move towards Chennai coast. Thereafter, it indicated the system to move northeastwards and then westwards. IMD MME also indicated the system to intensify into a marginal cyclonic storm. Thus, the 0000 UTC model runs of 27th November indicated large variation in track. IMD MME was also overestimating the intensity of the system. However, MME track indicated that the system would move across east Sri Lanka coast during 27th to 29th as a cyclonic storm. It also indicated weakening of the system after 29th.

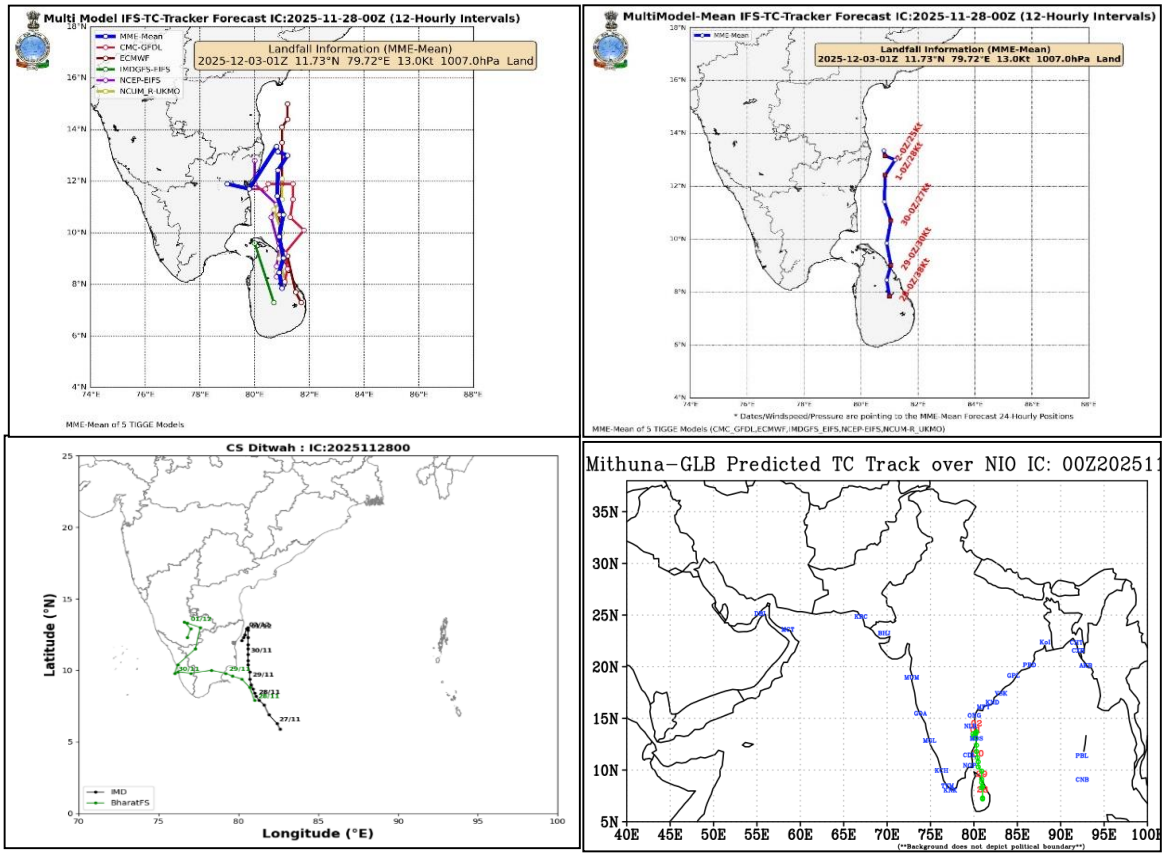


Fig.3.5.1. (vi) : NWP model track forecast based on 0000 UTC of 28.11.2025

The model runs at 0000 UTC of 28th November, IMD GFS indicated the system to move across Sri Lanka and weaken over Palk Strait. Other models like ECMWF, CMC, NCUM and NCEP indicated the system over eastcentral Sri Lanka to emerge into southwest Bay and move nearly northwards initially. CMC indicated westwards movement, NCEP indicated northwestwards movement & ECMWF indicated nearly northwards movement and weakening over westcentral BoB. IMD MME indicated the system to emerge into southwest BoB on 29th, move northwards and weaken over westcentral BoB on 2nd December/0000 UTC. BFS model indicated nearly northwards movement initially and then westwards movement towards Kerala coast, followed by north-northeastwards movement towards south Interior Karnataka. NCMRWF Mithuna-GLB model indicated nearly northwards movement form central parts of Sri Lanka to Chennai till 2nd December.

Various model runs at 0000 UTC of 29th November, indicated the system to move north-northwestwards towards Tamil Nadu coast. However, some of the models like NCUM, CMC & NCEP indicated entirely northwards movement followed by southwest wards movement towards Tamil Nadu coast. BFS indicated nearly north-northwestwards movement towards north Tamil Nadu-south Andhra Pradesh coast. Mithuna GLB indicated nearly northwards movement towards Chennai coast. IMD MME indicated north-northwestwards movement towards Chennai coast followed by south-southwestwards re-curvature.

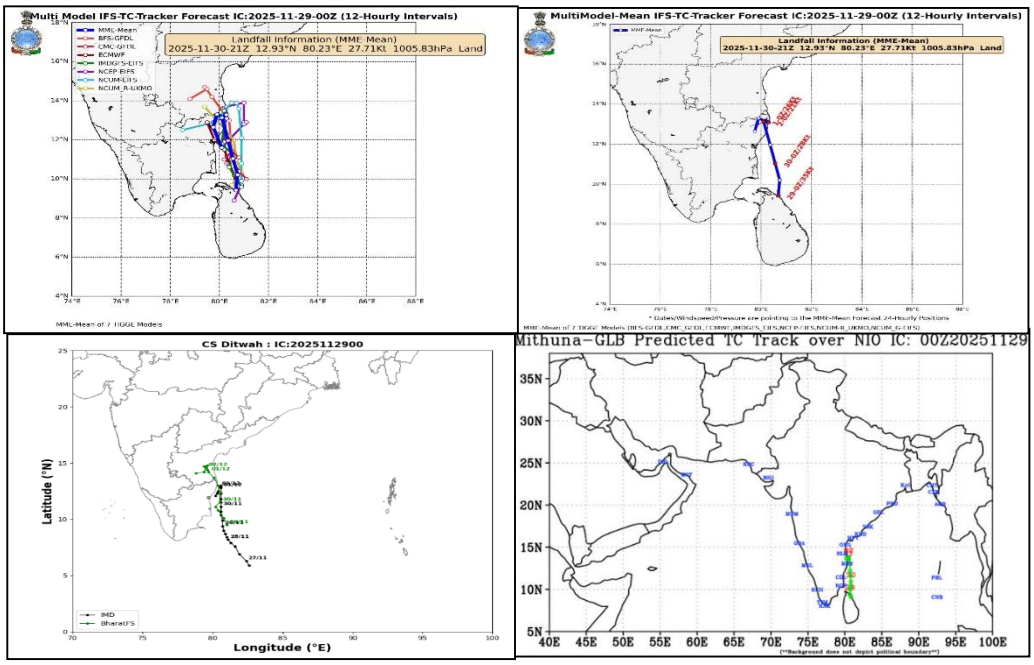


Fig.3.5.1 (vii) : NWP model track forecast based on 0000 UTC of 29.11.2025

The model runs at 0000 UTC of 30th November, all the models indicated the system to move north-northwestwards towards Tamil Nadu coast. However, some of the models like NCUM, CMC & NCEP indicated entirely northwards movement followed by southwestwards movement towards Tamil Nadu coast. BFS indicated nearly north-northwestwards movement towards north Tamil Nadu-south Andhra Pradesh coast. Mithuna GLB indicated nearly northwards movement towards Chennai coast. IMD MME indicated north-northwestwards movement towards Chennai coast followed by south-southwestwards re-curvature.

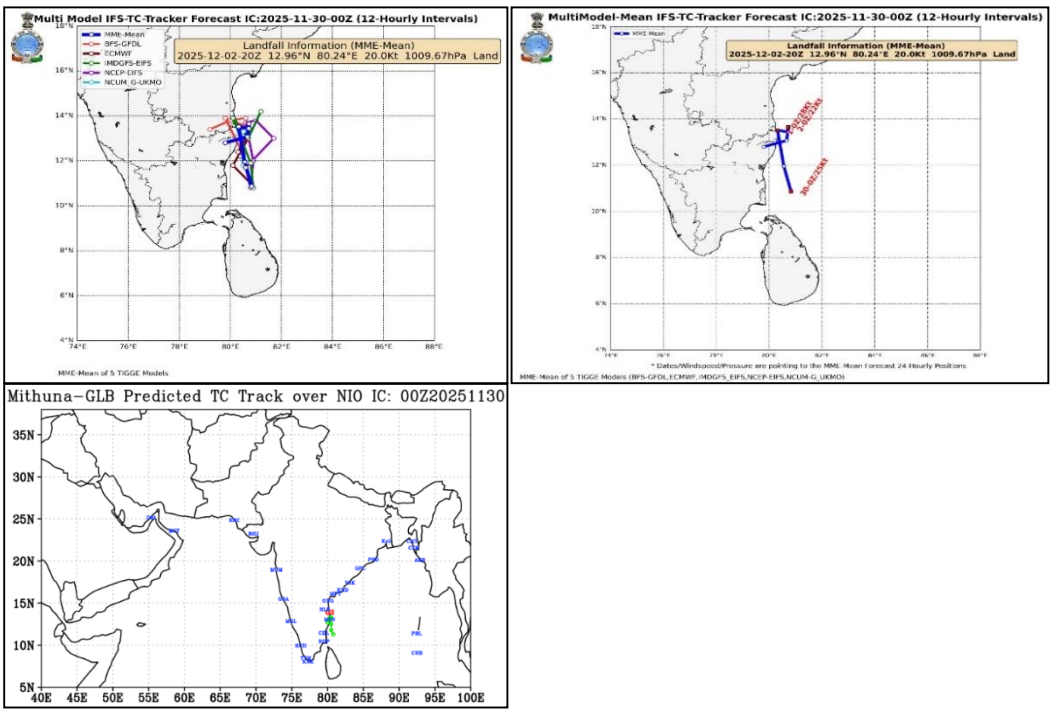


Fig.3.5.1 (viii): NWP model track forecast based on 0000 UTC of 30.11.2025

The average track forecast errors by various models compared to operational forecast errors is presented in **Table 3.5.1**. Model errors are compared with +12 hr operational errors. For 24 hrs lead period, the errors were the least by NCUM(G) followed by NCEP, MME and ECMWF. Similarly, for48 hrs lead period, the errors were the least by NCUM(G) followed by IMD MME and NCEP. For 72 hrs lead period, the errors were the least by NCUM(G) followed by MME and ECMWF. Overall, NCUM performed better than other models followed by ECMWF. However, operational errors were less than various model errors for all lead periods.

Table 3.5.1. Average track forecast errors (Direct Position Error (DPE)) in km (Number of forecasts verified is given in the parentheses)

Lead Time	12Hr	24Hr	36Hr	48Hr	60Hr	72Hr	84Hr	96Hr
NCUM_R-UKMO	80.74 (7)	57.77 (7)	56.78 (7)	91.05 (7)	89.40 (4)	107.67 (4)	NaN	NaN
NCEP-GFDL	27.17 (3)	41.82 (3)	109.69 (3)	129.10 (3)	174.58 (2)	205.79 (2)	125.50 (1)	124.87 (1)
ECMWF-EIFS	-	58.39 (8)	62.76 (8)	80.53 (8)	66.61 (7)	82.84 (6)	87.27 (4)	124.57 (2)
IMDGFS-EIFS	76.13 (8)	111.26 (7)	107.86 (7)	119.63 (5)	108.18 (3)	264.43 (1)	248.12 (1)	NaN
NCEP-EIFS	52.13 (5)	57.49 (5)	70.87 (5)	67.38 (4)	102.58 (5)	87.15 (4)	109.49 (1)	247.41 (1)
NCUM_G-EIFS	90.29 (2)	63.82 (2)	48.14 (2)	69.21 (2)	90.23 (2)	85.46 (2)	58.56 (2)	76.73 (1)
NCUM_G-UKMO	43.85 (3)	35.37 (3)	40.49 (3)	50.78 (2)	66.72 (1)	33.36 (1)	58.62 (1)	NaN
CMC_GFDL	93.67 (5)	135.18 (5)	129.10 (5)	167.39 (5)	163.48 (5)	178.49 (5)	163.00 (4)	150.98 (4)
MMEM	35.29 (8)	43.63 (8)	54.06 (8)	53.71 (8)	59.91 (7)	57.06 (6)	64.00 (5)	48.93 (4)
IMDOPER	-	32.23 (8)	47.92 (7)	52.58 (6)	49.53 (5)	35.87 (4)	58.50 (3)	90.86 (3)

The average intensity forecast errors by various models compared to operational forecast errors is presented in **Table 3.5.2**. Model errors are compared with +12 hr operational errors. For 24 hrs lead period, the errors were the least by NCUM(G) followed by NCEP, MME and ECMWF. Similarly, for 48 hrs lead period, the errors were the least by NCEP followed by NCUM(G), IMD MME and ECMWF. For 72 hrs lead period, the errors were the least by NCEP followed by NCUM(G), IMD MME and ECMWF. Overall, NCEP and NCUM performed better than other models followed by ECMWF. However, operational errors were less than various model errors for all lead periods.

Table 3.5.2: Average Intensity Forecast Errors of maximum sustained wind in knots (Number of forecasts verified is given in the parentheses).

Lead Time	12Hr	24Hr	36Hr	48Hr	60Hr	72Hr	84Hr	96Hr
NCUM_R-UKMO	7.57 (7)	5.29 (7)	6.00 (7)	5.29 (7)	5.00 (4)	3.25 (4)	NaN	NaN
NCEP-GFDL	3.67 (3)	3.33 (3)	7.00 (3)	2.67 (3)	2.00 (2)	0.50 (2)	1.00 (1)	1.00 (1)
ECMWF-EIFS	7.25 (8)	7.50 (8)	7.62 (8)	6.88 (8)	8.29 (7)	8.50 (6)	8.25 (4)	7.00 (2)
IMDGFS-EIFS	4.88 (8)	8.00 (7)	8.71 (7)	9.60 (5)	12.67 (3)	19.00 (1)	5.00 (1)	NaN
NCEP-EIFS	3.80 (5)	7.40 (5)	5.60 (5)	12.00 (4)	10.00 (5)	10.50 (4)	4.00 (1)	5.00 (1)
NCUM_G-EIFS	7.50 (2)	7.50 (2)	4.00 (2)	4.00 (2)	7.50 (2)	8.00 (2)	5.50 (2)	7.00 (1)
NCUM_G-UKMO	1.33 (3)	1.00 (3)	0.33 (3)	4.50 (2)	10.00 (1)	4.00 (1)	5.00 (1)	NaN
CMC_GFDL	4.80 (5)	7.40 (5)	10.80 (5)	9.20 (5)	9.00 (5)	6.20 (5)	7.00 (4)	7.50 (4)
MMEM	3.12 (8)	4.12 (8)	4.91 (8)	4.66 (8)	5.41 (7)	4.26 (6)	4.02 (5)	2.92 (4)
IMDOPER		1.88 (8)	3.57 (7)	5.00 (6)	4.00 (5)	3.75 (4)	5.00 (3)	6.67 (3)

3.6. Annual performance of NWP models:

The annual average track, intensity and landfall forecast errors for Cyclones over the North Indian Ocean during 2025 by various NWP models is presented in this section.

3.6.1. Mean track forecast error (km) – 2025

The annual average track forecast errors (Direct Position Error; DPE) of various NWP models during the year 2025 are presented in Table 3.6.1. For the 24-hour lead period, the least average track forecast error was recorded by the IMDGEFS Mean (49 km), closely followed by NCUM-G (57km) followed by MMEM (67 km) and ECMWF-EIFS (72 km). For 48-hour lead time, the minimum error was by IMDGEFS Mean (58 km), followed by MMEM (81 km) and NCUM-G (82 km). For the 72-hour lead period, the least track error was by NCUM-G UKMO (33 km) followed by NCUM-G EIFS and IMDGFS Mean (92 km). Overall, the NCUM-G demonstrated better performance across most lead periods during 2025. The lead-time-wise variation of track forecast errors are presented in **Table 3.6.1** and in left panel of **Fig. 3.6.1**.

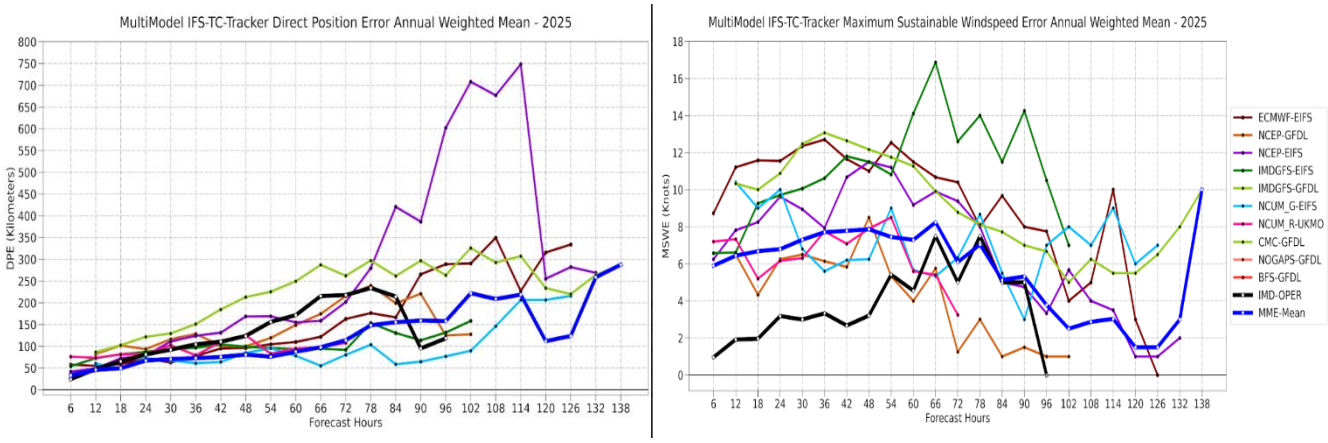


Fig 3.6.1: **Annual average (a) track (in km) and (b) intensity (in kt) forecast errors of various models during the year 2025 computed using the Multi-model IFS–TC Tracker.**

Table 3.6.1: **Annual average track forecast errors (DPE) of various models for the year 2025 (Number of forecasts verified given in the parentheses)**

Model / Lead Period (hr)	12	24	36	48	60	72	84	96	108	120
BharatFS Model	87 (37)	112 (35)	146 (31)	175 (27)	179 (23)	191 (18)	210 (15)	191 (11)	223 (9)	227 (7)
NCEP-EIFS	48.84	78.67	124.04	168.37	154.97	201.57	420.38	602.18	676.87	255.15
NCUM-R (UKMO)	73.49	81.91	79.03	125.28	94.60	107.67				
ECMWF-EIFS	54.84	72.15	77.44	95.95	109.69	162.71	166.36	288.60	349.40	315.55
NCUM-G (UKMO)	39.04	56.89	51.19	82.17	106.39	33.36	58.62			
IMDGEFS Mean	47.62	49.25	52.15	57.95	83.82	115.52	165.16	254.74	300.55	
CMC-GFDL	86.41	121.69	151.06	213.01	249.42	262.16	261.52	263.41	292.47	233.62

MMEM	45.41	67.12	72.70	80.64	87.52	113.83	155.42	157.79	208.56	111.70
NCUM-G EIFS	60.09	72.11	60.99	84.62	78.00	80.19	58.56	76.73	146.27	206.40
IMDGFS-EIFS	72.51	87.17	96.50	98.94	93.63	91.73	130.48	131.43		
NCEP-GFDL	82.31	93.34	128.27	99.79	148.81	215.38	198.98	124.87		
IMD-OPER	47.77	81.25	104.43	123.72	171.46	217.65	214.34	118.14		

3.6.2. Mean Intensity forecast error during 2025

The annual average intensity forecast errors (knots) of various models during the year 2025 are presented in Table 3.6.2. For the 24-hour lead period, the least intensity error was by NCUM-G UKMO (about 3 kt), followed by NCUM-R (about 6 kt) and IMD MMEM (7 kt). For 48-hour lead time, errors were least by BFS (0 kt) and NCUM-G UKMO (4 kt), followed by NCUM-G EIFS (6 kt) and IMD MMEM (8 kt), while MMEM also maintained comparatively smaller errors among ensemble-based guidance. For the 72-hour lead period, the minimum intensity forecast error was by NCUM-R UKMO (3 kt), followed by NCUM-G (4 kt) and MMEM (6 kt). However, IMD operational forecast demonstrated better skill in predicting cyclone intensity across most lead periods during 2025.

Table 3.6.2: **The annual Average Intensity Forecast Errors of maximum sustained wind in knots)**

Model / Lead Period (hr)	**12**	**24**	**36**	**48**	**60**	**72**	**84**	**96**	**108**	**120**
BharatFS Model (AE)	4 (37)	3 (35)	0 (31)	0 (27)	-4 (23)	-9 (18)	-12 (15)	-10 (11)	-6 (9)	1 (7)
NCEP-EIFS	7.81	9.62	7.93	11.50	9.18	9.38	5.00	5.67	4.00	1.00
NCUM-R (UKMO)	7.33	6.16	7.75	7.90	5.60	3.25				
ECMWF-EIFS	11.21	11.55	12.70	11.00	11.50	10.40	9.67	7.75	5.00	3.00
NCUM-G (UKMO)	3.22	3.43	2.80	3.67	6.00	4.00	5.00			
IMDGEFS Mean	7.83	11.17	12.83	12.40	11.80	11.75	10.67	7.50	9.00	
CMC-GFDL	10.33	10.88	13.07	12.17	11.27	8.78	7.72	6.67	6.25	5.50
MMEM	6.44	6.79	7.71	7.86	7.29	6.09	5.13	3.78	2.87	1.50
NCUM-G EIFS	10.40	10.00	5.60	6.25	5.67	6.33	5.50	7.00	7.00	6.00
IMDGFS-EIFS	6.61	9.71	10.62	11.50	14.11	12.60	11.50	10.50		
NCEP-GFDL	6.50	6.25	6.14	8.50	4.00	1.25	1.00	1.00		
IMD-OPER	1.92	3.18	3.33	3.21	4.55	5.00	5.00	0.00		

3.6.3. Mean Landfall Point and time forecast error during 2025

The annual average accuracy in landfall point and time by various models is presented in Table 3.6.3 and Table 3.6.4 respectively. Considerable variability is noted among the models across different lead times and errors are significantly higher as all the cyclones were recurving cyclones.

Table 3.6.3: **Annual average landfall Point Errors (in km)**

Model / Lead hr	6	18	30	42	54	66
ECMWF-EIFS		45.81		7.70		
IMDGFS-EIFS		24.64		13.89		
MMEM	5.78	34.89	60.13	59.59	5.33	223.01
CMC-GFDL		88.44		311.22		
NCEP-GFDL			68.31		234.51	223.01
NCUM-G (UKMO)	60.13	31.74		91.87		
NCEP-EIFS		36.08		252.03		
NCUM-R (UKMO)	130.93	14.94		107.03		
IMD-OPER		65.47	74.87	99.00	69.24	67.46

Table 3.6.4: **Annual average landfall time Errors (in hr)**

Model / Lead hr	6	18	30	42	54	66
ECMWF-EIFS		0.0		-2.0		
IMDGFS-EIFS		2.0		8.0		
MMEM	0.0	2.0	0.0	2.0	0.0	-16.0
CMC-GFDL		-6.0		-16.0		
NCEP-GFDL			4.0		-20.0	-16.0
NCUM-G (UKMO)	0.0	2.0		4.0		
NCEP-EIFS		3.0		-10.0		
NCUM-R (UKMO)	0.0	1.0		-3.0		
IMD-OPER		0.0	0.0	2.0	5.0	5.0

Legends: BharatFS: Bharat Forecast System, NCEP: National Centers for Environmental Prediction, EIFS: Ensemble Integrated Forecast System, NCUM: National Centre for Medium Range Weather Forecasting Unified Model, UKMO: United Kingdom Met Office, ECMWF: European Centre for Medium-Range Weather Forecasts, GEFS: Global Ensemble Forecast System, IMD: India Meteorological Department, GFDL: Geophysical Fluid Dynamics Laboratory, IMD-OPER: IMD Operational Forecast. MMEM: Mean Multi Model Ensemble introduced in 2021 based on average forecast by TC trackers, NEPS: NCUM Ensemble Prediction System.

CHAPTER-IV
PERFORMANCE OF RSMC, NEW DELHI
Prediction of cyclonic disturbances and associated adverse weather during 2025

4.1 Introduction

The Cyclone Warning Division/ Regional Specialized Meteorological Centre (RSMC)-Tropical Cyclone, IMD, New Delhi mobilized all its resources for monitoring and prediction of cyclonic disturbances over the north Indian Ocean during 2025. It issued pre-genesis forecast once daily from the stage of low-pressure area. It was followed by 6 hourly forecast and warning/advisory bulletins in the stage of depression/deep depression, 3 hourly advisories from the stage of cyclonic storm and hourly advisories on the day of landfall to various national disaster management agencies including National Disaster Management Authority (NDMA), Ministry of Home Affairs (MHA), concerned state Govts. and other users. It also issued advisories to World Meteorological Organization (WMO)/Economic and Social Cooperation for Asia and the Pacific (ESCAP) Panel member countries including Bangladesh, Myanmar, Thailand, Sri Lanka and Maldives during cyclone period. As tropical cyclone advisory centre (TCAC), it also issued tropical cyclone advisories with effect from the stage of deep depression for international civil aviation purpose as per the requirement of international civil aviation organization (ICAO) to the Meteorological watch offices of Asia Pacific region and middle east countries. The TCAC bulletin was also sent to Aviation Disaster Risk Reduction (ADRR) centre of WMO at Hong Kong like previous years.

IMD continuously monitor and predict cyclogenesis, track, intensity and structure of cyclones. The genesis forecast in probabilistic terms in medium range forecast was issued from 01 June 2015 for a lead period of 72 hours and was extended to 120 hours in 2018 and 168 hours in 2023. Extended range outlook for next two weeks in probabilistic terms commenced in 2018. Pre-genesis forecast for track, intensity, landfall and structure commenced in March, 2022. Bulletins containing track & intensity forecast at +06, +12, +18, +24, +36, +48, +60, +72, +84, +96, +108 and +120 hrs or till the system weakened into a low-pressure area were issued regularly. The above structured track and intensity forecasts were issued from the stage of well marked low pressure area onwards. The cone of uncertainty in the track forecast was also given for all deep depressions and cyclones. The radius of maximum wind and radius of ≥28 kts, ≥ 34 kts, ≥ 50 kts wind in four quadrants of deep depression and cyclones was also issued every six hourly. The graphical display of the observed and forecast track with cone of uncertainty and the wind forecast for different quadrants were uploaded in the RSMC website regularly. The storm surge guidance and coastal inundation was provided as and when required to the member countries of WMO/ESCAP Panel based on IMD's statistical model, IITD model and INCOIS ADCirc Model. The prognosis and diagnosis of the systems have been described in the special tropical weather outlook and tropical cyclone advisory bulletins since 2008.

The statistics of bulletins issued by IMD, New Delhi with respect to cyclonic disturbances is presented in Sec. 4.2. The performance of RSMC-New Delhi in track and intensity prediction of the cyclones during 2025 are analysed and discussed in Sec.4.3.

4.2 Bulletins issued by IMD

The following are the statistics of bulletins issued by IMD in association with the cyclonic disturbances during 2025

Bulletins issued during 'SHAKHTI'

Bulletins for national disaster management agencies	:	42
Bulletin for WMO/ESCAP Panel counties		42
(Special Tropical Weather Outlook and Tropical Cyclone Advisory)	:	
Tropical cyclone advisory for international civil aviation	:	18

Bulletins issued during 'MONTHA'

Bulletins for national disaster management agencies	:	52
Bulletin for WMO/ESCAP Panel counties		
(Special Tropical Weather Outlook and Tropical Cyclone Advisory)	:	44
Tropical cyclone advisory for international civil aviation	:	12
Hourly Bulletins	:	16

Bulletins issued during 'SENYAR'

Bulletins for national disaster management agencies	:	18
Bulletin for WMO/ESCAP Panel counties		
(Special Tropical Weather Outlook and Tropical Cyclone Advisory)	:	24
Tropical cyclone advisory for international civil aviation	:	7

Bulletins issued during 'DITWAH'

Bulletins for national disaster management agencies	:	51
Bulletin for WMO/ESCAP Panel counties		
(Special Tropical Weather Outlook and Tropical Cyclone Advisory)	:	57
Tropical cyclone advisory for international civil aviation	:	8

Bulletins issued for all cyclones during 2025

Bulletins for national disaster management agencies	:	163
RSMC bulletin for WMO/ESCAP Panel member countries		167
(Special Tropical Weather Outlook and Tropical Cyclone Advisory)	:	
TCAC bulletin for international civil aviation	:	45
Hourly bulletins on the day of landfall	:	16

The number of bulletins issued during 2009-2025 for all cyclones over the NIO is shown in Fig.**4.2.1**.

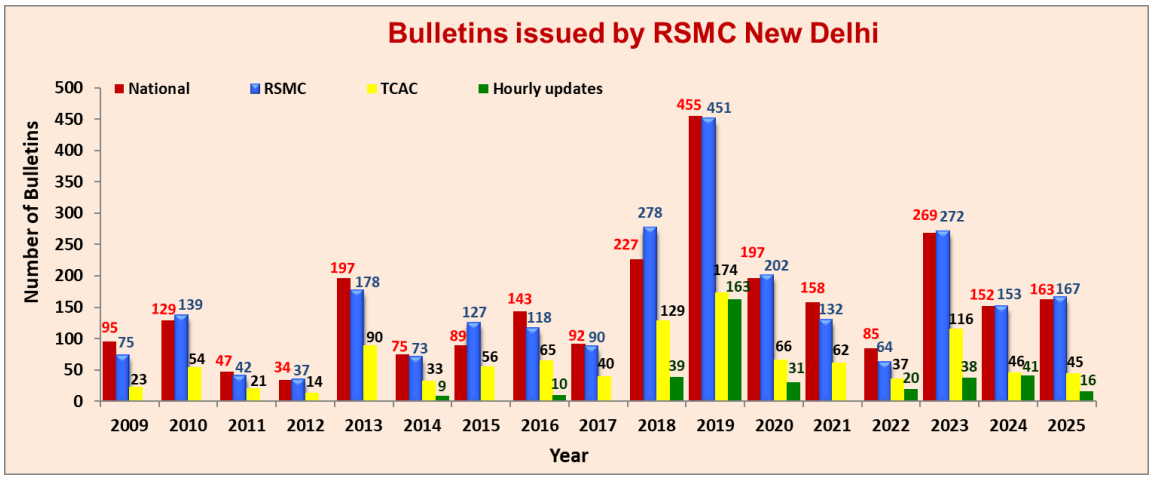


Fig.4.2.1: Total Number of bulletins issued by RSMC, New Delhi for all cyclones during 2009-2025

4.3 Performance of Operational Genesis, Track, intensity and landfall forecast

The performance of operational genesis, track, landfall and intensity forecasts issued by IMD, New Delhi for the four cyclones during 2025 is described in following sections:

4.3.1 Severe Cyclonic Storm SHAKHTI over Arabian Sea (AS) during 01st – 07th October, 2025

4.3.1.1 Genesis Forecast

- The extended range outlook issued on 25th Sep. indicated emergence of remnant of depression over northwest & adjoining westcentral Bay of Bengal (BoB) into northeast AS and adjoining South Gujarat with moderate probability of its intensification into a depression around 30th Sep. Actually, it moved across central India and emerged into Gulf of Cambay on 29th Sep. It then moved across Gujarat and emerged into northeast AS on 1st Oct. morning. (about 6 days in advance of formation of depression over northeast AS).
- Regular Tropical Weather Outlooks issued from 28th Sep. onwards, on weakening of the depression into a well marked low pressure area over Vidarbha region, indicated that the remnant would continue to move across North Madhya Maharashtra, south Gujarat and Saurashtra during 28th to 30th September and emerge as a low-pressure area over Northeast Arabian Sea off Gujarat coast by 1st October. Considering the chances of further intensification, continuous monitoring of the system was maintained.

4.3.1.2. Track forecast error and skill

The operational track forecast errors for 24, 48 and 72 hrs lead period were 90, 237 and 440 km against the long period average errors of 72, 111 and 154 km respectively based on the data of 2020-24 (Fig. 4.3.1.1a). The operational track forecast skills compared to climatological & persistence (CLIPER) based forecast for 24, 48 and 72 hours lead period were 74, 70 and 64% against long period average (2020-24) skills of 65, 74 and 77 % respectively (Fig. 4.3.1.1b). For all lead periods, the operational track forecast errors were more the long period average errors (2020-24). However, the skill was comparable to long period average errors for all lead periods. It is mainly attributed to the fact that the Shakhti exhibited multiple recurvatures and the predictability of recurving cyclones is less than that of straight moving cyclones.

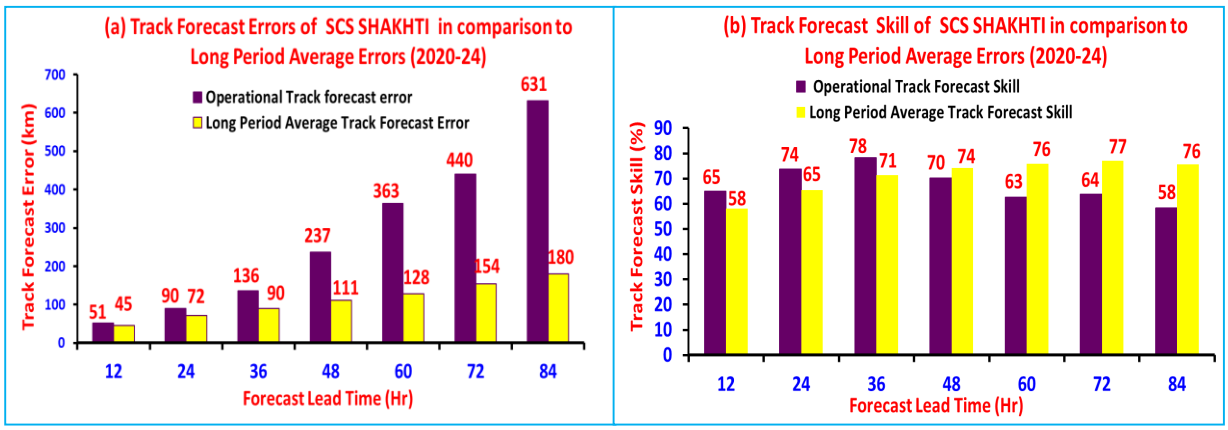


Fig. 4.3.1.1: (a) Track forecast errors and (b) skills against Climatology & Persistence (CLIPER) compared to long period average (LPA of 2020-2024) errors & skills respectively

Table 4.3.1.1: Operational Track forecast errors and skill as compared to long period average (2020-24)

Lead Period (hrs)	N	Operational Track forecast error (km)	Operational Track Forecast Skill (%)	Long Period Average (2020-24)	
				Track Forecast Error (km)	Track Forecast Skill (%)
12	16	51	144	65	45
24	14	90	341	74	72
36	12	136	621	78	90
48	10	237	794	70	111
60	8	363	968	63	128
72	6	440	1209	64	154
84	3	631	1517	58	180

4.3.1.3. Intensity forecast error and skill

- The absolute errors (AE) in intensity (wind) forecast for 24, 48 and 72 hrs lead period were 2.5, 2.0 and 5.0 knots against the long period average errors of 5.9, 8.3 and 9.8 knots based on the data of 2020-24 respectively (Fig. 4.3.1.2a). The root mean square errors (RMSE) of intensity (wind) forecast for 24, 48 and 72 hrs lead period were 3.5, 3.2 and 5.8 knots against the long period average errors of 7.9, 13.3 and 12.6 knots based on data of 2020-24 respectively (Fig. 4.3.1.2b). For all lead periods, the operational intensity forecast errors were markedly less than the long period average errors.
- The skills in intensity (wind) forecast for 24, 48 and 72 hrs lead period were 74, 94 and 92 % against the long period average skills of 57, 69 and 79% based on the data of 2020-24 respectively (Fig. 4.3.1.3a). The skills in intensity (wind) forecast based on RMSE for 24, 48 and 72 hrs lead period were 73, 92 and 92 % against the long period average errors of 60, 71 and 79 knots based on the data of 2020-24 respectively (Fig. 4.3.1.3b).

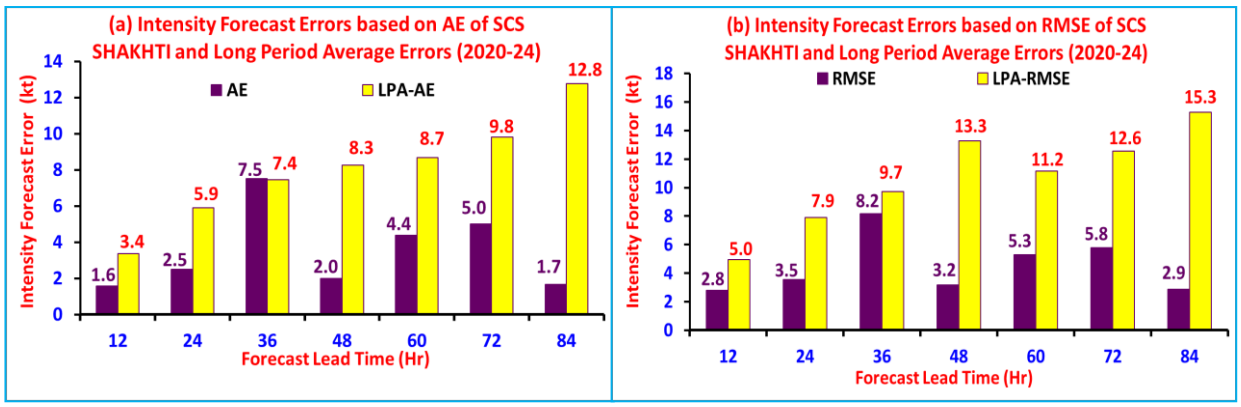


Fig. 4.3.1.2: (a) Absolute errors (AE) and (b) Root Mean Square errors (RMSE) in intensity forecast (winds in knots) as compared to long period average (2020-24)

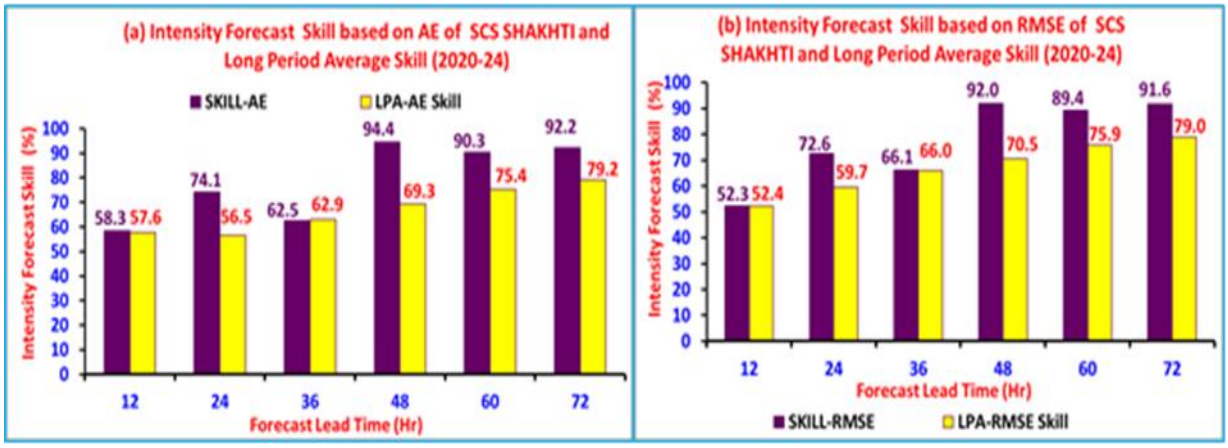


Fig. 4.3.1.3: Skill (%) in intensity forecast based on (a) Absolute errors (AE) and (b) Root Mean Square errors (RMSE) as compared to long period average (2020-24)

Table 4.3.1.2: Operational Absolute errors (AE) and Root Mean Square errors (RMSE) and corresponding skill in intensity forecast as compared to long period average (2020-24)

Lead Period	N	AE	RMSE	Skill-AE	Skill-RMSE	Long Period Average (2020-24)			
						AE	RMSE	Skill-AE	Skill-RMSE
12	16	1.6	2.8	58	52	3.4	5.0	58	52
24	14	2.5	3.5	74	73	5.9	7.9	57	60
36	12	7.5	8.2	63	66	7.4	9.7	63	66
48	10	2.0	3.2	94	92	8.3	13.3	69	71
60	8	4.4	5.3	90	89	8.7	11.2	75	76
72	6	5.0	5.8	92	92	9.8	12.6	79	79
84	3	1.7	2.9	97	96	12.8	15.3	81	79

N: No. of observations verified, AE: Absolute error, RMSE: Root Mean Square Error, LPA: Long Period Average

4.3.2 Severe Cyclonic Storm "MONTHA" over the westcentral Bay of Bengal (25th - 29nd Oct, 2025)

4.3.2.1 Genesis Forecast

- IMD provided 1st information about the likely development of low-pressure area over southeast BoB on 9th October (**15 days ahead of formation of low pressure area on 24th Oct**) and formation of depression on 16th October (**about 9 days ahead of formation of depression on 25th Oct**).
- On 24th October at 1400 hrs IST/0830 UTC (about 4.5 days ahead of landfall), IMD issued **Pre-genesis (before formation of depression) track and intensity forecasts**, indicating movement towards Andhra Pradesh coast and intensification into a cyclonic storm over southwest BoB when the system lay as low-pressure area over southwest BoB on 24th October.
- Actually, low pressure area formed over southeast BoB on 24th October, depression over southeast BoB on 25th October, cyclonic storm "MONTHA" over southwest BoB on 27th and severe cyclonic storm on 28th October. Montha crossed Andhra Pradesh and Yanam coasts between Machilipatnam and Kalingapatnam to the south of Kakinada close to Narsapur near latitude 16.35N and longitude 81.70 E during midnight of 28th October (2330 hrs IST of 28th October and 0030 hrs IST of 29th October) with maximum sustained wind speed of 90-100 gusting to 110 kmph.

4.3.2.2. Track forecast error and skill

The operational track forecast errors for 24, 48 and 72 hrs lead period were 68, 63 and 113 km against the long period average errors of 72, 111 and 154 km respectively based on the data of 2020-24 (**Fig. 4.3.2.1a**). However, the operational track forecast skills compared to climatological & persistence (CLIPER) based forecast for 24, 48 and 72 hours lead period were 39, 54 and 15% against long period average (2020-24) skills of 65, 74, 77 and 78 % respectively (**Fig. 4.3.2.1b). For all lead periods, the operational track forecast errors were less than the long period average errors (2020-24).**

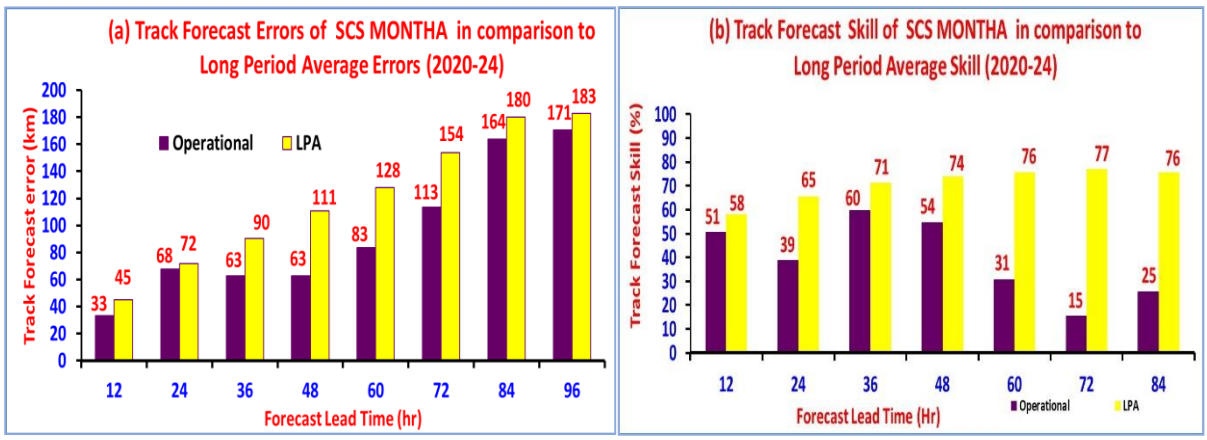


Fig. 4.3.2.1: (a) Operational track forecast errors and (b) skill compared to long period average during 2020-24

Table 4.3.2.1: Operational Track forecast errors and skill as compared to long period average (2020-24) errors

Lead Period (hrs)	N	Operational Track forecast error (km)	Operational Track Forecast Skill (%)	Long Period Average (2020-24)	
				Track Forecast Error (km)	Track Forecast Skill (%)
12	16	33	51	45	58
24	14	68	39	72	65
36	12	63	60	90	71
48	10	63	54	111	74
60	8	83	31	128	76
72	6	113	15	154	77
84	4	164	25	180	76
96	2	171	56	183	78

N: No. of observations verified,

4.3.2.3. Intensity forecast error and skill

- The absolute errors (AE) in intensity (wind) forecast for 24, 48 and 72 hrs lead period were 2.5, 3.0 and 1.7 knots against the long period average errors of 5.9, 8.3 and 9.8 knots based on the data of 2020-24 respectively (**Fig. 4.3.2.2a**). The root mean square errors (RMSE) of intensity (wind) forecast for 24, 48 and 72 hrs lead period were 3.5, 5.0 and 2.9 knots against the long period average errors of 7.9, 13.3 and 12.6 knots based on data of 2020-24 respectively (**Fig.4.3.2.2b**). **For all lead periods, the operational intensity forecast errors were markedly less than the long period average errors.**
- The skills in intensity (wind) forecast for 24, 48 and 72 hrs lead period were 75, 79 and 93 % against the long period average skills of 57, 71 and 77% based on the data of 2020-24 respectively (**Fig. 4.3.2.3a**). The skills in intensity (wind) forecast for 24, 48 and 72 hrs lead period were 2.5, 3.0 and 1.7 % against the long period average errors of 5.9, 8.3 and 9.8 knots based on the data of 2020-24 respectively (**Fig. 4.3.2.3b**)

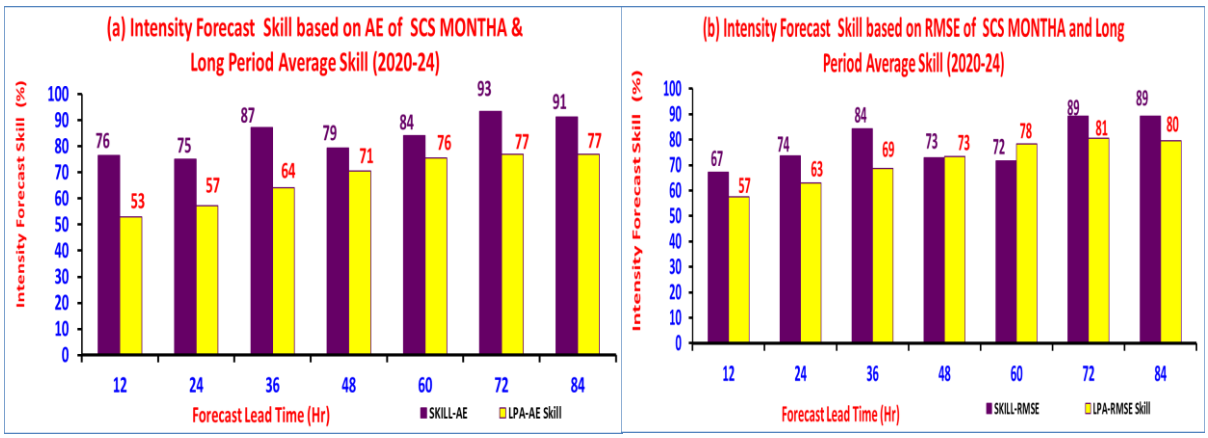


Fig. 4.3.2.2: (a) Absolute errors (AE) and (b) Root Mean Square errors (RMSE) in intensity forecast (winds in knots) as compared to long period average (2020-24)

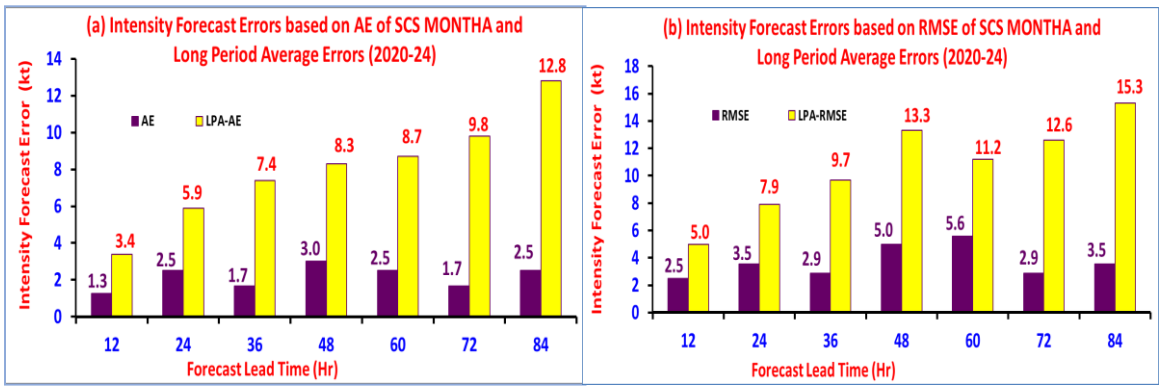


Fig. 4.3.2.3: Skill (%) in intensity forecast based on (a) Absolute errors (AE) and (b) Root Mean Square errors (RMSE) as compared to long period average (2020-24)

Table 4.3.2.2: Operational Absolute errors (AE) and Root Mean Square errors (RMSE) and corresponding skill in intensity forecast as compared to long period average (LPA) errors during 2020-24 errors

Lead Period	N	AE (kt)	RMSE (kt)	Skill-AE (%)	Skill-RMSE (%)	Long Period Average (2020-24)			
						AE (kt)	RMSE (kt)	Skill-AE (%)	Skill-RMSE (%)
12	16	1.3	2.5	76	67	3.4	5.0	53	57
24	14	2.5	3.5	75	74	5.9	7.9	57	63
36	12	1.7	2.9	87	84	7.4	9.7	64	69
48	10	3.0	5.0	79	73	8.3	13.3	71	73
60	8	2.5	5.6	84	72	8.7	11.2	76	78
72	6	1.7	2.9	93	89	9.8	12.6	77	81
84	4	2.5	3.5	91	89	12.8	15.3	77	80
96	2	2.5	3.5	76	67	3.4	5.0	53	57

N: No. of observations verified

4.3.2.4. Landfall point and time forecast error

The operational landfall point forecast errors for 24, 48 and 72 hrs lead period were 76, 82 and 120 km respectively against the long period average (LPA) errors of 16, 39 and 70 km based on data of 2020 – 24 (Fig. **4.3.2.4**a). The operational landfall point errors were about 60-70 km higher than long period average errors (2020-24) for different lead periods. It could be mainly attributed to the fact that the system changed its track just before landfall.

The operational landfall time forecast errors for 24, 48 and 72 hrs lead period were 3.0, 3.0 and 1.5 hours respectively against the long period average error of 2.9, 4.2 and 7.5 hours respectively based on the data of 2020-24 (Fig. **4.3.2.4**b). The operational landfall time forecast errors were markedly less than the LPA errors for all lead periods.

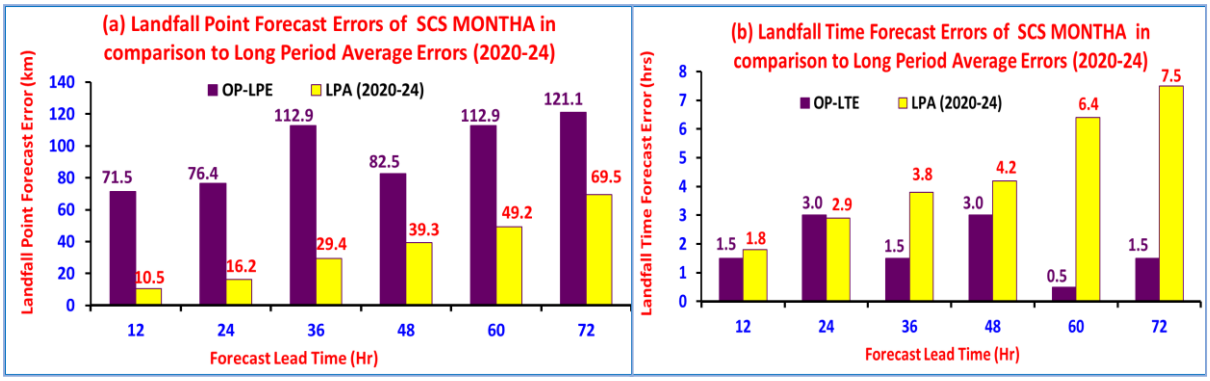


Fig. 4.3.2.4: (a) Operational landfall point and (b) time forecast errors compared to long period average during 2020-24

Table 4.3.2.3: Operational landfall point and time forecast errors compared to long period average (2020-24)

Lead Period	Base Time (UTC)	Landfall Point (^{0}N/^{0}E)		Landfall Time (hours) (IST)		Landfall Point (^{0}N/^{0}E) and Time errors			
		Forecast	Actual	Forecast	Actual	LPE (km)		LTE (hrs)	
						Op.	LPA	Op.	LPA
12	28/06	16.6/82.3	16.35/81.7	28/1700	28/1830	71.5	10.5	1.5	1.8
24	27/18	16.7/82.3	16.35/81.7	28/1530	28/1830	76.4	16.2	3.0	2.9
36	27/06	17.1/82.4	16.35/81.7	28/1700	28/1830	112.9	29.4	1.5	3.8
48	26/18	16.8/82.3	16.35/81.7	28/1530	28/1830	82.5	39.3	3.0	4.2
60	26/06	17.1/82.4	16.35/81.7	28/1800	28/1830	112.9	49.2	0.5	6.4
72	25/18	17.2/82.4	16.35/81.7	28/1700	28/1830	121.1	69.5	1.5	7.5

4.3.2.4. Adverse weather forecast performance:

The verification of heavy rainfall, wind and storm surge warnings is presented in table 4.3.2.3, 4.3.2.4 and 4.3.2.5 respectively.

Table 4.3.2.3: Verification of Heavy Rainfall Forecast

Date/Base Time of observation	24 hr. Heavy rainfall warning ending at 0300 UTC of next day.	Realised rainfall 24 – hour ending on
22.10.2025 /0830 hrs. IST	**22.10.2025 /0830 hrs. IST** **Tamil Nadu & Puducherry: H** rainfall at isolated places is very likely on 23rd & 24th and **H to EH** rainfall at isolated places over North Tamil Nadu on today, the 22nd October. **Andhra Pradesh: H to EH** heavy rainfall at isolated places coastal Andhra Pradesh and Rayalaseema is very likely during 22nd, **H to VH** rainfall at isolated places on 23rd and isolated **H** rainfall 24th & 25th October.	**23.10.2025 /0830 hrs. IST** **Tamil Nadu, Puducherry & Karaikal: VH** rainfall at isolated places, **H** rainfall at scattered places.

	South Interior Karnataka: H to VH rainfall at isolated places is very likely on 22nd and isolated **H** rainfall on 23rd & 24th October. **Telangana: H** rainfall at isolated places is very likely during 23rd to 25th October.	**South Interior Karnataka: H** rainfall at scattered places. **Coastal Karnataka: H** rainfall at scattered places. **Coastal Andhra Pradesh & Yanam: H** rainfall at scattered places. **Rayalaseema: H** rainfall at scattered places. **24.10.2025 /0830 hrs. IST** **Coastal Andhra Pradesh & Yanam: VH** rainfall at isolated places, **H** rainfall at scattered places. **Tamil Nadu: : VH** rainfall at isolated places, **: H** rainfall at most places, **North Interior Karnataka**: **VH** rainfall at isolated places, **H** rainfall at most places. **Rayalaseema: VH** rainfall at isolated places, **H** rainfall at most places. **Kerala: H** rainfall at scattered places. **South Interior Karnataka: H** rainfall at isolated places **Tripura: H** rainfall at isolated places. **25.10.2025 /0830 hrs. IST** **Tamil Nadu & Puducherry: VH** rainfall at isolated places. **H** rainfall at most places.
23.10.2025 /0830 hrs. IST	**23.10.2025 /0830 hrs. IST** **Andaman & Nicobar Islands: H to VH** rainfall at isolated places till 26th October. **Tamil Nadu: H** rainfall at isolated over interior Tamil Nadu is very likely on 23rd & 24th and during 26th to 28th October. **Andhra Pradesh: H to VH** rainfall at isolated places over coastal Andhra Pradesh and Rayalaseema on 23rd ,27th & 28th and isolated **H** rainfall during 24th to 26th October. **South Interior Karnataka:** Isolated **H to VH** rainfall at isolated places on 23rd and isolated **H** rainfall on 24th & 25th October. **Telangana: H** rainfall at isolated places is very likely during 23rd to 25th October.	
24.10.2025 /0830 hrs. IST	**24.10.2025 /0830 hrs. IST** **Andaman & Nicobar Islands: H** rainfall at isolated places till 25 th October. **Tamil Nadu: H** rainfall at isolated over interior Tamil Nadu is very likely during 24 th to 26 th & on 28th October and **H to VH** rainfall at isolated places on 27th October. **Andhra Pradesh: H** rainfall at isolated over interior Tamil Nadu is very likely during 24th-25th and **VH to EH** rainfall at isolated places over coastal Andhra Pradesh and Rayalaseema during 26 th to 28th and isolated **H** rainfall during 29th October. **Telangana: H** rainfall at isolated places is very likely on 24 th October and on 27th & 28th October. **Odisha: H** rainfall at isolated places is very likely during 24 th & 26th October, and isolated **H to EH** rainfall during 27th to 29 th October. **West Bengal: H** rainfall at isolated places is very likely during 28th to 30th October.	
25.10.2025 /0830 hrs. IST	**25.10.2025 /0830 hrs. IST** **Andaman & Nicobar Islands: H** rainfall at isolated places on 25 th October. **Tamil Nadu, Puducherry & Karaikal: H** rainfall at isolated over interior Tamil Nadu is very likely during 25 th to 26 th & on 28th October and **H to VH** rainfall at isolated places on 27th October. **Andhra Pradesh & Yanam of Puducherry: H** rainfall at isolated **H to VH** rainfall	

	over Andhra Pradesh & Yanam of Puducherry during 26th to 29th October with **EH** rainfall at isolated places over south Coastal Andhra Pradesh & Yanam on 27th and coastal Andhra Pradesh & Yanam on 28th & 29th October and over Rayalaseema on 27th & 28th October. **Telangana: H** rainfall at isolated places is very likely on 27th & 28th October. **Odisha: H** rainfall at isolated places is very likely on 26th October, and isolated **H to VH** rainfall over Odisha during 27th to 29th October and isolated **EH** rainfall on 28th & 29th October over south Odisha. **West Bengal: H** rainfall at isolated places is very likely during 28th to 30th October.	**Nicobar Island: H** rainfall at scattered places **Rayalaseema: H** rainfall at isolated places **Coastal Andhra Pradesh: H** rainfall at isolated places **26.10.2025 /0830 hrs. IST** **Tamil Nadu & Puducherry: VH** rainfall at isolated places, **H** rainfall at scattered **Coastal Andhra Pradesh: H** rainfall at isolated places **27.10.2025 /0830 hrs. IST** **Coastal Andhra Pradesh**: **H** rainfall at isolated places **28.10.2025 /0830 hrs. IST** **Saurashtra & Kutch: VH** rainfall at isolated places, **H** rainfall at scattered places, **Gujarat Region: VH** rainfall at isolated places, **H** rainfall at scattered places. **Coastal Andhra Pradesh & Yanam: VH** rainfall at isolated places, **H** rainfall at scattered places. **Rayalaseema: H** rainfall at isolated places. **Odisha: H** rainfall at scattered places.
26.10.2025 /0830 hrs. IST	**26.10.2025 /0830 hrs. IST** **Andaman & Nicobar Islands: H** rainfall at isolated places on 26 th October and decrease thereafter. **Tamil Nadu, Puducherry & Karaikal: H** rainfall at isolated places over Tamil Nadu is very likely on 26 th & on 28th October and **H to VH** rainfall at isolated places on 27th October. **Andhra Pradesh & Yanam of Puducherry: H** rainfall at isolated places very likely on 26th; **H to VH** rainfall at isolated places on 27th. **H to VH** rainfall at isolated places very likely over north coastal Andhra Pradesh on 29th October. **Telangana: H** rainfall at isolated places is very likely on 27th; isolated **H to VH** rainfall on 28th October and isolated **H** rainfall on 29th October. **Odisha: H** rainfall at isolated places is very likely on 26 th, and **H to VH** rainfall at isolated places on 27th. **EH** rainfall (>20 cm) at isolated places over south Odisha and isolated **H to VH** rainfall over north Odisha on 28th & 29th October. Isolated **H** rainfall likely over Odisha on 30th October. **Chhattisgarh:** isolated **H** rainfall likely over south Chhattisgarh on 27th. Isolated **EH** rainfall (> 20 cm) is likely on 28th October. Isolated **H** rainfall is also likely over north Chhattisgarh on 28th & 29th October. Isolated **H** rainfall likely on 30th October. **Gangetic West Bengal: H** rainfall at isolated places is very likely during 28th to 30th October. **Sub-Himalayan West Bengal & Sikkim:** Isolated **H** rainfall likely on 30th October. **Jharkhand:** isolated **H** rainfall at isolated places is very likely during 28th to 30th October.	

	Bihar: H rainfall at isolated places is very likely during 29 th to 30th October.	**29.10.2025 /0830 hrs. IST** **Coastal Andhra Pradesh & Yanam: EH** rainfall at few places, **VH** rainfall at scattered places, **H** at most places **Rayalaseema: VH** rainfall at isolated places, **H** at most places **Telangana: VH** rainfall at few places, **H** at most places **Odisha: VH** rainfall at isolated places; **H** at most places **Gangetic West Bengal: H rainfall** at isolated places. **Tamil Nadu, Puducherry & Karaikal: H rainfall** at isolated places **Bihar: H rainfall** at isolated places. **30.10.2025 /0830 hrs. IST** **Telangana: EH** rainfall at scattered places, **VH** rainfall at most places, **H** rainfall at most places. **Konkan & Goa: H** rainfall at most places. **Coastal Andhra Pradesh: H** rainfall at isolated places. **Odisha: H** rainfall at few places. **Marathawada: H** rainfall at isolated places.
27.10.2025 /0830 hrs. IST	**27.10.2025 /0830 hrs. IST** **Tamil Nadu, Puducherry & Karaikal: H to VH** rainfall at isolated places on 27th and 28th October. **Andhra Pradesh & Yanam of Puducherry: H to VH** rainfall at a few places with **EH** rainfall (> 20 cm) at isolated places during 27th-29th October. **H** rainfall at isolated places over north coastal Andhra Pradesh on 30th October. **Odisha: H to VH** rainfall at isolated places on 27th October. **EH** rainfall (>20 cm) at isolated places over south Odisha and isolated **H to VH** rainfall over north Odisha on 28th & 29th October. Isolated **H** rainfall is likely over Odisha on 30th October. **Telangana: H** rainfall at isolated places on 27th October with isolated **H to VH** rainfall on 28th & 29th October. **Chhattisgarh:** isolated **H** rainfall likely over south Chhattisgarh on 27th. Isolated **H to VH** rainfall at isolated places is very likely on 29th October. Isolated **H** rainfall is likely on 30th October. **Gangetic West Bengal: H** rainfall at isolated places during 28th to 31st October. **Sub-Himalayan West Bengal & Sikkim:** Isolated **H** rainfall on 30th October and **H to VH** rainfall on 31st October. **Jharkhand: H** rainfall at isolated places on 28th, 29th & 31st October with **H to VH** rainfall on 30th October. **Bihar: H** rainfall at isolated places during 29th October with **H to VH** rainfall on 30th & 31st October	
28.10.2025 /0830 hrs. IST	**28.10.2025 /0830 hrs. IST** **Tamil Nadu, Puducherry & Karaikal: H to VH** rainfall at isolated places on 28th October. **Andhra Pradesh & Yanam of Puducherry: H to VH** rainfall at a few places with **EH** rainfall (> 20 cm) at isolated places till 29th October. **H** rainfall at isolated places over north coastal Andhra Pradesh on 30th October. **Odisha: H to VH** rainfall at a few places and **EH** rainfall (>20 cm) at isolated places over south Odisha and isolated **H to VH** rainfall over north Odisha on till 29th October. Isolated **H** rainfall is likely over Odisha on 30th October. **Telangana:** isolated **H to VH** rainfall till 29th October.	

	Chhattisgarh: H to VH rainfall with **EH** rainfall (> 20 cm) at isolated places over south Chhattisgarh on 28th October. Isolated **H to VH** rainfall at isolated places is very likely on 29 th October. Isolated **H** rainfall is likely on 30th October. **Gangetic West Bengal: H** rainfall at isolated places till 31st October. **Sub-Himalayan West Bengal & Sikkim:** Isolated **H** rainfall on 30th October and **H to VH** rainfall on 31st October. **Jharkhand: H** rainfall at isolated places during 28th to 31st October with **H to VH** rainfall on 30th October. **Bihar: H** rainfall at isolated places on 29th October with **H to VH** rainfall on 30th & 31st October.	**Vidarbha: H** rainfall at isolated places. **Jharkhand: H** rainfall at isolated places. **Coastal Karnataka: H** rainfall at isolated places. **31.10.2025 /0830 hrs. IST** **Bihar:** V**H** rainfall at isolated places **H** rainfall at most places. **Jharkhand: H** rainfall at scattered places. **Sub-Himalayan West Bengal: H** rainfall at most places. **Chhattisgarh: H** rainfall at isolated places. **East Madhya Pradesh: H** rainfall at isolated places. **West Madhya Pradesh: H** rainfall at isolated places.
29.10.2025 /0830 hrs. IST	**29.10.2025 /0830 hrs. IST** **Andhra Pradesh & Yanam of Puducherry: H to VH** rainfall at a few places on 29th October. **Odisha: H** rainfall at isolated places over Odisha on 29th October. **Telangana:** Isolated **H to EH** rainfall on 29th October. **Chhattisgarh: H** rainfall at isolated places on 29th & 30th October. **Gangetic West Bengal: H** rainfall at isolated places till 31st October. **Sub-Himalayan West Bengal & Sikkim: H** heavy rainfall at isolated places on 30th October and **H to VH** rainfall at isolated places on 31st October. **Jharkhand: H** rainfall at isolated places on 30th and 31st October. **Bihar: H to VH** rainfall at isolated places on 30th & 31st October.	
30.10.2025 /0830 hrs. IST	**30.10.2025 /0830 hrs. IST** **Chhattisgarh & East Madhya Pradesh: H** rainfall at isolated places on 30th October. **Vidarbha**: **H** rainfall at isolated places on 30th October. **Sub-Himalayan West Bengal & Sikkim: H** rainfall at isolated places on 30th October & 01st November and **H to EH** rainfall at isolated places on 31st October. **Jharkhand: H** rainfall at isolated places on 30th and 31st October. **Bihar:** Isolated **H** rainfall on 30th and **H to VH** rainfall at isolated places on 31st October.	

Table 4.3.2.4 Verification of Wind forecast

Date/Base Time of observation	Forecasted Wind	Reported Wind
25.10.2025/ 0830 hrs IST	❖ 40-50 kmph gusting to 60 kmph is prevailing over southeast Bay of Bengal and adjoining areas of Eastcentral Bay of Bengal. 45-55 kmph gusting to 65 kmph over central parts of Bay of Bengal from evening of 25th. ❖ 60-70 kmph gusting to 80 kmph over southwest and adjoining areas of southeast & West central Bay of Bengal Bay of Bengal from 26th October evening. ❖ 80-90 kmph gusting to 100 kmph over westcentral and adjoining northwest Bay of Bengal from 27th October evening and would further increase 90 to 100 kmph from 28th October morning. ❖ 35-45 kmph gusting to 55 kmph prevail along & off Tamil Nadu - Puducherry coast during from 25th to 28th October, ❖ 35-45 kmph gusting to 55 kmph prevail along & off Andhra Pradesh & Yanam (of Puducherry) coasts from 25th October. 45-55 kmph gusting to 65 kmph from 27th morning and 60-70 kmph gusting to 80 kmph from 28th morning, becoming 90-100 kmph gusting to 110kmph from 28th evening to early hours of 29th October and becoming 60-70kmph gusting to 80 kmph by 29th October noon. The winds would further decrease becoming 45-55 kmph gusting 65 kmph by 29th October evening and decrease gradually thereafter. ❖ 35-45 kmph gusting to 55 kmph prevail along & off south Odisha coast from 26th evening. 45-55 kmph gusting to 65 kmph from 27th evening and becoming gale wind speed reaching, 60-70 kmph gusting to 80 kmph from 28th evening to early hours of 29th October early hours along and off south Odisha coast, becoming 45-55 kmph gusting to 65 kmph till 29th October evening and decrease gradually thereafter. Squally wind speed reaching 50-60 kmph gusting to 70 kmph prevail from 28th evening to early hours of 29th October early hours along and off north Odisha coast, becoming 40-50 kmph gusting to 60 kmph till 29th October evening and decrease gradually thereafter	Maximum sustained wind speed 90-100 gusting to 110 kmph prevailed along & off Andhra Pradesh coast around the time of landfall.
26.10.2025 / 0830	❖ 55-65 kmph gusting to 75 kmph prevailing over southeast Bay of Bengal and adjoining areas of Eastcentral Bay of Bengal. ❖ 60-70 kmph gusting to 80 kmph over southwest and adjoining areas of southeast & West central Bay of Bengal Bay of Bengal from 26th October evening. ❖ 80-90 kmph gusting to 100 kmph over westcentral and adjoining northwest Bay of Bengal from 27th October evening and would further increase 90 to 100 kmph from 28th October morning. ❖ Along & Off Andhra Pradesh & Yanam Coasts: 35-45 kmph gusting to 55 kmph is prevailing along & off Andhra Pradesh & Yanam (of Puducherry) coasts. It increase becoming 45-55	

	kmph gusting to 65 kmph from 27th morning and gale wind speed reaching 60-70 kmph gusting to 80 kmph from 28th morning, becoming 90-100 kmph gusting to 110kmph from 28th evening to early hours of 29th October and becoming 60-70kmph gusting to 80 kmph by 29th October noon. Winds would further decrease becoming 45-55 kmph gusting 65 kmph by 29th October evening and decrease thereafter. ❖ Along & Off Odisha Coast: 35-45 kmph gusting to 55 kmph prevail along & off south Odisha coast from 26th evening. 45-55 kmph gusting to 65 kmph from 27th evening and becoming gale wind speed reaching, 60-70 kmph gusting to 80 kmph from 28th evening to early hours of 29th October early hours along and off south Odisha coast, becoming 45-55 kmph gusting to 65 kmph till 29th October evening and decrease gradually thereafter. 50-60 kmph gusting to 70 kmph prevail from 28th evening to early hours of 29th October early hours along and off north Odisha coast, becoming 40-50 kmph gusting to 60 kmph till 29th October evening and decrease gradually thereafter. ❖ Along & Off West Bengal coast: 35-45 kmph gusting to 55 kmph prevail along & off west Bengal coast from 28th to 29th October. ❖ Along & Off Tamil Nadu & Puducherry Coasts: 35-45 kmph gusting to 55 kmph prevail along & off Tamil Nadu - Puducherry coast on 26th and wind speed reaching 45-55 kmph gusting to 65 kmph during 27th to 28th October.	
27.10.2025	❖ 70-80 kmph gusting to 90 kmph prevailing over southwest & adjoining areas of Westcentral Bay of Bengal. Thereafter, winds would increase becoming 80-90 kmph gusting to 100 kmph over westcentral from 27th October evening and would further increase to 90 to 100 kmph from 28th October morning. Northwest Bay of Bengal 30-40 kmph gusting to 50 kmph is prevailing over adjoining areas of northwest Bay of Bengal and likely to increase becoming gale wind speed reaching 60-70 kmph gusting to 80 kmph over the same region from evening of 28th morning till 29th morning and decrease gradually squally wind speed reaching 35- 45 kmph gusting to 55 kmph on 30th October morning. ❖ Along & Off Andhra Pradesh & Yanam Coasts: 45-55 kmph gusting to 65 kmph is prevailing along & off Andhra Pradesh & Yanam (of Puducherry) coasts, becoming gale wind speed reaching 60-70 kmph gusting to 80 kmph from 28th morning, 90-100 kmph gusting to 110kmph from 28th evening to early hours of 29th October. It would decrease gradually to 60-70kmph gusting to 80 kmph by 29th October noon, along and off North Andhra Pradesh and Yanam coasts. The winds would be squally wind speed reaching 45-55 kmph gusting 65 kmph by 29th October evening and decrease gradually thereafter over the region.	

	❖ Along & Off Tamil Nadu & Puducherry Coasts: 40-50 kmph gusting to 60 kmph prevail along & off Tamil Nadu - Puducherry coast on 27th and becoming 45-55 kmph gusting to 65 kmph by 27th morning to 28th October morning. It would decease gradually thereafter. ❖ Along & Off Odisha Coast: 35-45 kmph gusting to 55 kmph is prevailing along & off south Odisha coast 45-55 kmph gusting to 65 kmph from 27th evening, becoming gale wind speed reaching, 60-70 kmph gusting to 80 kmph from 28th evening to early hours of 29th October early hours. It would be squally wind speed reaching 45-55 kmph gusting to 65 kmph along and off south Odisha coast till 29th October evening and decrease gradually thereafter. 50-60 kmph gusting to 70 kmph prevail along and off north Odisha coast from 28th evening to early hours of 29th October, 40-50 kmph gusting to 60 kmph till 29th October evening, and decrease gradually thereafter. ❖ Along & Off West Bengal coast: 35-45 kmph gusting to 55 kmph prevail along & off west Bengal coast from 28th to 29th October.	
28.10.2025	❖ 90-100 kmph gusting to 110 kmph continue to prevail over Westcentral & adjoining areas of southwest Bay of Bengal till night of 28th October. 30-40 kmph gusting to 50 kmph is prevailing over adjoining areas of northwest Bay of Bengal and likely to increase becoming gale wind speed reaching 60-70 kmph gusting to 80 kmph over the same region from evening of 28th morning till 29th morning and decrease gradually becoming squally wind speed reaching 35-45 kmph gusting to 55 kmph on 30th October morning. ❖ Along & Off Andhra Pradesh & Yanam Coasts: 60-70 kmph gusting to 80 kmph is prevailing along & off Andhra Pradesh & Yanam (of Puducherry) coasts, becoming 90-100 kmph gusting to 110 kmph from 28th evening to early hours of 29th October. 60-70 kmph gusting to 80 kmph by 29th October noon, along and off North Andhra Pradesh and Yanam coasts. The winds would be squally wind speed reaching 45-55 kmph gusting 65 kmph by 29th October evening and decrease gradually thereafter over the region. ❖ Along & Off Tamil Nadu & Puducherry Coasts: 45-55 kmph gusting to 65 kmph is prevailing along & off Tamil Nadu - Puducherry coast and it decease gradually. ❖ Along & Off Odisha Coast: 45-55 kmph gusting to 65 kmph is prevailing along & off south Odisha coast, 60-70 kmph gusting to 80 kmph from 28th evening to early hours of 29th October early hours. 45-55 kmph gusting to 65 kmph along and off south Odisha coast till 29th October evening and decrease gradually thereafter. Squally wind speed reaching 50-60 kmph gusting to 70 kmph prevail along and off north Odisha coast from 28th evening to early hours of 29th October, 40-50 kmph gusting to 60 kmph till 29th October evening, and decrease gradually thereafter.	

	❖ Along & Off West Bengal coast: 35-45 kmph gusting to 55 kmph prevail along & off west Bengal coast from 28th to 29th October	
29.10.2025	❖ 45-55 kmph gusting to 65 kmph prevail over Westcentral Bay of Bengal and along & off Andhra Pradesh coast till evening of 29th October and decrease thereafter. ❖ 35-45 kmph gusting to 55 kmph prevail over adjoining areas of northwest Bay of Bengal till evening of 29th October. ❖ Coastal Andhra Pradesh & Yanam: 50-60 kmph gusting to 70 kmph prevail till afternoon of 29th and decrease thereafter. ❖ Telangana: 45-55 kmph gusting to 65 kmph prevail till afternoon of 29th and decrease thereafter. ❖ South Chhattisgarh and South interior Odisha: 40-50 kmph gusting to 60 kmph prevail till afternoon of 29th and decrease thereafter. ❖ Along & off south Odisha coast: 55 kmph till 29th October afternoon and decrease gradually thereafter. ❖ Along & off North Tamil Nadu & Puducherry coasts: 35-45 kmph gusting 55 kmph till 29th afternoon and decrease further thereafter.	

Table 4.3.2.5 Verification of forecasted Storm Surge

Date/Base Time of observation	**Forecasted Storm Surge**	**Reported Storm Surge**
25.10.2025/0830	Storm surge of height about 1 m above astronomical tide likely to cause inundation over low-lying areas of coastal Andhra Pradesh & Yanam (of Puducherry) around the landfall time	Maximum storm surge of height about 0.8 m above astronomical tide has been reported in Kakinada around 0230 hours IST of 29th October in association with the landfall of the severe cyclonic storm “MONTHA” over Coastal Andhra Pradesh. The height of the tidal wave including storm surge and astronomical tide was about 2.2 m in that area as per the tide gauge measurements.
26.10.2025/0830	-do-	
27.10.2025/0830	-do-	
28.10.2025/0830	-do-	

4.3.3 Severe Cyclonic Storm "SENYAR" over the Strait of Malacca (25th - 27th November, 2025)

4.3.3.1 Genesis Forecast

- First information about likely cyclogenesis (formation of Depression) over the Bay of Bengal (BoB) during 21st-27th November was issued on 13th November about 12 days ahead of formation of depression over strait of Malacca on 25th November. It indicated likely formation of low pressure area over southeast BoB around 21st Nov. with low probability of formation of depression around 23rd. Subsequently, the extended range outlook issued on 20th November (6 days ahead of genesis of depression) indicated high (67-100%) probability of cyclogenesis (formation of Depression) over south BoB. Thus, the system was monitored with respect to genesis, track, intensity and landfall since 13th Nov. The genesis area was not captured well in the extended range forecast issued by RSMC New Delhi.
- Cyclonic circulation over Strait of Malacca was detected and mentioned in the tropical weather outlook issued at 1130 hrs. IST/0600 UTC of 20th Nov. It was indicated that under the influence of cyclonic circulation over Strait of Malacca, a low-pressure area would form over southeast BoB around 22nd Nov. and it was indicated to intensify into a depression with low probability (1-33%) over central parts of South BoB by morning (0830 hours IST/0300 UTC) of 24th Nov.
- With the formation of low-pressure area over central parts of Strait of Malacca and adjoining South Andaman Sea in the morning (0830 hrs. IST/ 0300 UTC) of 22nd Nov., it was predicted that the system would intensify further into a depression over southeast BoB and adjoining south Andaman Sea around 24th Nov. At that time, the conditions were becoming favorable for formation of an upper air cyclonic circulation over Comorin area as well.
- The advisories were further upgraded in the tropical weather outlook issued at 1430 hrs. IST/0900 UTC of 24th Nov. indicating likely formation of depression over south Andaman Sea by 25th Nov. and further intensification into a cyclonic storm over south BoB by 27th Nov.
- The first Special Tropical Weather Outlook issued at 1330 hours IST/ 0800 UTC of 25th Nov. on formation of depression over Strait of Malacca at 0830 hrs IST/ 0300 UTC indicated the system to move west-northwestwards and intensify further during 25th to 27th Nov.
- Thus, in the initial stage till the formation of depression, the area of genesis could not be predicted, as it was displaced to west compared to actual area of genesis over Strait of Malacca.
- The subsequent special tropical weather outlook issued at early morning hours (0130 hrs. IST) of 26th Nov/ (2030 UTC of 25th Nov.) on formation of deep depression over Strait of Malacca indicated the system to move west-southwestwards, intensify into a cyclonic storm and cross Indonesia coast as a cyclonic storm in the morning hours (around 0830 hrs IST/ 0300 UTC) of 26th Nov. It was also indicated that the system would recurve east-southeastwards while moving across Indonesia.
- First Tropical Cyclone Advisory issued in the morning (0930 hrs IST/ 0400 UTC) of 26th Nov., further reiterated the above forecast.
- The system caused extremely heavy rains, flash floods and landslides in Indonesia and Malaysia, as per media reports leading to loss of lives and properties.
- Maximum sustained wind speed reaching 70-80 gusting to 90 kmph prevailed over the Strait of Malcca and along & off adjoining Indonesia during 26th morning to 26th evening

and 65 to 75 gusting to 85 kmph during 26th evening and 27th morning. The sea condition over Malacca strait and along & off adjoining Indonesia coast was high on 26th and 27th Nov.

- No adverse weather was observed over the Andaman and Nicobar Islands in association with this system, though the sea condition remained rough to very rough.
- The operational track and intensity forecast errors were comparatively higher than the long period average errors, as the system exhibited multiple recurvatures and was interacting with other cyclonic vortices over south BoB and the northwest Pacific during its life period.

4.3.3.2. Track forecast error and skill

The operational track forecast errors for 12, 24 and 36 hours lead period were 82, 194 and 404 km against long period average (2020-24) of 45, 72 and 90 km respectively **(Fig. 4.3.3.1a**). The operational track forecast skill compared to climatological & persistence (CLIPER) based forecast for 12, 24 and 36 hours lead period were 33, 31 and 14 91% against long period average (2020-24) of 58, 65 and 71 % respectively (**Fig. 4.3.3.1b**).

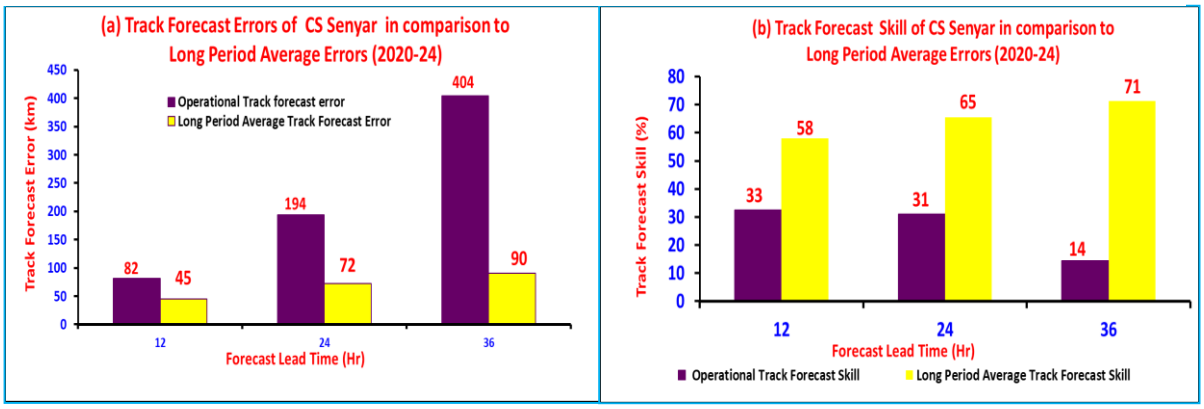


Fig. 4.3.3.1: Track forecast errors and (b) skills against Climatology & Persistence (CLIPER) compared to long period average (LPA) errors & skills respectively based on 2020-2024

Table 4.3.3.1: Operational track forecast errors and skill as compared to long period average (2020-24)

Lead Period (hrs)	N	Operational Track forecast		Long Period Average (2020-24)	
		Error (km)	Skill (%)	Track Forecast Error (km)	Track Forecast Skill (%)
12	6	82	33	45	58
24	4	194	31	72	65
36	2	404	14	90	71

N: no. of observations verified

4.3.3.3. Intensity forecast error and skill

- The operational intensity forecast absolute errors (AE) for 12, 24 and 36 hours lead period were 3.3, 7.5 and 10.0 kt against long period average (2020-24) of 3.4, 5.9, and 7.4 kt respectively (**Fig. 4.3.3.2a**). The operational intensity forecast root mean square

errors (RMSE) for 12, 24 and 36 hours lead period were 4.1, 7.9 and 10.0 kt against long period average (2020-24) of 5.0, 7.9 and 9.7 respectively (**Fig. 4.3.3.2b**). The intensity forecast errors were quite comparable to long period average errors.

- However, the operational intensity forecast skill based on AE for 12, 24 and 36 hours lead period was 84, 81 and 88 % against long period average (2020-24) of 58, 57 and 63% respectively **(Fig. 4.3.3.3a**). The operational intensity forecast skill based on RMSE for 12, 24 and 36 hours lead period was 86, 83 and 88% against long period average (2020-24) of 52, 60 and 66% respectively (**Fig. 4.3.3.3b**). **For all lead periods, the intensity forecast skills were markedly above the long period average skill.**

Table 4.3.3.2: Operational Absolute errors (AE) and Root Mean Square errors (RMSE) and corresponding skill in intensity forecast as compared to long period average (2020-24)

Lead Period	N	AE (kt)	RMSE (kt)	Skill-AE (%)	Skill-RMSE (%)	Long Period Average (2020-24)			
						AE (kt)	RMSE (kt)	Skill-AE (%)	Skill-RMSE (%)
12	6	3.3	4.1	60	62	3.4	5.0	53	57
24	4	7.5	7.9	71	73	5.9	7.9	57	63
36	2	10.0	10.0	83	83	7.4	9.7	64	69

N: No. of observations verified

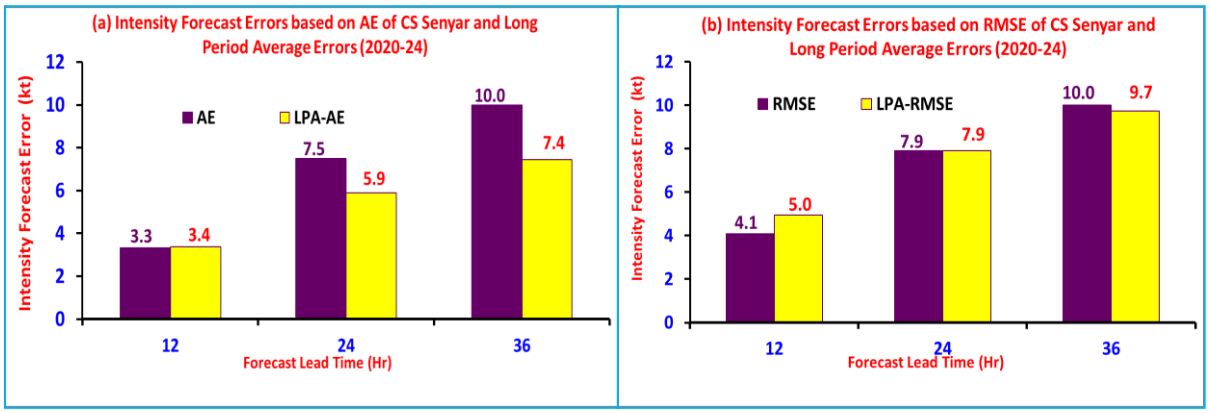


Fig. 4.3.3.2: Intensity forecast errors (AE) and (b) skills against Persistence compared to long period average (LPA) errors & skills respectively based on AE

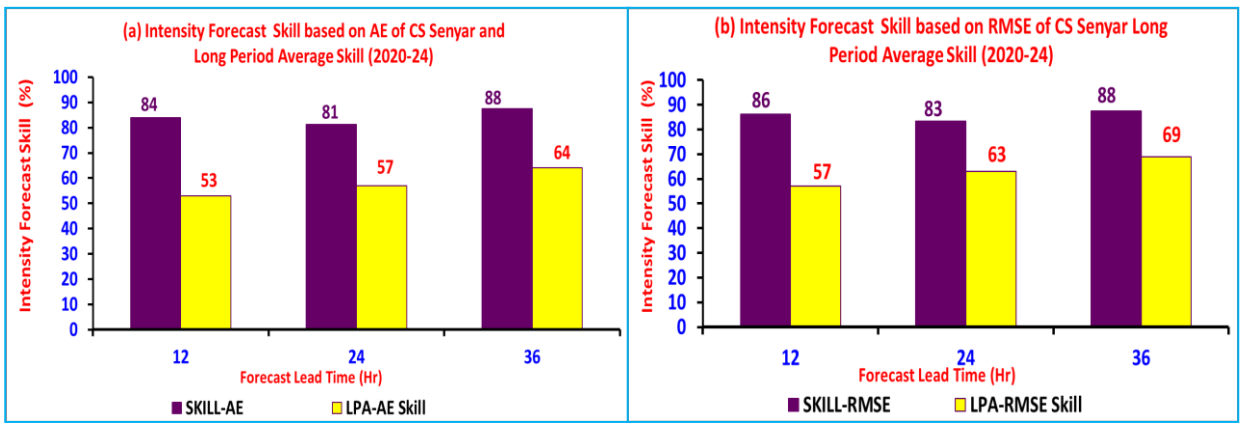


Fig. 4.3.3.3: (a): Intensity forecast errors and (b) skills against Persistence forecast compared to LPA errors & skills respectively based on RMSE

4.3.4 Cyclonic Storm "DITWAH" over the Bay of Bengal (26th November– 03rd December, 2025)

4.3.4.1 Genesis Forecast

- First information about likely cyclogenesis (formation of Depression) over the BoB was issued on 13th November for 26th November about 13 days ahead of formation of depression. Subsequently, the extended range outlook issued on 20th November (6 days ahead) indicated high (67-100%) probability of cyclogenesis (formation of Depression) over south BoB.
- In the tropical weather outlook issued at 1430 hrs. IST/ 0900 UTC of 23rd Nov., it was indicated that a low-pressure area would form over Comorin and adjoining southeast Sri Lanka around 25th Nov. with moderate probability of formation of depression by 25th morning (0830 hrs. IST/ 0300 UTC) and high probability of formation of depression by 26th morning (0830 hrs. IST/ 0300 UTC). Actually, the low-pressure area formed over Comorin & adjoining southeast BoB and Sri Lanka in the early morning (0530 hrs. IST/ 0000 UTC) of 25th Nov.
- The same was reiterated in the tropical weather outlook issued at 1430 hrs. IST/ 0900 UTC of 24th Nov.
- The tropical weather outlook issued at 1330 hrs. IST/ 0800 UTC of 25th Nov. on formation of low-pressure area over southwest Bay of Bengal and adjoining areas of south Sri Lanka and adjoining Equatorial Indian Ocean indicated north-northwestwards movement and likely intensification onto a well-marked low-pressure area by morning of 26th (0830 hrs. IST/ 0300 UTC) and depression by morning of 27th November (0830 hrs. IST/ 0300 UTC).
- Subsequently, the advisory issued in the morning of 26th Nov. (0930 hrs. IST/ 0400 UTC) on formation of well-marked low-pressure area over southwest BoB and adjoining areas of southeast Sri Lanka and Equatorial Indian Ocean predicted that the system would move north-northwestwards and intensify into a depression by morning of 27th Nov. (0830 hrs. IST/ 0300 UTC).
- The update issued in the noon of 26th (1230 hrs. IST/0700 UTC) indicated the well-marked low-pressure area to intensify into a depression by 27th morning and intensify further thereafter. It was predicted to move north-northwestwards across southwest BoB towards north Tamil Nadu and Puducherry coasts till 29th morning. Actually, it reached southwest BoB and adjoining north Sri Lanka and Tamil Nadu-Puducherry coasts as a cyclonic storm by 29th morning (0830 hrs. IST/ 0300 UTC).
- Actually, low pressure area formed over Comorin on 25th Nov. early morning (0530 hrs. IST/ 0000 UTC), well-marked low-pressure area over southwest BoB and adjoining southeast Sri Lanka on 26th early morning (0530 hrs. IST/ 0000 UTC) and depression over southwest BoB and adjoining Sri Lanka on 26th midnight (2330 hrs. IST/ 1800 UTC), Cyclonic Storm "DITWAH" over southwest BoB and adjoining Sri Lanka in the noon of 27th Nov. (1130 hrs. IST/ 0600 UTC).
- The first track and intensity forecast issued in the morning (0930 hrs IST/ 0400 UTC) of 27th Nov., indicated the system to reach peak intensification of 80-90 gusting to 100 kmph over southwest Bay of Bengal and along & off North Tamil Nadu-Puducherry coasts and adjoining North Sri Lanka from early morning of 29th Nov. to early morning of 30th Nov. Actually, Gale wind speed reaching 60 to 70 kmph gusting to 80 kmph was observed over south Sri Lanka on 27th Nov. and 65 to 75 gusting to 85 kmph was observed over central & north Sri Lanka during 27th to 28th Nov. Gale wind speed reaching 70-80 gusting to 90

kmph prevailed over southwest Bay of Bengal and south Tamil Nadu and adjoining north Tamil Nadu-Puducherry & north Sri Lanka during 29th morning to 30th morning.

- The first track and intensity forecast issued at 1540 hrs. IST of 27th indicated the system to gradually weaken into a deep depression while reaching near Tamil Nadu-Puducherry and adjoining south Andhra Pradesh coast by 01st Dec.

4.3.4.2. Track forecast error and skill

The operational track forecast errors for 24, 48, 72 and 96 hours lead period were 49, 62, 60 and 100 km against long period average (2020-24) of 72, 111, 154 and 183 km respectively **(Fig. 4.3.4.1a, Table 4.3.4.1**). The operational track forecast skill compared to climatological & persistence (CLIPER) based forecast for 24, 48, 72 and 96 hours lead period were 79, 88, 92 and 91% against long period average (2020-24) of 65, 74, 77 and 78 % respectively (**Fig. 4.3.4.1b, Table 4.3.4.1**). **For all lead periods, the track forecast errors were markedly less than the long period average errors.**

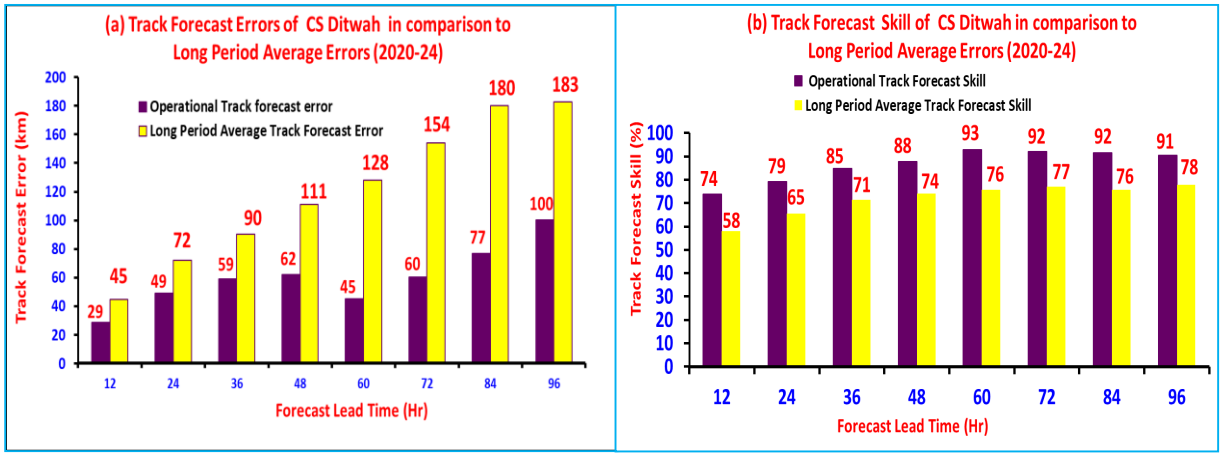


Fig. 4.3.4.1: (a) Track forecast errors and (b) skill against Climatology & Persistence (CLIPER) compared to long period average (LPA of 2020-2024) errors & skill respectively

Table 4.3.4.1: Operational Track forecast errors and skill as compared to long period average (2020-24)

Lead Period (hrs)	N	Operational Track forecast error (km)	Operational Track Forecast Skill (%)	Long Period Average (2020-24)	
				Track Forecast Error (km)	Track Forecast Skill (%)
12	20	29	74	45	58
24	13	49	79	72	65
36	12	59	85	90	71
48	10	62	88	111	74
60	7	45	93	128	76
72	6	60	92	154	77
84	5	77	92	180	76
96	3	100	91	183	78

N: no. of observations verified

4.3.4.3. Intensity forecast error and skill

- The operational intensity forecast absolute errors (AE) for 24, 48, 72, and 96 hours lead period were 3.1, 3.0, 5.0 and zero kt against long period average (2020-24) of 5.9, 8.3, 9.8 and 15.7 kt respectively (Fig. 4.3.4.2a, Table 4.3.4.2). The operational intensity forecast root mean square errors (RMSE) for 24, 48, 72 and 96 hours lead period were 4.4, 4.5, 5.8 and zero kt against long period average (2020-24) of 7.9, 13.3, 12.6 and 17.7 kt respectively (Fig. 4.3.4.2b, Table 4.3.4.2). For all lead periods, the intensity forecast errors were markedly less than the long period average errors.
- The operational intensity forecast skill based on AE for 24, 48, 72 and 96 hours lead period was 76, 84, 86 and 100% against long period average (2020-24) of 57, 69, 79 and 81% respectively (Fig. 4.3.4.3a, Table 4.3.4.2). The operational intensity forecast skill based on RMSE for 24, 48, 72 and 96 hours lead period was 81, 84, 86 and 100% against long period average (2020-24) of 60, 71, 79 and 79% respectively (Fig. 4.3.4.3b, Table 4.3.4.2). For all lead periods, the intensity forecast skills were markedly above the long period average skill.

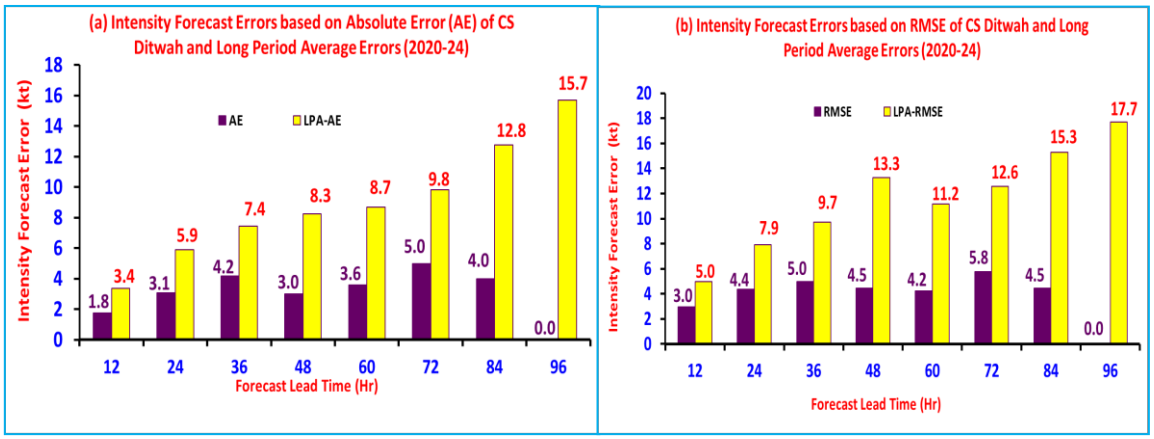


Fig. 4.3.4.2: Intensity forecast errors based on (a) AE and (b) RMSE against long period average (LPA of 2020-24) errors respectively.

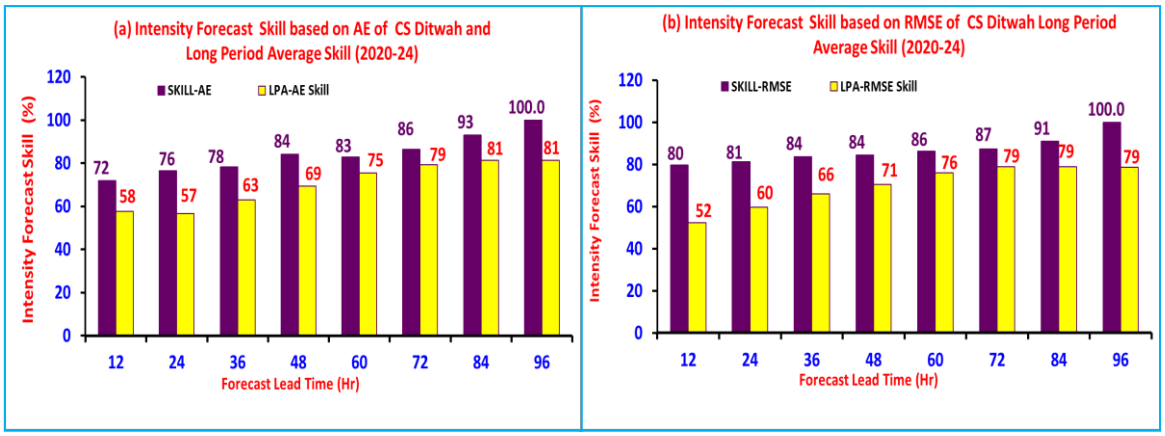


Fig. 4.3.4.3: Skill (%) in intensity forecast based on (a) Absolute errors (AE) and (b) Root Mean Square errors (RMSE) as compared to long period average (2020-24)

Table 4.3.4.2: Operational Absolute errors (AE) & Root Mean Square errors (RMSE) and corresponding long period average (2020-24) errors and skills in intensity forecast

Lead Period	N	AE	RMSE	Skill-AE	Skill-RMSE	Long Period Average (2020-24)			
						AE	RMSE	Skill-AE	Skill-RMSE
12	20	1.8	3.0	72	80	3.4	5.0	58	52
24	13	3.1	4.4	76	81	5.9	7.9	57	60
36	12	4.2	5.0	78	84	7.4	9.7	63	66
48	10	3.0	4.5	84	84	8.3	13.3	69	71
60	7	3.6	4.2	83	86	8.7	11.2	75	76
72	6	5.0	5.8	86	87	9.8	12.6	79	79
84	5	4.0	4.5	93	91	12.8	15.3	81	79

N: No. of observations verified

4.3.4.5. Adverse weather forecast performance:

Table 4.3.4.4: Verification of Heavy Rainfall Forecast issued by IMD

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
27.11.2025 /0830 hrs. IST	❖ **Tamil Nadu & Puducherry: H** rainfall at isolated places during 27th November, 2025. The rainfall activity would increase thereafter **H** to **VH** at many places & **EH** rainfalls at isolated places on 28th and 29th November, 2025. **H** to **V H** rainfall at isolated places on 30th November, 2025. ❖ **Coastal Andhra Pradesh**: **H** rainfall at isolated places is very likely over south coastal Andhra Pradesh on 28th November. **H** to **VH** rainfall at isolated places on 29th November and **H** to **VH** at a few places & **EH** rainfall (>20 cm) at isolated places on 30th November. Many places with **H** to **VH** rainfall at isolated places on 1st December and **H** rainfall at isolated places on 02nd December. ❖ **Rayalaseema: H** rainfall at isolated places is very likely on 28th November. **H** to **VH** rainfall at isolated places on 29th November and **H** to **VH** at a few places & **EH** rainfall (>20 cm) at isolated places on 30th November. **H** rainfall at isolated places on 1st December. ❖ **Kerala & Mahe: H** rainfall at isolated places is very likely during 27th -29th November.	**29.11.2025 /0830 hrs. IST** **Tamil Nadu, Puducherry & Karaikal**: Kodiayakarai 25; Vedaranyam) 18; Velankanni 13; Nagapattinam, Tirupoondi 12 Each; Thalaignayer 11; Karaikal, Pamban 10 Each; Rameswaram Illayangudi Mandapam Kayalpattinam, Thirukuvalai, Thangachimadam 7 Each. **30.11.2025/0830 IST** **Tamil Nadu, Puducherry & Karaikal:** Karaikal 19; Sembanarkoil 17; Mayiladuthurai, Nagapattinam 15 Each; Mayiladuthurai, Sirkali, Tiruvarur 14 Each; Tondi, Tirupoondi, Thangachimadam 13 Each; Sethiathope, Vedaranyam, Nannilam, Velankanni, Kodiayakarai, Kurungulam 12 Each; Srimushnam, Thiruthuraipoondi, Tiruvarur AWS, Thalaignayer, Thirukuvalai, Neivasal

	❖ **Telangana: H** rainfall at isolated places is very likely on 30th November and 01st December.	Thenpathi, Echanviduthi 11 Each; Cuddalore, Parangipettai, Kollidam, Tiruvadanai, Orthanad, Mannargudi, Mimisal, Collectorate, Theerthandathanam 10 Each; Chidambaram, Rameswaram, Pattukottai, Peravurani, Thiruvidaimaruthur, Needamangalam, Valangaiman, Manalmedu, Avudayarkoil, Vattanam, Ayyampettai, Budalur, Vadakuthu, Ayinkudi, Nagudi, Vettikadu 9 Each; Arantangi, Pamban, Madukkur, Thanjavur, Tiruvaiyaru, Sivakasi, Aduthurai AWS, Thanjavur, Bhuvanagiri, Mandapam, Manjalaru, Annamalai Nagar, Lalpet, Nandhiyar Head 8 Each; K.M.Koil, Mahabalipuram, Tarangambadi, Puducherry, Alangudi, Pudukottai, Devakottai, Adirampatnam, Vallam, Muthupet, Pandavaiyar Head, Kodavasal, Kothavacherry, Lower Anaicut 7 Each. **<u>01.12.2025 /0830 hrs. IST</u>** **Coastal Andhra Pradesh & Yanam:** Kavali 11 **<u>02.12.2025 /0830 hrs. IST</u>** **Tamil Nadu, Puducherry & Karaikal:** Ennore Zone1 26, Parrys 25, Ice House 22, Ponneri 21; Manali New Town 21, EnnorE, Perambur, Chennai Collectorate BU 20 Each; DGP Office, Chennai, Red Hills 18 Each; Gummidipoondi, Ayanavaram Taluk Office, CD Hospital Tondaipet 17 Each; Puzhal 16; Cholavaram, MGR Nagar 14 Each; Anna University 13; Anna Uty, Sholinganallur 11 Each; Chennai AP, Sivakasi, Hindusthan University, Alandur, Avadi 9 Each; Taramani 8; Kolapakkam, Ambathur 7 Each.
28.11.2025 /0830 hrs. IST	❖ **Tamil Nadu & Puducherry**: **H** to **VH** at many places & **EH rainfall (>20 cm**) **at isolated places** over south coastal Tamil Nadu on 28th, over coastal Tamil Nadu on 29th and over north coastal Tamil Nadu & Puducherry on 30th November, 2025. **H rainfall** at isolated places on 1st December. ❖ **Coastal Andhra Pradesh-Yanam & Rayalaseema**: **H to VH rainfall** at isolated places on 29th November and **H to VH at a few places & EH rainfall (>20 cm**) **at isolated places on 30th November**. **H rainfall** at isolated places on 1st December. ❖ **Kerala & Mahe: H** rainfall at isolated places is very likely during 28th-29th November. ❖ **Telangana: H rainfall** at isolated places is very likely on 30th November	
29.11.2025 /0830 hrs. IST	❖ **Tamil Nadu & Puducherry**: **H to VH** at many places & **EH rainfall (>20 cm**) **at isolated places** over coastal Tamil Nadu on 29th and over north coastal Tamil Nadu & Puducherry on 30th November, 2025. **H rainfall** at isolated places on 1st December. ❖ **Coastal Andhra Pradesh-Yanam & Rayalaseema**: **H to V rainfall** at isolated places on 29th November and **H to VH** at a few places & **EH** rainfall (>20 cm) at isolated places on 30th November. **H** rainfall at isolated places on 1st December. ❖ **Kerala & Mahe: H** rainfall at isolated places is very likely on 29th November. ❖ **Telangana: H** rainfall at isolated places is very likely on 30th November.	
30.11.2025 /0830 hrs. IST	❖ **Tamil Nadu & Puducherry**: **H** to **VH** at a few places & **EH** rainfall (>20 cm) at isolated places likely over north coastal Tamil Nadu & Puducherry and isolated **H** rainfall likely over north interior Tamil Nadu on 30th November, 2025. **H** rainfall at isolated places on 1st December over North Tamil Nadu. ❖ **South Coastal Andhra Pradesh & Rayalaseema**: **H to VH** at a few places & **EH** rainfalls at isolated places (over Southern districts of South coastal Andhra Pradesh**)** on 30th November. It would then decrease gradually becoming **H** rainfall at isolated places on 1st December.	

	❖ **Kerala & Mahe: H** rainfall at isolated places on 30th November.	**<u>03.12.2025/0830 hrs. IST</u>** **Rayalaseema:** Chittamur 27, Kota 23, Gudur, Satyavedu, Tada 9 Each; Sullurpeta 7; **Tamil Nadu, Puducherry & Karaikal:** Hindusthan University 15; Chetpet 13; Tirumayam, Thamaraipakkam 12 Each; Tiruvarur, Satyabama Uty, Thirukalukundram, Kudimiyanmalai 11 Each; Kelambakkam, Mahabalipuram, Illuppur, Red Hills, Ulundurpet, Vadakuthu 10 Each; Pollachi, Tondi, Cholavaram, Ponneri, Tiruvarur, Gummidipoondi, Ambathur, Perambur, Neivasal Thenpathi 9 Each; Needamangalam, Uthukottai, RSCL Vallam 8 Each; Virudachalam, Karaikal, Mannargudi, Sholinganallur, DSCL Eraiyur, Avadi, Ranipet 7 Each; **Coastal Andhra Pradesh & Yanam:** Edagali 24, Nellore 9; **Kerala & Mahe:** Vannamada 7.
01.12.2025 /0830 hrs. IST	❖ **North coastal Tamil Nadu & Puducherry**: **H** rainfall at isolated places likely on 1st December, 2025. ❖ **South Coastal Andhra Pradesh & Rayalaseema**: **H to VH** rainfall at isolated places on 01st December. ❖ **North Coastal Andhra Pradesh: H** rainfall at isolated places on 30th November and 01st December. ❖ **Odisha: H** rainfall at isolated places on 01st December.	
02.11.2025 /0830 hrs. IST	❖ **Tamil Nadu & Puducherry**: **H to VH** rainfall at isolated places over North Coastal Tamil Nadu is very likely on 2nd December and **H** rainfall at isolated places on 03rd December, 2025. ❖ **South Coastal Andhra Pradesh & Rayalaseema**: **H** rainfall at isolated places is very likely on 2nd December, 2025. ❖ **Kerala**: **H** rainfall at isolated places is very likely on 2nd and 3rd December, 2025.	

H: Heavy rainfall (7-11 cm), VH: Very Heavy rainfall (12-20 cm), EH: Extremely Heavy rainfall (≥20 cm)

Table 4.3.4.5: Verification of Storm surge Forecast issued by IMD

Date/Base Time of observation	**24 hr Storm Surge Warning ending at 0300 UTC of next day**	**Realised 24-hour storm surge ending at 0300 UTC of date.**
27.11.2025 /0300 UTC	Storm surge of height about 0.5 m above the astronomical tide is likely to inundate the low-lying coastal areas of east Sri Lanka till 28th forenoon.	**30.11.2025 /0300 UTC** Storm surge of height 0.5 m – 1.0 m above astronomical tide inundated low lying areas of coastal Tamil Nadu – Puducherry on 29th November. Significant wave height of 1.8 m was observed near Pamban bridge.
28.11.2025 /0300 UTC	Storm surge of height about 1.0 to 1.5 m above the astronomical tide is likely to inundate the low-lying coastal areas of north Sri Lanka till 29th evening.	
29.11.2025 /0300 UTC	Storm surge of height about 1.0 to 1.5 m above the astronomical tide is likely to inundate the low-lying coastal areas of north Sri Lanka till 29th evening. Storm surge of height about 0.5 m to 1m above the astronomical tide is likely to inundate the low-lying coastal areas of Tamil Nadu-Puducherry till 30th morning**.**	
30.11.2025 /0300 UTC	Storm surge of height about 0.5 m to 1m above the astronomical tide (0.4 m during high tide) is likely to inundate the low-lying coastal areas of Tamil Nadu-Puducherry till 30th afternoon.	

4.4 Annual Performance of cyclone landfall, track and intensity forecast

4.4.1 Genesis forecast (Medium & Extended range)

India Meteorological Department (IMD) maintains a continuous watch over the north Indian Ocean (NIO) including the Bay of Bengal (BoB) and the Arabian Sea (AS) and issues extended range probabilistic cyclogenesis (formation of depression) forecast over the BoB & AS for the next two weeks, every Thursday.

IMD introduced extended range forecast on 22nd April, 2018. The probability of cyclogenesis inextended range forecast (ERF) is issued in four categories viz. nil (0%), low (1-33%), moderate (34-67%) and high (68-100%) based on diagnosis of various large-scale features leading to cyclogenesis and the guidance from various global deterministic & ensemble numerical weather prediction (NWP) models & extended range forecasting models.

IMD evaluates the performance of operational ERF of cyclogenesis based on the forecasts issued for week 1 and week 2 for AS, BoB and NIO during April 2018 to 2025. For this purpose, Brier Score Operational (BSo) is calculated and analysed. To evaluate the skill, the climatological probability of cyclogenesis for each week is derived basedon the data during 1891-2020 and the same is used to determine reference BSref. Subsequently, comparing the operational BSo with reference BSref, the Brier Skill Score (BSS) has been calculated and analysed. BSS indicates the degree of improvement of the BS of a forecast (BSv) compared to the BS of a climatological forecast (BSc) as reference, based on an assumed equal occurrence probability of 33% for each event. The forecast is perfect when BSS is equal to one.

Similarly, in the medium range, IMD commenced the cyclogenesis forecast for next 3 days in 2014, next 5 days in 2018 and next 7 days in 2023 as nil (0% probability), low (1-33% probability), moderate (34-67% probability) and high (68-100% probability). To evaluate the skill of genesis forecast, in a similar manner the BSS is calculated from day1 to day7 for BoB, AS and NIO regions. Every forecast is valid upto 0300 UTC of next day.

Annual BSS during the period 2018 to 2025 is presented in Fig. 4.4.1 for BOB, AS and NIO. In 2025, considering week 1 accuracy, BSS was 49 % for BOB, 56 % for AS and 52 % for the NIO region. For week 2 the accuracy was 12 % for BOB, 35 % for AS and 20 % for the NIO region.

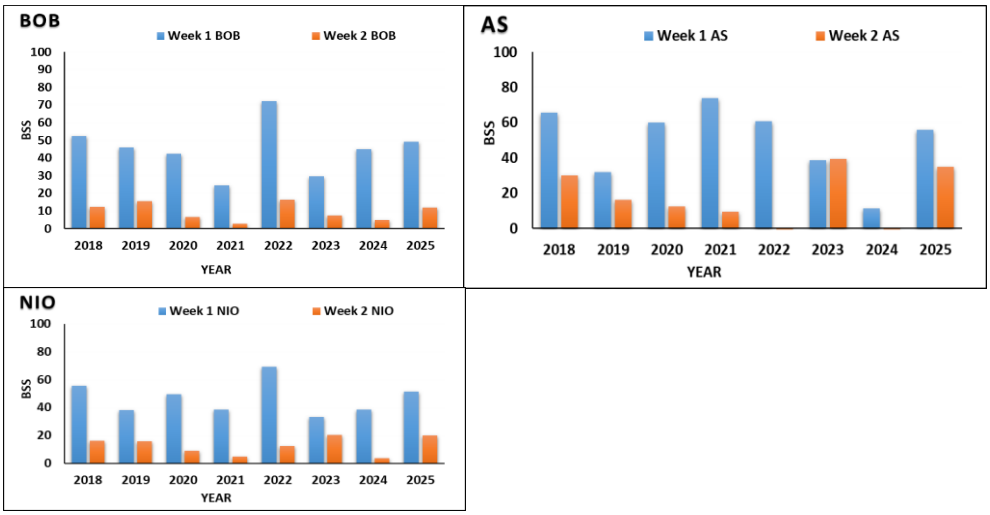


Fig.4.4.1: Annual BSS in the extended range scale for next 2 weeks

Table 4.4.1: Representation of BSS Data for verification of medium range forecast over (a) BOB, (b) AS & (c) NIO for 7 days during 2019-2025.

BSS		2019	2020	2021	2022	2023	2024	2025
Week 1	BOB	45.8	42.2	24.4	72.1	29.4	44.9	49.0
	AS	31.8	60.0	73.9	60.8	38.9	11.3	56.0
	NIO	38.2	49.6	38.5	69.3	33.2	38.5	51.5
Week 2	BOB	15.5	6.7	2.7	16.4	7.6	5.0	11.8
	AS	16.1	12.6	9.7	-0.8	39.5	-3.0	34.9
	NIO	15.9	8.9	4.7	12.2	20.3	3.4	19.8

Table 4.4.2: Representation of BSS Data for verification of extended range forecast over (a) BOB, (b) AS & (c) NIO for week 1 & 2 during 2019-2025.

BSS		2019	2020	2021	2022	2023	2024	2025
Day 1	BOB	49.9	11.2	28.7	20.4	93.6	86.6	29.6
Day 2	BOB	28.9	35.6	41.4	45.3	41.2	74.9	32.9
Day 3	BOB	43.4	39.6	37.7	45.1	42.5	66.7	19.3
Day 4	BOB	36.3	21.6	44.5	42.9	42.2	61.7	21.3
Day 5	BOB	41.6	10.2	47.9	36.1	45.8	58.4	27.0
Day 6	BOB						52.3	23.7
Day 7	BOB						49.2	-31.0
BSS		2019	2020	2021	2022	2023	2024	2025
Day 1	AS	21.1	15.5	14.8	67.5	-0.1	61.8	34.8
Day 2	AS	29.7	30.2	34.3	49.0	8.4	54.3	45.9
Day 3	AS	53.4	52.1	47.3	44.2	15.3	56.7	31.0
Day 4	AS	71.8	40.0	47.0	28.7	30.2	55.2	6.6
Day 5	AS	58.8	30.8	39.6	1.3	33.0	47.1	-6.1
Day 6	AS						39.3	0.8
Day 7	AS						24.9	-24.2
BSS		2019	2020	2021	2022	2023	2024	2025
Day 1	NIO	36.7	12.5	22.6	29.0	29.0	79.9	30.7
Day 2	NIO	29.4	33.7	38.8	46.1	26.1	69.6	36.1
Day 3	NIO	49.0	44.8	40.8	44.9	31.9	64.5	22.5
Day 4	NIO	55.4	29.3	45.4	40.1	37.9	60.7	16.4
Day 5	NIO	50.8	18.8	44.9	29.5	41.8	56.3	12.3
Day 6	NIO						49.8	11.7
Day 7	NIO						43.5	-26.9

Colour Legend for BSS (Red shades indicate BSS <50 and green shades indicate BSS>50)

100	90	80	70	60	50	40	30	20	10	0

For the medium range forecast, the BSS has been between 15% to 30 % for the lead period of day 1 to day 7 for BoB. For the AS it has been low and for NIO, it has been upto 30 % for the lead period of day 1 to day 7 (Fig. 4.4.2).

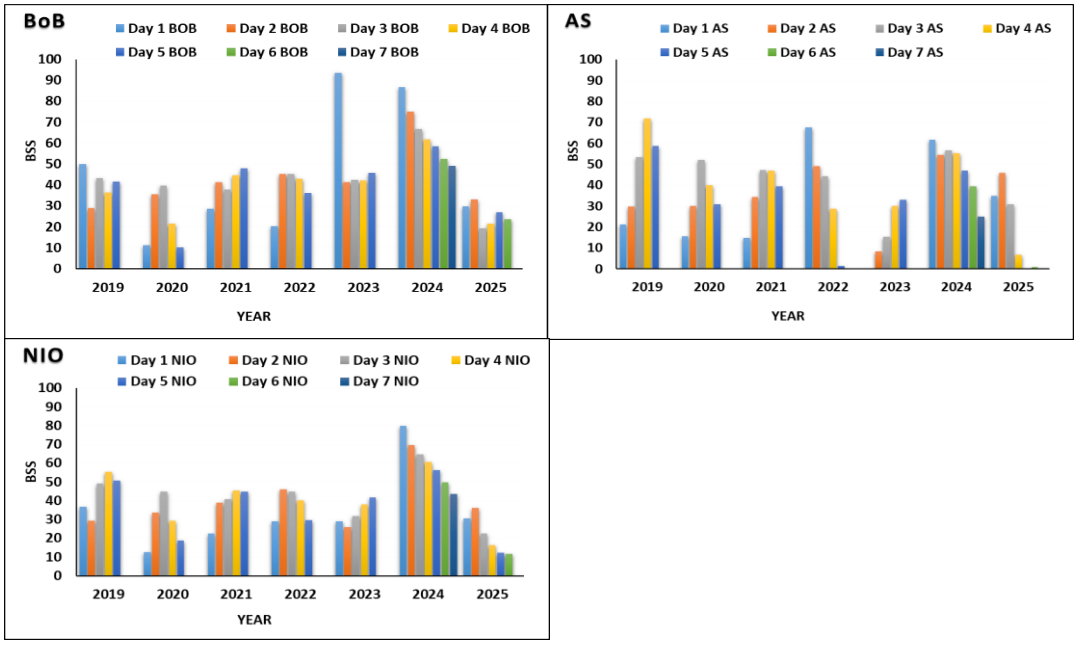


Fig.4.4.2: Annual BSS for medium range forecast for day 1 to day 7:

4.4.2 Track Forecast

Annual average track forecast error is calculated by considering the track forecast errors of all the cyclones during the year. The mean error of each cyclone is weighted by number of forecasts verified to calculate the annual average track forecast errors as mentioned below. This is calculated for 12, 24, 36, 48, 60, 72, 84, 96, 108, 120 hr forecasts.

$$\text{Annual average track forecast error} = \frac{(n1 * E1 + n2 * E2 + n3 * E3 + \ldots)}{(n1 + n2 + n3 + \ldots)}$$

Where n1, n2, n3... are number of six hourly forecasts verified for cyclone 1, 2, 3 and E1, E2, E3... are the average track forecast errors for cyclone n1, n2, n3.

Similarly, annual average CLIPER model-based track forecast errors are calculated. Subsequently, skill is calculated for a given cyclone by comparing the six hourly operational track forecast errors with track forecast errors of a reference model.

$$\text{Track forecast skill (\%)} = \frac{(\text{CLIPER track forecast} - \text{Operational track forecast})\text{error}}{\text{CLIPER track forecast error}} * 100$$

The annual average track forecast errors and skill during 2025 are presented in Fig. 4.4.3 (a-b).

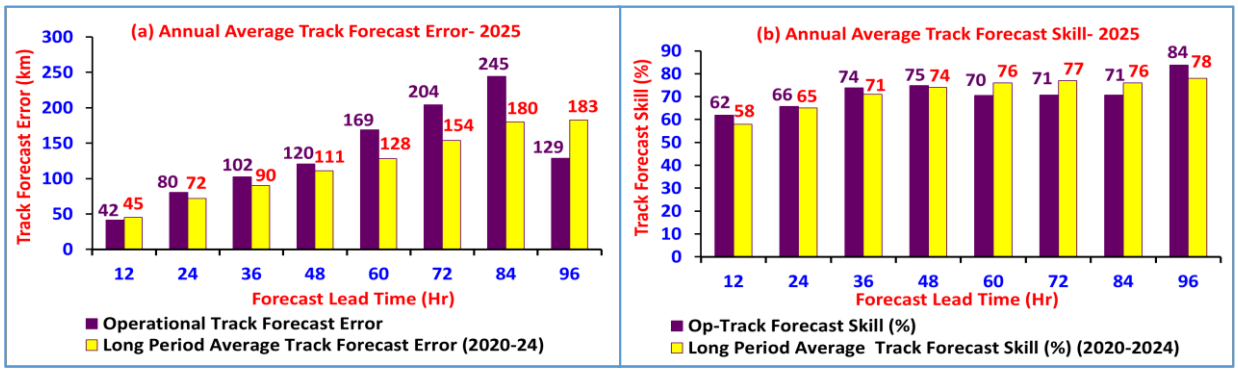


Fig.4.4.3 Annual average (a) track forecast error (km) and (b) track forecast skill against the climatology and persistence forecast during 2025 as compared to that during 2020-2024

The annual average track forecast errors in 2025 have been 80 km, 120 km and 204 km, respectively for 24, 48 and 72 hrs against the past five-years average error of 72, 111 and 154 km based on data of 2020-2024. The errors have been lesser during this year as compared to long period average (LPA) (2020-24), The track forecast skills compared to climatology and persistence forecast have been 66%, 75% and 71% respectively for the 24, 48 and 72 hrs lead period which was also less than long period average of 2020-2024 (65%, 74% & 77% respectively).

4.4.3 Landfall Forecast

The annual average landfall forecast errors for the year 2025 have been 76 km, 82 km and 121 km for 24, 48 and 72 hrs lead period against the past five years average errors of 16 km, 39 km and 70 km during 2020-2024. The landfall time forecast errors have been 3.0, 3.0 and 1.5 hrs for 24, 48 and 72 hrs lead period during 2025 against the average of past five years of 2.9, 4.2 and 7.5 hrs during 20120-2024. The annual average landfall points and time forecast errors are presented in **Fig. 4.4.4 (a-b)**.

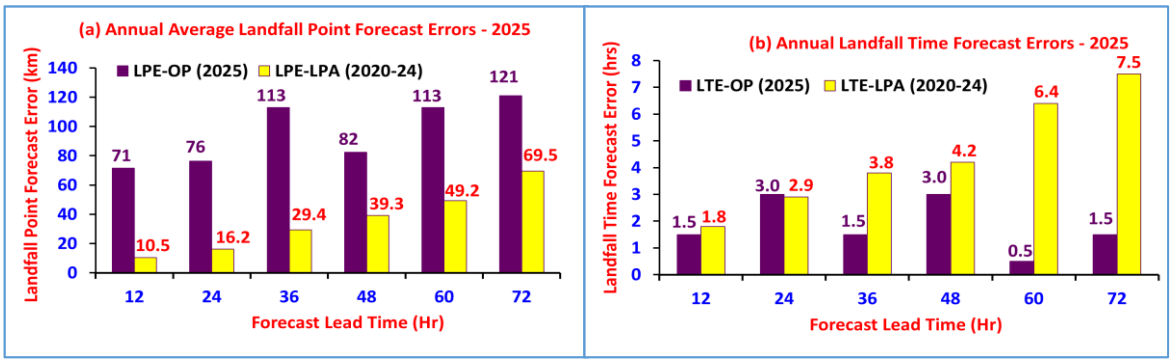


Fig.4.4.4. Annual average (a) landfall point forecast error (km) and (b) landfall time forecast errors as compared to long period average errors during 2020-2024

4.4.4 Intensity Forecast

The annual average absolute error (AE) in intensity forecast error is the weighted mean of the absolute error for each cyclone. Similarly, the annual average error is calculated by persistence method. Based on these two errors, the intensity forecast skill with reference to absolute error is calculated. Errors and skills are calculated for 12, 24, 36, 48, 60, 72, 84, 96, 108 and 120 hour forecasts. The annual average intensity forecast error based on RMSE is calculated by taking square root of the average of squared error between the forecast and observed intensity values for 12, 24, 36, 48, 60, 72, 84, 96, 108 and 120 hours forecast period for every six hourly forecasts. Similarly, RMSE error based on persistence is calculated and hence the skill.

The annual average absolute error (AE) in intensity forecast error (Fig.4.4.5 a-b) has been 3.1 knots, 2.7 knots and 3.9 knots respectively for 24, 48 and 72 hrs lead period of forecast against the past five-year average of 5.9, 8.3 and 9.8 knots. The skill in terms of AE compared to persistence forecast was 73%, 88% and 90% as compared to long period average (2020-24) of 57%, 69% and 79% for 24, 48 and 72 hours period. The annual average root mean square error (RMSE) in intensity forecast (Fig.4.4.6 a-b) has been 4.2 knots, 4.2 knots and 4.8 knots respectively for 24, 48 and 72 hrs lead period of forecast against the past five-year average of 7.9, 13.3 and 12.6 knots. The skill in terms of RMSE compared to persistence

forecast was 73%, 85% and 90% as compared to long period average (2020-24) of 60%, 71% and 79% for 24, 48 and 72 hours lead period.

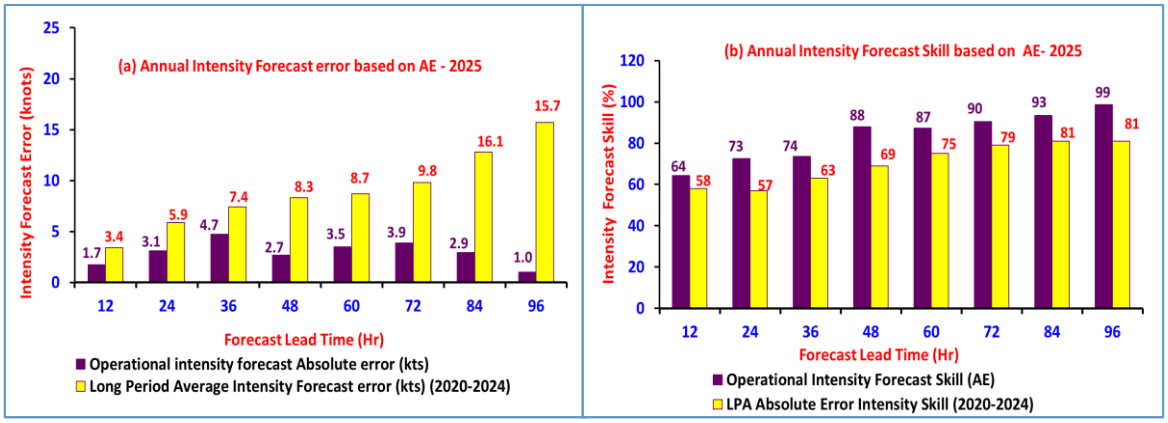


Fig.4.4.5. Annual average (a) absolute error (AE) in kts and (b) skill in % during 2025 as compared to that during 2020-2024

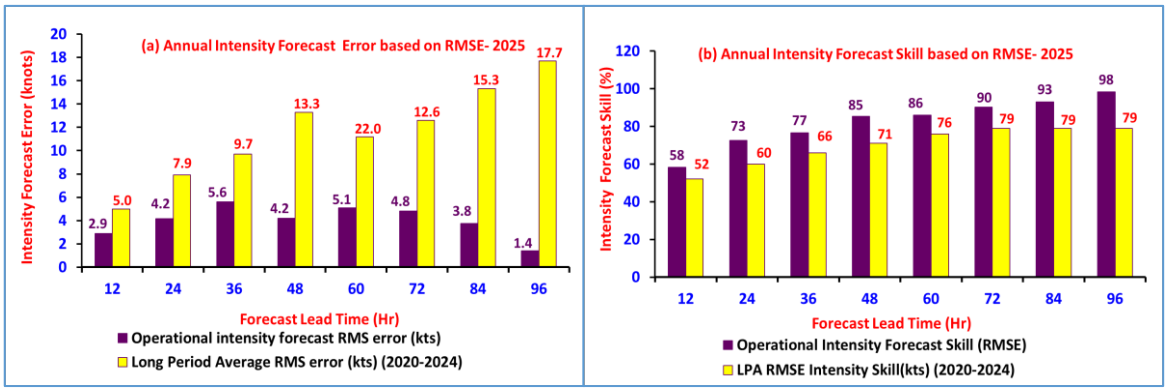


Fig.4.4.6. Annual average (a) root mean square error (RMSE) in kts and (b) skill in percentage during 2025 as compared to that during 2020-2024

4.5. Interannual variation of forecast errors of TCs over north Indian Ocean

4.5.1. Track forecast error and skill

Inter-annual variation of ftrack forecast errors and skill in track forecast since 2003 are presented in Fig.4.5.1 a & b and table 4.5.1 a & b. There has been significant improvement in annual average track forecast errors and skill due to modernization programme of IMD in 2009 with respect to observation, analysis and prediction tools & techniques which has been further augmented through improvement in observations, mainly from DWR and satellite and in terms of improved numerical modelling including enhanced data assimilation, higher resolution, improved physics etc.

There has been continuous improvement in track forecast accuracy with decrease in track forecast errors at the rate of 4.8 km/year (48 km in 10 years) for 24 hrs lead period and increase in skill at the rate of 2.7% per year (27% in 10 years) since 2003. Similarly, for 12 hrs lead period, there has been improvement in track forecast accuracy with decrease in track forecast errors at the rate of 3.0 km/year (30 km in 10 years) and increase in skill at the rate of 4.1% per year (41% in 10 years) since 2003.

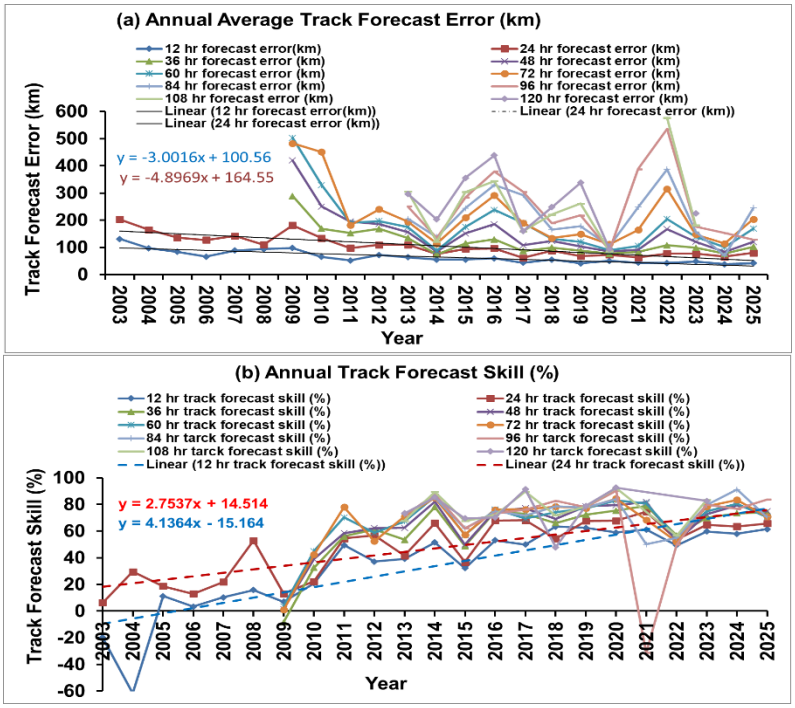


Fig. 4.5.1 Inter-annual variation of average track forecast (a) errors and (b) skill during 2025

Table. 4.5.1 (a) Inter-annual average Track forecast errors during 2003 to 2025 (Values shown in "()" indicate number of cases verified)

Year	12-hr	24-hr	36-hr	48-hr	60-hr	72-hr	84-hr	96-hr	108-hr	120-hr
2003	131 (41)	203 (41)								
2004	97 (3)	165 (3)								
2005	84 (32)	136 (26)								
2006	66 (25)	127 (19)								
2007	88 (29)	142 (24)								
2008	94 (22)	110 (16)								
2009	98 (32)	181 (26)	289 (16)	420 (8)	503 (6)	483 (2)				
2010	65 (56)	134 (48)	169 (38)	250 (29)	329 (23)	451 (19)				
2011	52 (21)	98 (19)	153 (16)	195 (14)	191 (10)	181 (7)				
2012	72 (16)	109 (13)	168 (8)	186 (6)	197 (4)	240 (2)				
2013	63.7 (94)	109 (84)	135.1 (72)	156.9 (65)	175 (55)	194.7 (44)	205.1 (34)	251.3 (26)	304.9 (18)	296.4 (11)
2014	55 (49)	76.1 (44)	74.7 (38)	85.6 (32)	88.5 (25)	114.3 (20)	138.1 (14)	135.1 (10)	121.5 (6)	203 (3)

2015	54.7 (66)	94.4 (60)	114.7 (52)	150.9 (43)	174.9 (37)	209.1 (30)	244.3 (22)	283.3 (17)	303.5 (12)	356 (8)
2016	59.7 (58)	96.1 (50)	129.6 (42)	185.1 (34)	238 (27)	291.7 (21)	330.4 (15)	379.5 (9)	344.1 (4)	438.3 (2)
2017	43.7 (35)	61.4 (29)	87.2 (23)	107.6 (18)	190.1 (14)	189.6 (12)	292.5 (10)	304.2 (8)	158.7 (3)	159.7 (3)
2018	55.4 (127)	87.5 (111)	99.2 (97)	124.2 (80)	131.2 (63)	134.3 (51)	165.8 (34)	189 (24)	220.8 (16)	247.6 (7)
2019	41.0 (168)	68.6 (150)	87.8 (136)	103.7 (123)	120.4 (109)	148.6 (89)	177.7 (66)	217.8 (55)	261.3 (46)	337.5 (33)
2020	50.3 (62)	72.5 (51)	76.4 (44)	85.3 (36)	89.1 (27)	111.4 (21)	105.5 (7)	88.8 (5)	86.3 (3)	93.3 (1)
2021	43.7 (68)	62.9 (56)	82.6 (50)	91.4 (41)	105.7 (32)	164.0 (15)	248 (9)	15.3 (4)		
2022	42.3 (75)	77.5 (61)	108 (51)	167.1 (35)	204.2 (24)	315.3 (13)	378.2 (8)	535.3 (4)	576.5 (2)	
2023	48.3 (125)	76.5 (109)	98.4 (97)	120.7 (85)	138.8 (73)	147.2 (63)	157.3 (52)	176.8 (41)	181.5 (33)	224.8 (25)
2024	37.6 (68)	65.6 (55)	76.9 (48)	83.5 (39)	100.3 (30)	114 (23)	70 (5)	153 (1)		
2025	42 (58)	80 (45)	102 (38)	120 (30)	169 (23)	204 (18)	245 (12)	129 (5)		

Table. 4.5.1 (b) Inter-annual average track forecast skill (%) during 2003 to 2025 (Values shown in "()" indicate no. of cases)

Skill	12-hr	24-hr	36-hr	48-hr	60-hr	72-hr	84-hr	96-hr	108-hr	120-hr
2003	-19.8 (41)	6.3 (41)								
2004	-61.7 (3)	29.5 (3)								
2005	11.3 (32)	18.6 (26)								
2006	3.4 (25)	13 (19)								
2007	10.3 (29)	21.9 (24)								
2008	15.9 (22)	53 (16)								
2009	7 (32)	13.1 (26)	-8.4 (16)	1.5 (8)	3.6 (6)	1 (2)				
2010	20.9 (56)	22.3 (48)	32.5 (38)	39 (29)	45.1 (23)	42.3 (19)				
2011	49.5 (21)	54.5 (19)	56.1 (16)	58.5 (14)	70.4 (10)	78 (7)				
2012	37.1 (16)	56.8 (13)	61.2 (8)	62.3 (6)	58.8 (4)	52.6 (2)				
2013	39.2 (94)	41.6 (84)	53.5 (72)	62.5 (65)	67.3 (55)	70.9 (44)	72.7 (34)	71.7 (26)	67.8 (18)	73.4 (11)
2014	51.5 (49)	66 (44)	78.1 (38)	81.9 (32)	85.8 (25)	85.1 (20)	85.4 (14)	87.6 (10)	89.5 (6)	85.3 (3)

2015	32.3 (66)	36.8 (60)	48.8 (52)	50 (43)	57 (37)	57.3 (30)	62 (22)	62.3 (17)	67.7 (12)	69.6 (8)
2016	53.1 (58)	67.9 (50)	74.7 (42)	75.6 (34)	76.4 (27)	76 (21)	74.7 (15)	73.2 (9)	72.1 (4)	70.4 (2)
2017	50 (35)	68.1 (29)	73 (23)	77.2 (18)	69.4 (14)	76.4 (12)	71.8 (10)	76.2 (8)	89.6 (3)	91.4 (3)
2018	63.3 (127)	54.4 (111)	66.1 (97)	69.1 (80)	74.1 (63)	78.3 (51)	78.5 (34)	82.6 (24)	71.7 (16)	47.9 (7)
2019	62.4 (168)	67.6 (150)	72.4 (136)	78.5 (123)	77.1 (109)	77.3 (89)	77.6 (66)	78.1 (55)	78.7 (46)	78.8 (33)
2020	58.9 (62)	67.8 (51)	75.4 (44)	79.5 (36)	83 (27)	84.4 (21)	84 (7)	90.3 (5)	92.1 (3)	92.6 (1)
2021	61.2 (68)	74.6 (56)	78.9 (50)	81.8 (41)	80.3 (32)	68.4 (15)	50.1 (9)	-31.2 (4)		
2022	49.3 (75)	53.7 (61)	56.8 (51)	52.3 (35)	55.2 (24)	52.1 (13)	54.9 (8)	49.9 (4)	56.2 (2)	
2023	59.7 (125)	65 (109)	70 (97)	73 (85)	55.2 (73)	78.5 (63)	79.5 (52)	79.8 (41)	83.4 (33)	82.7 (25)
2024	58.1 (68)	63.6 (55)	73.3 (48)	79.3 (39)	80.6 (30)	83.4 (23)	91.2 (5)	76.6 (1)		
2025	61.5 (58)	65.8 (45)	74 (38)	74.8 (30)	70.5 (23)	70.8 (18)	70.6 (12)	83.7 (5)		

4.5.2. Landfall point and time forecast errors

There has been an improvement in landfall point forecast accuracy at the rate of 11.2 km/year (112 km in 10 years) for 24 hrs lead period since 2003. Similarly, for 12 hrs lead period, there has been improvement in landfall point forecast error at the rate of 5.2 km/year (52 km in 10 years) since 2003.

Considering the landfall time errors, there has been an improvement at the rate of 0.14 hrs/year (1.4 hrs in 10 years) for 24 hrs lead period since 2003. Similarly, for 12 hrs lead period, there has been an improvement at the rate of 0.18 hrs/year (18 hrs in 10 years) for 12 hrs lead period since 2003**.**

Table 4.5.2. (a): Inter-annual average landfall point errors (value shown in "()" indicate no. of cases)

Year	12-hr	24-hr	36-hr	48-hr	60-hr	72-hr	84-hr	96-hr	108-hr	120-hr
2003	142 (2)	257 (1)								
2004	197 (1)	550 (1)								
2005	137 (2)	167 (1)								
2006	67 (2)	113 (2)								
2007	80 (5)	102 (3)								
2008	43 (4)	96 (4)								
2009	57 (4)	119 (4)	117 (4)	114 (3)						
2010	30 (5)	77 (5)	120 (4)	86 (3)	78 (3)	133 (3)				

2011	64 (2)	137 (2)	94 (2)	134 (2)	150 (1)	140 (1)				
2012	15 (2)	12 (2)	48 (2)	45 (2)	11 (2)					
2013	31 (4)	29 (4)	70 (4)	102 (4)	108 (4)	109 (3)				
2014	10 (1)	20 (1)	17 (1)	4 (1)	8 (1)	2 (1)				
2015	48.8 (3)	80.7 (3)	48.8 (3)	129.2 (2)	170.1 (2)	165.2 (1)	284.5 (1)	272.7 (1)	403.8 (1)	435.9 (1)
2016	7.8 (2)	14.1 (2)	71.6 (2)	127.2 (2)	129.2 (2)	180.1 (2)	253.2 (1)	286 (1)	403.4 (1)	
2017	19.1 (2)	50.4 (2)	29.8 (2)	59 (2)						
2018	26.7 (8)	44 (7)	42.1 (7)	40.3 (5)	56.4 (5)	67.6 (3)				
2019	8.9 (2)	27.1 (3)	21.9 (3)	34.7 (2)	15 (1)	37.2 (1)				
2020	10 (6)	17.6 (5)	53.5 (5)	69.7 (4)	27.7 (2)	43 (1)	77 (1)	47 (1)	47 (1)	
2021	6.8 (4)	16.4 (4)	10.6 (4)	19.8 (4)	97 (3)	158.5 (2)				
2022	16.5 (4)	14.8 (4)	21.7 (2)	24.5 (2)	20.2 (2)	4.5 (1)	4.9 (1)			
2023	13.0 (6)	17.0 (6)	31.2 (6)	48.8 (5)	65.8 (5)	65.7 (5)	66.6 (4)	71.1 (4)	9.1 (1)	
2024	5.4 (4)	14.4 (4)	19 (4)	24 (4)	18 (4)	2.2 (1)	1.1 (1)	1.1 (1)		
2025	71 (1)	76 (1)	113 (1)	82 (1)	113 (1)	121 (1)	128 (1)			

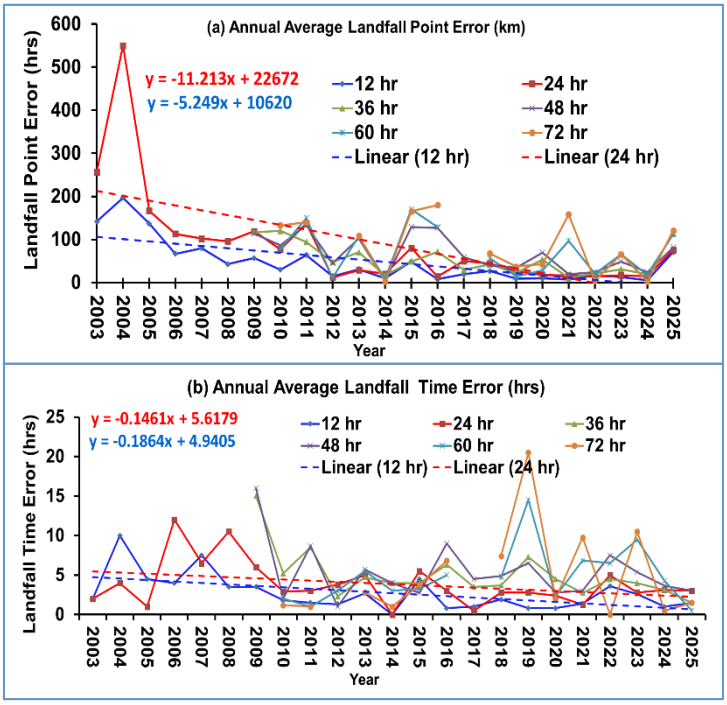


Fig. 4.5.2 Annual average (a) Landfall Point errors (b) Landfall Time errors

Table 4.5.2 (b): Inter annual average landfall time errors (value shown in "()" indicate no. of cases)

Year	12-hr	24-hr	36-hr	48-hr	60-hr	72-hr	84-hr	96-hr	108-hr	120-hr
2003	2 (2)	2 (1)								
2004	10 (1)	4 (1)								
2005	4.5 (2)	1 (1)								
2006	4 (2)	12 (2)								
2007	7.5 (5)	6.5 (3)								
2008	3.5 (4)	10.5 (4)								
2009	3.5 (4)	6 (4)	15 (4)	16 (3)						
2010	1.8 (5)	2.9 (5)	5.2 (4)	2 (3)	2 (3)	1.2 (3)				
2011	1.5 (2)	3 (2)	8.5 (2)	8.7 (2)	1 (1)	1 (1)				
2012	1.3 (2)	3.8 (2)	2.3 (2)	1 (2)	3 (2)					
2013	2.7 (4)	5 (4)	4.7 (4)	5.7 (4)	5.5 (4)	2.8 (3)				
2014	0 (1)	0 (1)	4 (1)	4 (1)	3 (1)	1 (1)				
2015	4.5 (3)	5.5 (3)	4 (3)	2.75 (2)	3.25 (2)	3.7 (1)	6.5 (1)	8.5 (1)	7.5 (1)	4.5 (1)
2016	0.8 (2)	3 (2)	6.3 (2)	9 (2)	5 (2)	6.8 (2)	3.5 (1)	2.5 (1)	5 (1)	
2017	1 (2)	0.5 (2)	3.5 (2)	4.5 (2)						
2018	1.9 (8)	2.8 (7)	3.7 (7)	4.9 (5)	4.7 (5)	7.4 (3)	6.4 (3)	15.5 (1)	14.5 (1)	
2019	0.8 (2)	2.8 (3)	7.3 (3)	6.5 (2)	14.5 (1)	20.5 (1)				
2020	0.8 (6)	2.4 (5)	4.5 (5)	2.8 (4)	2.3 (2)	2 (1)	0.5 (1)	1.5 (1)	0.5 (1)	
2021	1.4 (4)	1.3 (4)	2.75 (4)	3 (4)	6.8 (3)	9.75 (2)				
2022	3.6 (4)	5 (4)	4.5 (2)	7.5 (2)	6.5 (2)	0 (1)	0 (1)			
2023	2.6 (6)	2.8 (6)	4 (6)	5.4 (5)	9.5 (5)	10.5 (5)	9.8 (4)	10.6 (4)	9.5 (1)	
2024	1 (4)	3.1 (4)	3.1 (4)	3.6 (4)	4.3 (4)	0.5 (1)	2.5 (1)	2.5 (1)		
2025	1.5 (1)	3 (1)	1.5 (1)	3 (1)	0.5 (1)	1.5 (1)	1.5 (1)			

4.5.3 Inter-annual variation of intensity forecast error and skill

Inter-annual variation of intensity forecast errors and skill in intensity forecast since 2005 are presented in Fig. 4.5.3 (a&b) and 4.5.4 (a&b) and Tables 4.5.3 (a, b, c&d). As regards improvement in intensity forecast based on AE, there has been decrease in errors at the rate of 0.5 knots/year (5.0 knots in 10 years) for 24 hrs lead period and increase in skill at the rate of 2.4% per year (24% in 10 years) since 2005.

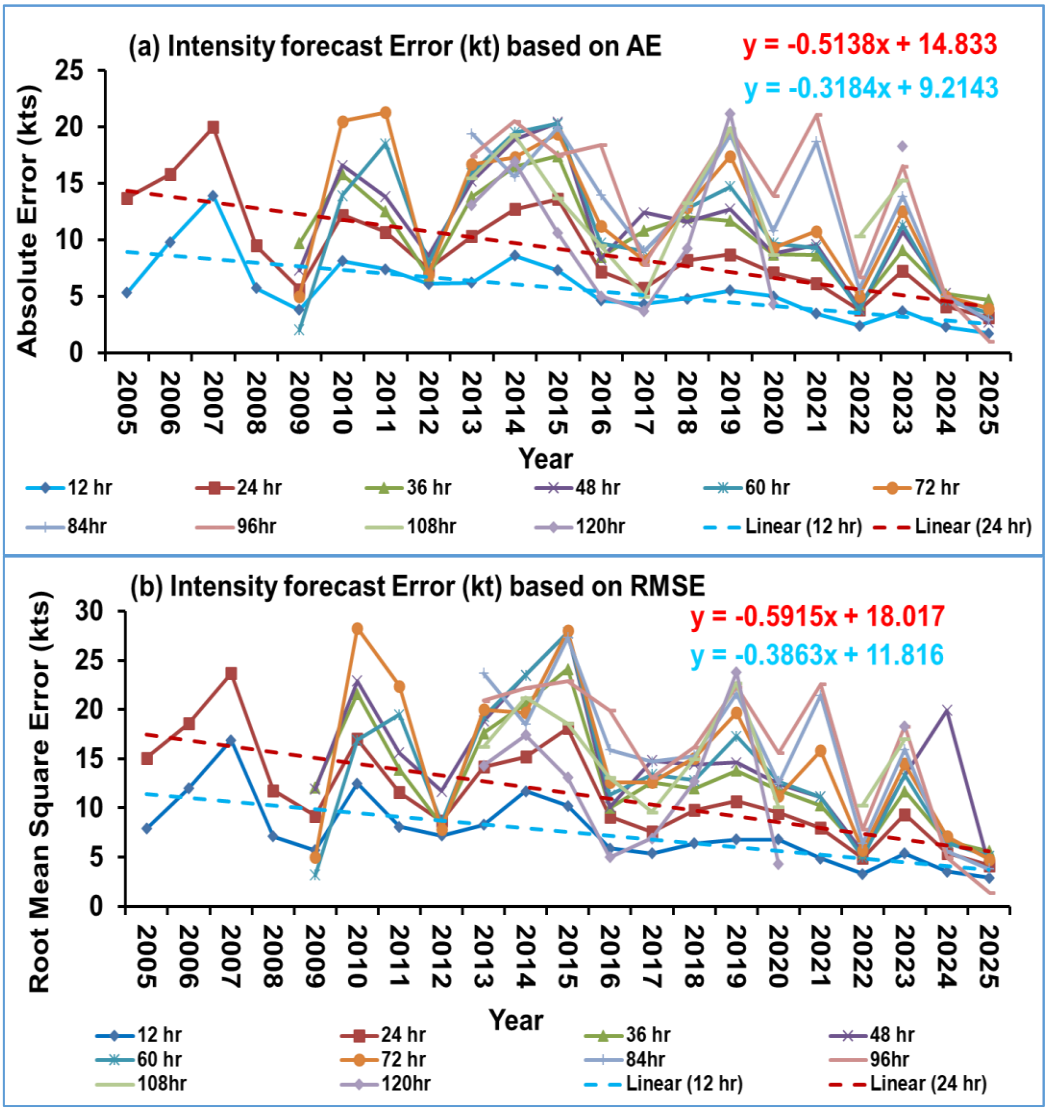


Fig. 4.5.3: Annual average intensity forecast (kt) errors based on (a) AE (b) RMSE

Similarly, for 12 hrs lead period, there has been decrease in intensity forecast errors at the rate of 0.3 knots/year (3.0 knots in 10 years) and increase in skill at the rate of 2.2% per year (22% in 10 years) since 2003. As regards improvement in intensity forecast errors based on RMSE, there has been decrease in errors at the rate of 0.59 knots/year (5.9 knots in 10 years) for 24 hrs lead period and increase in skill at the rate of 2.4% per year (24% in 10 years) since 2005. Similarly, for 12 hrs lead period, there has been decrease in intensity forecast errors at the rate of 0.39 knots/year (3.9 knots in 10 years) and increase in skill at the rate of 2.2% per year (22% in 10 years) since 2003.

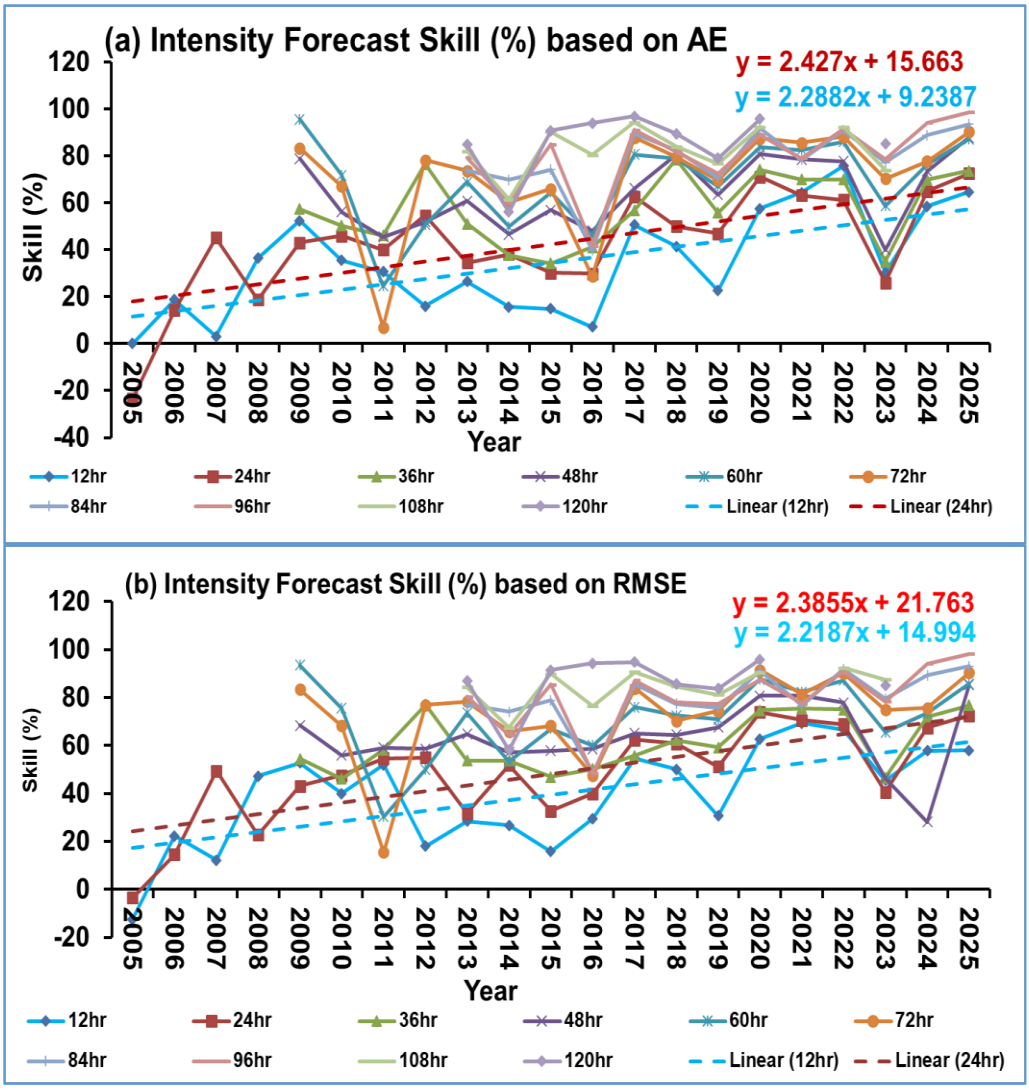


Fig. 4.5.4 Annual average intensity forecast skill (%) based on (a) AE (b) RMSE

Table 4.5.3: (a) Annual average Intensity forecast errors based on AE (Values shown in "()" indicate no. of cases)

Year	12-hr	24-hr	36-hr	48-hr	60-hr	72-hr	84-hr	96-hr	108-hr	120-hr
2003	9.7	17.8								
2004	7.5	15.8								
2005	5.3 (31)	13.7 (23)								
2006	9.8 (25)	15.8 (19)								
2007	13.9 (27)	20 (20)								
2008	5.7 (23)	9.5 (18)								
2009	3.8 (33)	5.6 (26)	9.7 (18)	7.3 (11)	2 (5)	5 (1)				

2010	8.1 (55)	12.2 (49)	15.8 (37)	16.6 (29)	13.9 (23)	20.5 (19)				
2011	7.4 (21)	10.7 (19)	12.5 (17)	13.8 (14)	18.5 (10)	21.3 (7)				
2012	6.1 (16)	7.4 (13)	6.8 (10)	8.6 (7)	7.9 (5)	6.9 (3)				
2013	6.2 (94)	10.3 (84)	13.8 (73)	15.2 (63)	15.9 (54)	16.7 (42)	19.4 (34)	17.4 (26)	15.5 (18)	13.1 (11)
2014	8.6 (49)	12.7 (44)	16.5 (38)	18.9 (32)	19.5 (25)	17.3 (20)	15.6 (14)	20.5 (10)	19.3 (6)	16.9 (3)
2015	7.3 (66)	13.6 (60)	17.4 (52)	20.4 (43)	20.3 (37)	19.4 (30)	20 (22)	17.5 (17)	13.7 (12)	10.6 (8)
2016	4.6 (58)	7.2 (50)	8.5 (42)	8.3 (34)	9.7 (27)	11.2 (21)	14 (15)	18.4 (9)	9.5 (4)	5 (2)
2017	4.3 (35)	5.7 (29)	10.8 (23)	12.4 (18)	9 (14)	8.2 (12)	9 (10)	7.8 (8)	5 (3)	3.7 (3)
2018	4.8 (127)	8.2 (112)	12 (98)	11.6 (81)	12.8 (63)	12.9 (51)	12.9 (34)	13.8 (24)	13.3 (16)	9.2 (7)
2019	5.5 (168)	8.7 (150)	11.7 (136)	12.7 (123)	14.7 (109)	17.4 (89)	19.3 (66)	19.8 (55)	19.9 (46)	21.2 (33)
2020	5 (62)	7.1 (51)	8.7 (44)	8.8 (36)	9.7 (27)	9.3 (21)	10.8 (7)	13.9 (5)	8.7 (3)	4.3 (1)
2021	3.5 (68)	6.2 (56)	8.6 (50)	9.5 (41)	9.3 (32)	10.8 (15)	18.8 (9)	21 (4)		
2022	2.4 (75)	3.8 (61)	4.2 (51)	4 (39)	3.8 (24)	5 (12)	5.6 (8)	6.7 (4)	10.3 (2)	
2023	3.7 (125)	7.3 (109)	9.1 (97)	10.7 (85)	11.3 (73)	12.5 (63)	13.9 (52)	16.5 (41)	15.3 (33)	18.3 (25)
2024	2.3 (68)	4.1 (55)	5.2 (48)	5.3 (39)	4.7 (30)	5 (24)	5 (5)	5 (1)		
2025	1.7 (58)	3.1 (45)	4.7 (38)	2.7 (30)	3.5 (23)	3.9 (18)	2.9 (12)	1 (5)		

Table 4.5.3 (b): Annual average Intensity forecast errors based on RMSE (Values shown in "()" indicate no. of cases)

Year	12-hr	24-hr	36-hr	48-hr	60-hr	72-hr	84-hr	96-hr	108-hr	120-hr
2003	11.4	24.1								
2004	8.5	17								
2005	7.9 (31)	15.1 (23)								
2006	12 (25)	18.6 (19)								
2007	16.9 (27)	23.7 (20)								
2008	7.1 (23)	11.8 (18)								
2009	5.7 (33)	9.2 (26)	12.1 (18)	11.9 (11)	3.2 (5)	5 (1)				
2010	12.5	17	21.6	22.9	16.9	28.3				

	(55)	(49)	(37)	(29)	(23)	(19)				
2011	8.1 (21)	11.6 (19)	13.9 (17)	15.6 (14)	19.5 (10)	22.4 (7)				
2012	7.2 (16)	8.7 (13)	8.3 (10)	11.7 (7)	8.5 (5)	7.8 (3)				
2013	8.3 (94)	14.2 (84)	17.6 (73)	18.8 (63)	19.3 (54)	20 (42)	23.7 (34)	20.9 (26)	16.2 (18)	
2014	11.7 (49)	15.2 (44)	20.6 (38)	23.5 (32)	23.5 (25)	19.7 (20)	18.5 (14)	22.2 (10)	21.2 (6)	
2015	10.2 (66)	18.1 (60)	24.1 (52)	27.8 (43)	27.8 (37)	28 (30)	27.3 (22)	22.9 (17)	18.6 (12)	
2016	5.9 (58)	9.1 (50)	10 (42)	10.1 (34)	11.3 (27)	12.6 (21)	15.9 (15)	19.9 (9)	13.1 (4)	
2017	5.4 (35)	7.6 (29)	12.6 (23)	14.8 (18)	13.4 (14)	12.6 (12)	14.7 (10)	13.1 (8)	9.6 (3)	
2018	6.4 (127)	9.8 (112)	12 (98)	14.4 (81)	12.8 (63)	15.1 (51)	15.3 (34)	16.2 (24)	15 (16)	
2019	6.8 (168)	10.7 (150)	13.8 (136)	14.6 (123)	17.3 (109)	19.7 (89)	21.6 (66)	22.3 (55)	22.7 (46)	
2020	6.8 (62)	9.5 (51)	11.8 (44)	12.4 (36)	12.7 (27)	11.2 (21)	12.5 (7)	15.6 (5)	10.1 (3)	
2021	4.9 (68)	8 (56)	10.3 (50)	11.1 (41)	11.1 (31)	15.8 (15)	21.5 (9)	22.6 (4)		
2022	3.3 (75)	4.9 (61)	5.5 (51)	5.5 (39)	5 (24)	5.7 (12)	6.4 (8)	7.8 (4)	10.3 (2)	
2023	5.4 (125)	9.3 (109)	11.7 (97)	13.3 (85)	13.4 (73)	14.5 (63)	15.9 (52)	18.3 (41)	17 (33)	
2024	3.5 (68)	5.4 (55)	6.7 (48)	19.9 (39)	6.5 (30)	7.1 (23)	5.6 (5)	5 (1)		
2025	2.9 (58)	4.2 (45)	5.6 (38)	4.2 (30)	5.1 (23)	4.8 (18)	3.8 (12)	1.4 (5)		

Table 4.5.3 (c) Annual average Intensity forecast skill based on AE (Values shown in "()" indicate no. of cases)

Year	12-hr	24-hr	36-hr	48-hr	60-hr	72-hr	84-hr	96-hr	108-hr	120-hr
2003										
2004										
2005										
2006	19 (25)	14 (19)								
2007	3 (27)	45 (20)								
2008	37 (23)	19 (18)								
2009	52 (33)	43 (26)	57 (18)	79 (11)	96 (5)	83 (1)				
2010	36 (55)	46 (49)	50 (37)	56 (29)	72 (23)	67 (19)				
2011	31 (21)	40 (19)	46 (17)	45 (14)	24 (10)	7 (7)				
2012	16	55	77	52	51	78				

	(16)	(13)	(10)	(7)	(5)	(3)				
2013	26 (94)	35 (84)	51 (73)	61 (63)	69 (54)	74 (42)	74 (34)	79 (26)	82 (18)	85 (11)
2014	16 (49)	38 (44)	38 (38)	47 (32)	50 (25)	60 (20)	70 (14)	60 (10)	61 (6)	56 (3)
2015	15 (66)	30 (60)	34 (52)	57 (43)	64 (37)	66 (30)	74 (22)	85 (17)	90 (12)	91 (8)
2016	7 (58)	30 (50)	41 (42)	48 (34)	46 (27)	29 (21)	40 (15)	42 (9)	81 (4)	94 (2)
2017	51 (35)	63 (29)	57 (23)	66 (18)	81 (14)	88 (12)	90 (10)	91 (8)	94 (3)	97 (3)
2018	41 (127)	50 (112)	78 (98)	80 (81)	79 (63)	79 (51)	82 (34)	82 (24)	84 (16)	89 (7)
2019	23 (168)	47 (150)	56 (136)	64 (123)	67 (109)	70 (89)	71 (66)	72 (55)	77 (46)	79 (33)
2020	58 (62)	71 (51)	74 (44)	81 (36)	84 (27)	88 (21)	92 (7)	89 (5)	92 (3)	96 (1)
2021	64 (68)	63 (56)	70 (50)	78 (41)	82 (32)	86 (15)	78 (9)	79 (4)		
2022	76 (75)	61 (61)	70 (51)	78 (39)	86 (24)	88 (12)	91 (8)	91 (4)	92 (2)	
2023	30 (125)	26 (109)	35 (97)	40 (85)	59 (73)	70 (63)	77 (52)	79 (41)	74 (33)	85 (25)
2024	59 (68)	65 (55)	70 (48)	74 (39)	76 (30)	78 (24)	89 (5)	94 (1)		
2025	65 (58)	73 (45)	74 (38)	88 (30)	87 (23)	90 (18)	93 (12)	99 (5)		

Table 4.5.3 (d) Annual average Intensity skill based on RMSE (Values shown in "()" indicate no. of cases)

Year	12-hr	24-hr	36-hr	48-hr	60-hr	72-hr	84-hr	96-hr	108-hr	120-hr
2003										
2004										
2005	-12 (31)	-4 (23)								
2006	22 (25)	15 (19)								
2007	12 (27)	50 (20)								
2008	47 (23)	23 (18)								
2009	53 (33)	43 (26)	55 (18)	68 (11)	93 (5)	83 (1)				
2010	40 (55)	48 (49)	46 (37)	56 (29)	76 (23)	68 (19)				
2011	52 (21)	55 (19)	58 (17)	59 (14)	30 (10)	15 (7)				
2012	18 (16)	55 (13)	77 (10)	59 (7)	50 (5)	77 (3)				
2013	28 (94)	32 (84)	54 (73)	65 (63)	74 (54)	78 (42)	77 (34)	80 (26)	84 (18)	87 (11)

2014	27 (49)	52 (44)	54 (38)	57 (32)	53 (25)	66 (20)	74 (14)	64 (10)	67 (6)	58 (3)
2015	16 (66)	33 (60)	47 (52)	58 (43)	67 (37)	68 (30)	79 (22)	86 (17)	90 (12)	91 (8)
2016	30 (58)	40 (50)	50 (42)	59 (34)	60 (27)	47 (21)	49 (15)	48 (9)	76 (4)	94 (2)
2017	55 (35)	62 (29)	56 (23)	65 (18)	76 (14)	84 (12)	85 (10)	87 (8)	91 (3)	95 (3)
2018	50 (127)	61 (112)	62 (98)	64 (81)	72 (63)	70 (51)	77 (34)	78 (24)	85 (16)	86 (7)
2019	31 (168)	51 (150)	59 (136)	68 (123)	71 (109)	74 (89)	76 (66)	77 (55)	81 (46)	84 (33)
2020	63 (62)	74 (51)	75 (44)	81 (36)	88 (27)	91 (21)	91 (7)	87 (5)	90 (3)	96 (1)
2021	69 (68)	71 (56)	75 (50)	81 (41)	82 (31)	81 (15)	77 (9)	78 (4)		
2022	67 (75)	69 (61)	75 (51)	78 (39)	87 (24)	90 (12)	92 (8)	91 (4)	92 (2)	
2023	46 (125)	41 (109)	47 (97)	46 (85)	66 (73)	75 (63)	79 (52)	78 (41)	87 (33)	85 (25)
2024	58 (68)	67 (55)	72 (48)	28 (39)	73 (30)	76 (23)	89 (5)	94 (1)		
2025	69 (68)	71 (56)	75 (50)	81 (41)	82 (31)	81 (15)	77 (9)	78 (4)		

4.6 Comparative analysis of forecast accuracy in recent five years (2021-25) as compared to previous five years (2016-20)

4.6.1 . Landfall Forecast Error

Comparative analysis of landfall point error (LPE) and landfall time error (LTE) during 2021-25 vis-à-vis 2016-20 is presented in Fig. 4.6.1 (a & b). The LPE for 24, 48 and 72 hrs lead period during 2021-25 were 19.0 km, 34.4 km and 77.3 km against 31.9 km, 61.5 km and 91.9 km respectively during 2016-20 which shows an improvement of 41%, 44% and 16% respectively. The LTEs for 24, 48 and 72 hrs lead period during 2021-25 were 3.0hrs, 4.5hrs & 7.4hrs against 2.5hrs, 5.0hrs & 8.3hrs respectively during 2016-20 registering an improvement of -22% and 12% for 24 and 48 hours lead period respectively.

4.6.2 Track forecast error and skill

The comparative analysis of average track forecast error and skill during 2021-25 and 2016-20 is presented in Fig.4.6.2. The average track forecast errors during 2021-25 were 73 km, 116 km & 168 km against 77 km, 117 km & 159 km during 2016-20 for 24, 48 and 72 hrs lead period respectively. There has been an improvement of 6%, 1% & -6% in track forecast errors for 24, 48 and 72 hours lead period during 2021-25 with respect to 2016-2020. The 24, 48 and 72 hr average track forecast skill during 2021-25 were 65%, 73% and 75% against 64%, 76% and 78% respectively during 2016-20 with an improvement of 1%, -2% and -3% for 24, 48 and 72 hours lead period.

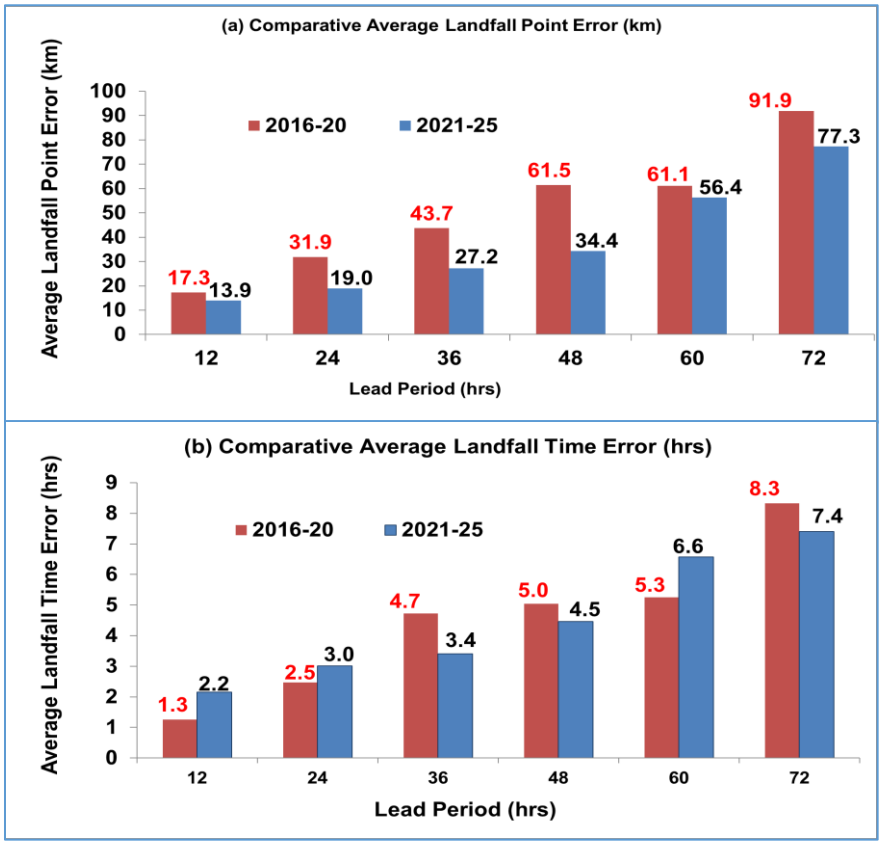


Fig. 4.6.1: Comparative average landfall (a) point and (b) time forecast errors during 2021-25 vis-à-Vis 2016-20

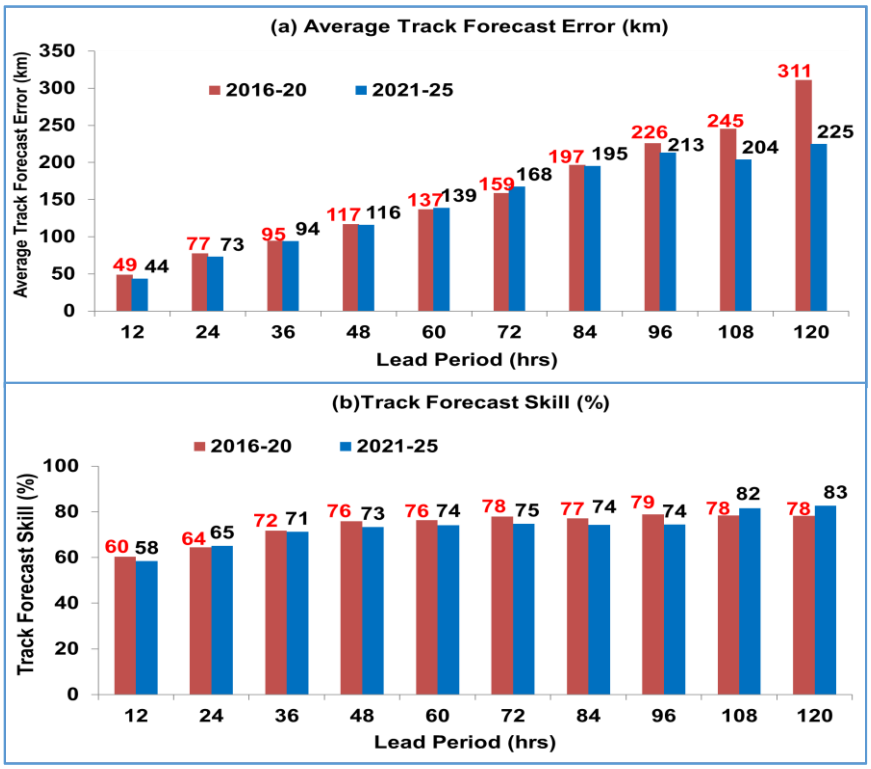


Fig. 4.6.2: Comparative average track forecast (a) error and (b) skill during 2021-25 Vis-à-Vis 2016-20

4.6.3 Intensity forecast error and skill

The comparative analysis of average intensity forecast error and skill based on AE and RMSE during 2021-25 and 2016-20 are presented in Fig.4.6.3 and 4.6.4 respectively. The average intensity forecast error based on AE for 24hrs, 48hrs and 72hrs are 5.3 knots, 7.5 knots and 9.1 knots during 2021-25 against 7.9 knots, 11.4 knots and 14.1 knots during 2016-20. Based on RMSE the intensity forecast errors were 7.9 knots, 13.3 knots and 12.6 knots during 2021-25 against 9.9 knots, 13.8 knots, and 16.7 knots during 2016-20. It can be seen that there has been marginal improvement in intensity forecast during recent five years (2021-25) as compared to previous five years (2016-20).

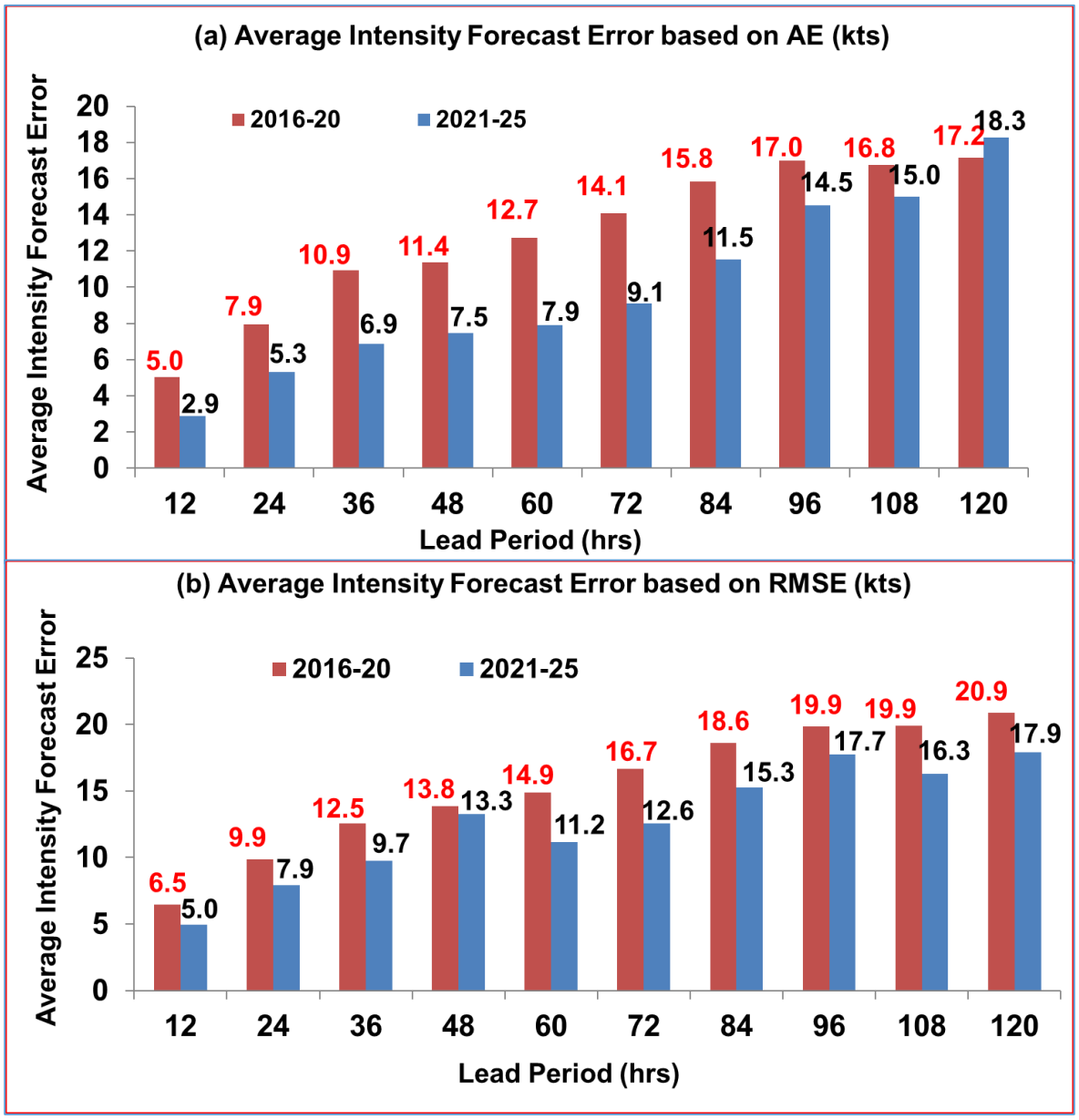


Fig. 4.6.3: Comparative Average Intensity forecast errors (kts) based on (a) absolute error and (b) root mean square errors during 2021-25 vis-à-vis 2016-20

The average intensity forecast skill based on AE for 24hrs, 48hrs and 72hrs are 54%, 68% and 78% during 2021-25 against 52%, 72% and 75% during 2016-20. Based on RMSE the intensity forecast skill were 65%, 67% and 83% during 2021-25 against 59%, 69% and 78% during 2016-20. It can be seen that there has been marginal improvement in intensity forecast during recent five years (2021-25) as compared to previous five years (2016-20).

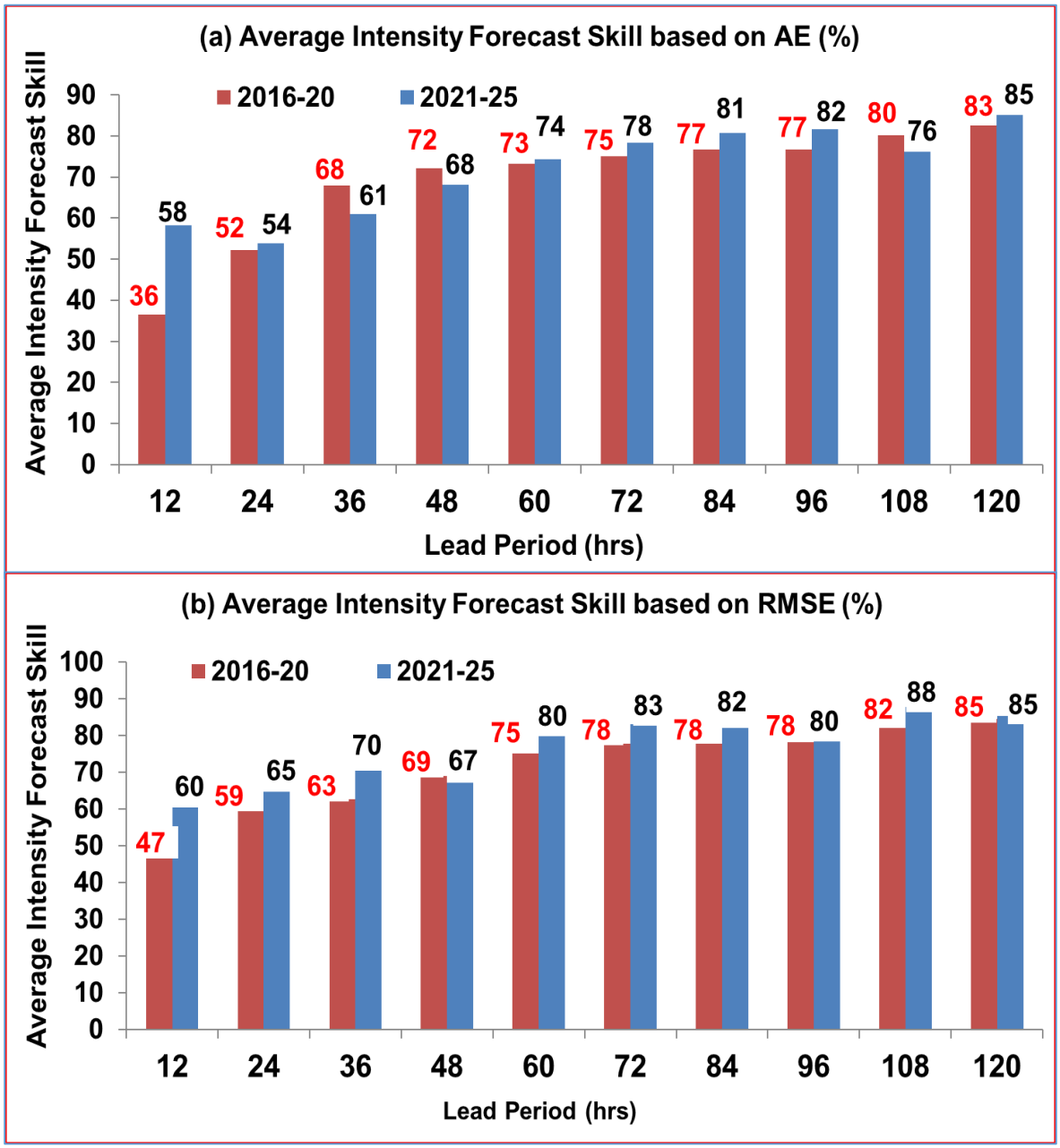


Fig. 4.6.4: Comparative Average Intensity forecast skill (%) based on (a) absolute error and (b) root mean square errors during 2021-25 vis-à-vis 2016-20

4.7 Five Year Moving Average errors and skill over north Indian Ocean

It can be seen from Fig.4.7.1-4.7.2 that there has been continuous improvement in forecast accuracy with decrease in landfall and track forecast errors and increase in skill over the years. Due to modernization programme of IMD and other initiatives of MoES, the improvement has been more significant since 2009. However, the rate of improvement in intensity forecast over the years has been marginal as can be seen from Fig.4.7.3 and Fig 4.7.4. The 36-72 hours forecasts commenced from 2009 and it was further extended to 120 hrs from 2013 onwards.

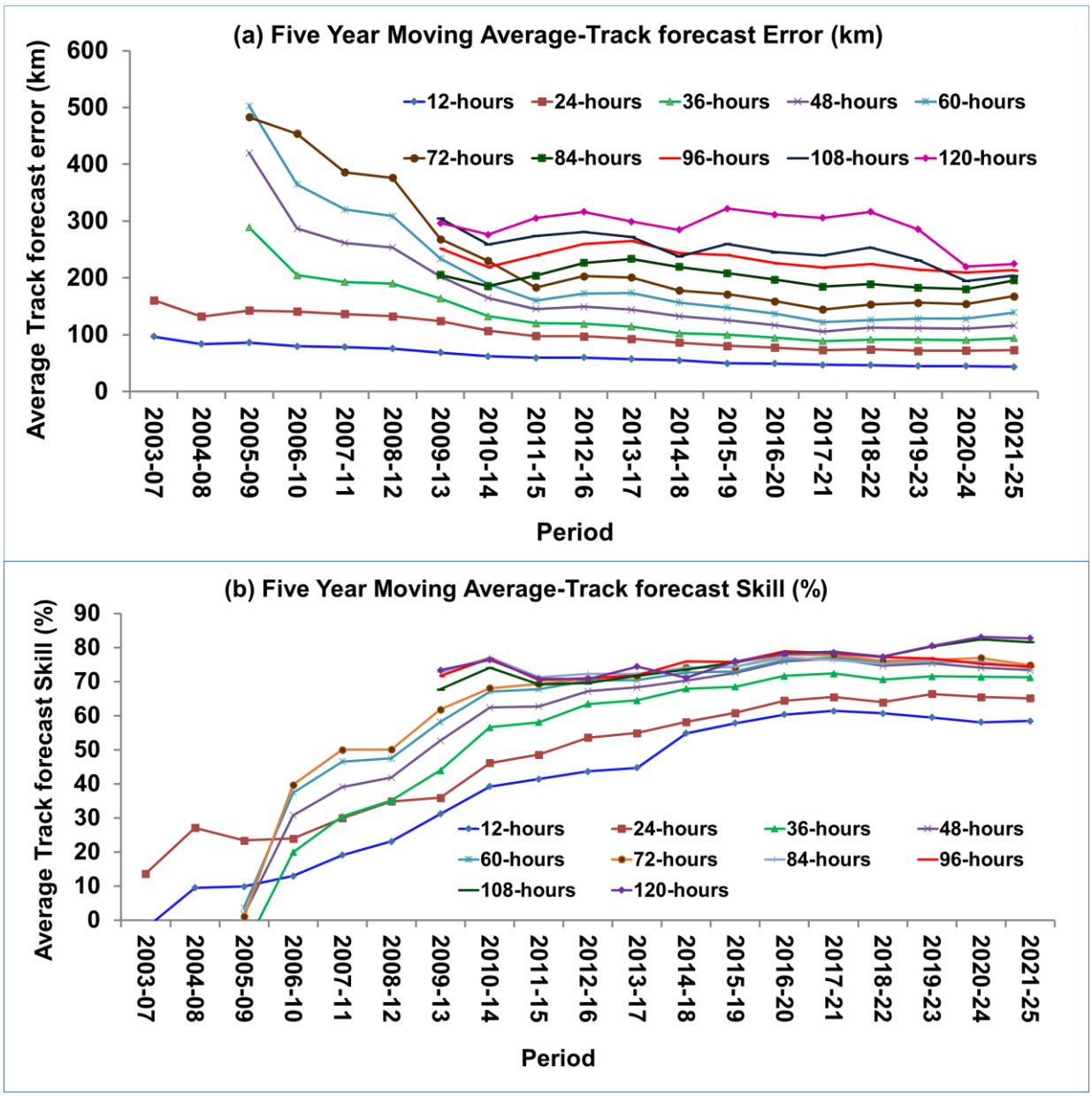


Fig. 4.7.1: (a) Five Year Moving Average Track Forecast Error (km) of RSMC, New Delhi over North Indian Ocean, (b) Five Year Moving Average Track Forecast Skill (%) of RSMC, New Delhi over North Indian Ocean

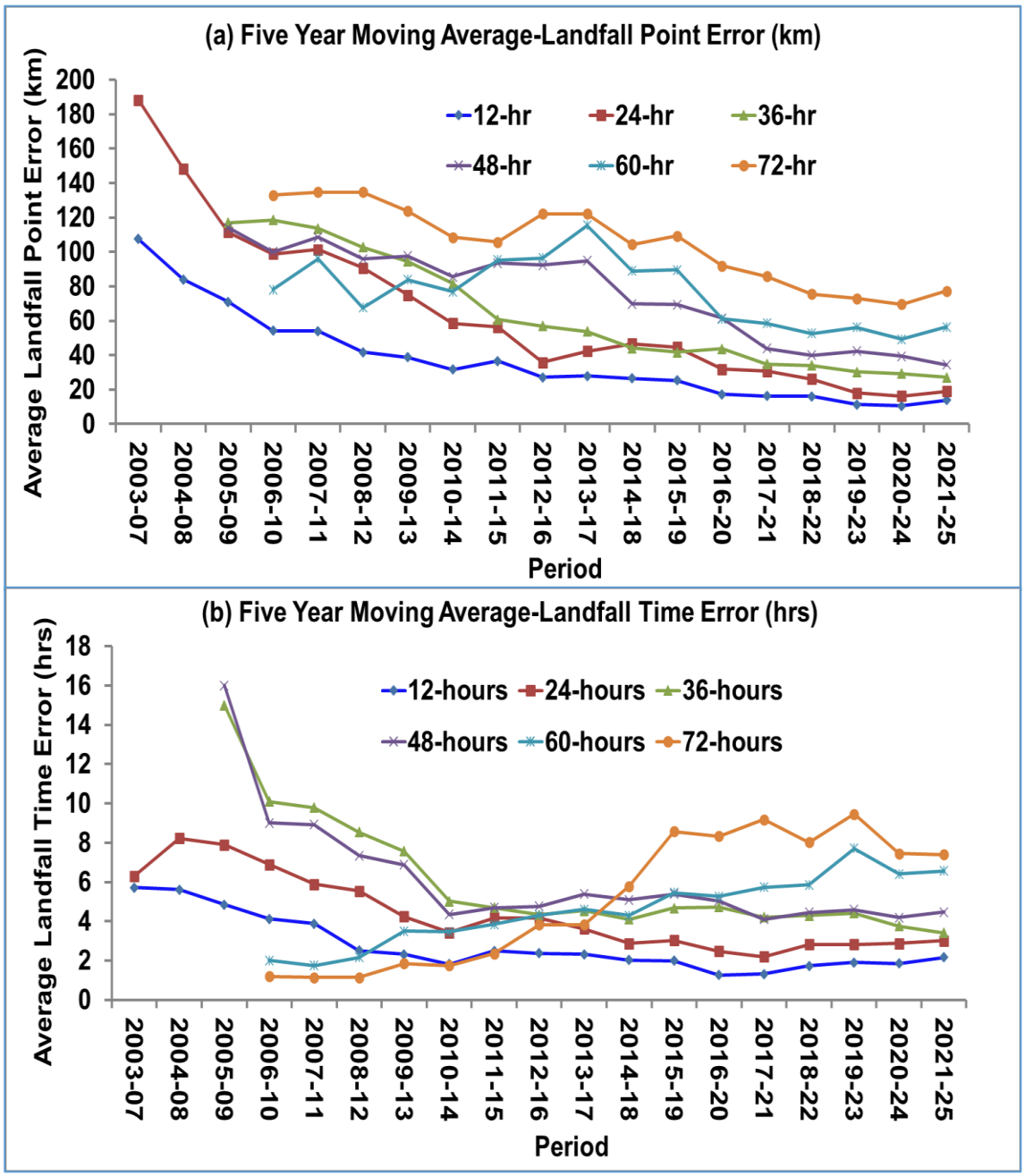


Fig. 4.7.2: Five Year Moving Average Errors in (a) Landfall Point (km) and (b) Landfall Time (hrs) of RSMC, New Delhi over north Indian Ocean.

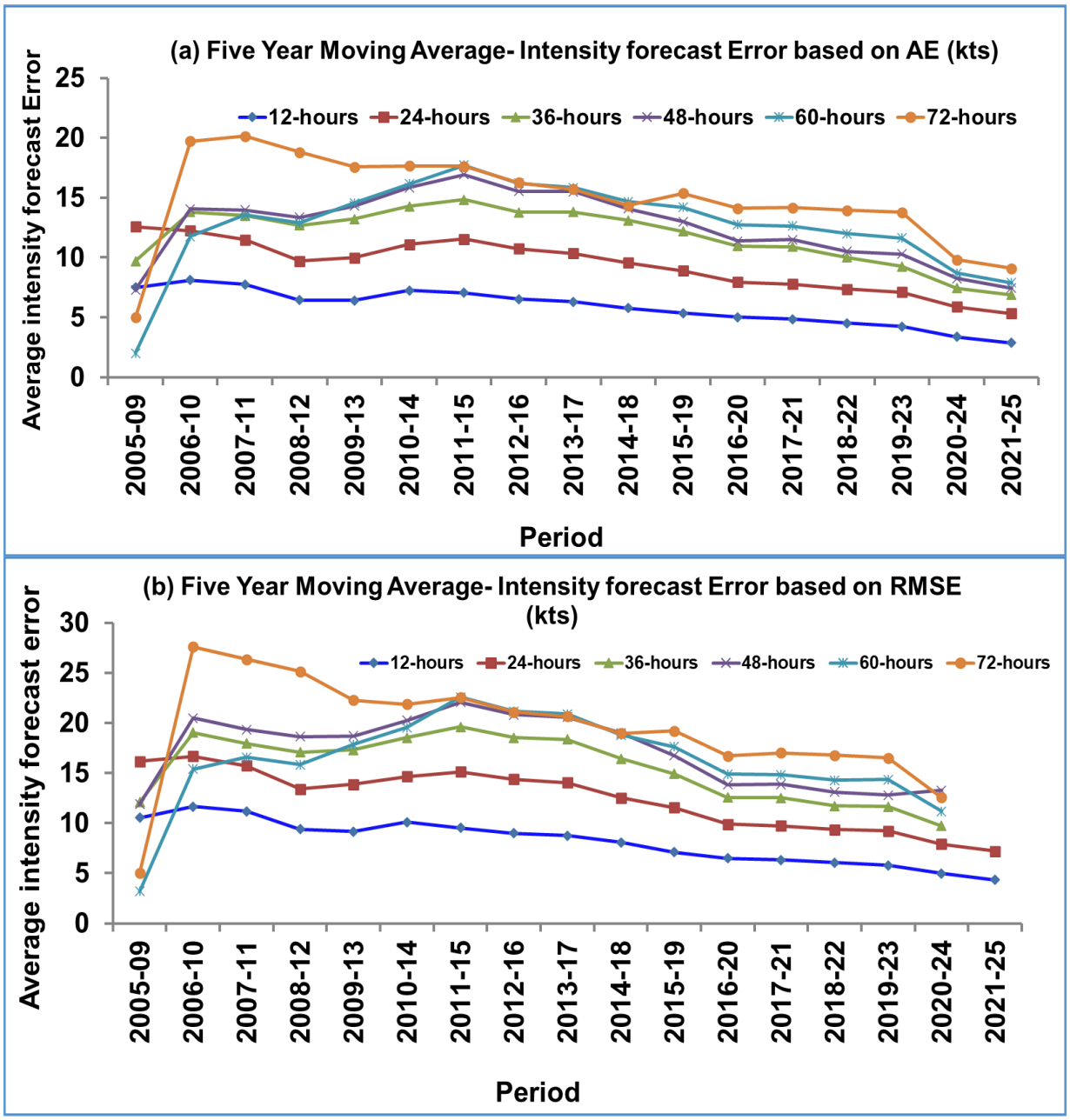


Fig. 4.7.3: Five Years Moving Average Intensity Forecast (a) Absolute Error (kts) and (b) Root Mean Square Error (kts) of RSMC, New Delhi over the NIO

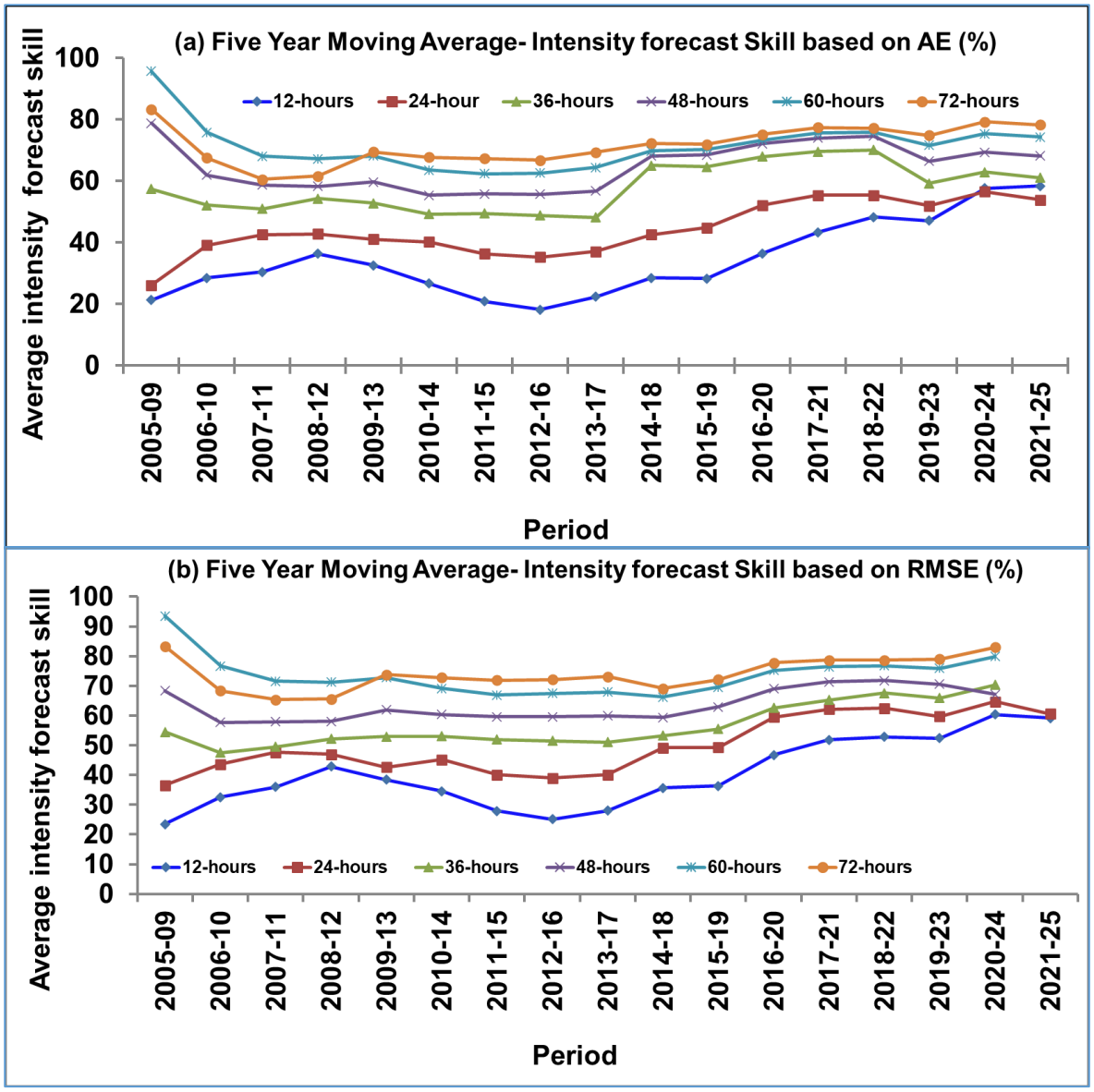


Fig. 4.7.4: Five Year Moving Average Intensity Forecast skill based on (a) AE and (b) RMSE of RSMC, New Delhi over North Indian Ocean

Table 4.7.1: Homogeneous comparison of official landfall forecast errors over north Indian Ocean in 2025 with averages during 2020-24 and 2015-24.

Parameter	Forecast Period (hr)					
	12	**24**	**36**	**48**	**60**	**72**
2025						
2025 Mean OFCL Landfall Point Error (km)	71	76	113	82	113	121
2025 Mean OFCL Landfall Time Error (hr)	1.5	3.0	1.5	3.0	0.5	1.5
2025 No. of cases	1	1	1	1	1	1
2020-24						
Mean OFCL Landfall Point Error (km)	11	16	29	39	49	70
Mean OFCL Landfall Time Error (hr)	1.8	2.9	3.8	4.2	6.4	7.5
No. of cases	24	23	21	19	16	10
2015-24						
Mean OFCL Landfall Point Error (km)	17	28	35	52	65	86
Mean OFCL Landfall Time Error (hr)	1.9	2.9	4.2	4.7	6.0	7.9
No. of cases	41	40	38	32	26	17

The landfall forecast was issued upto 24 hrs from 2003 to 2008, upto 72 hrs from 2009 to 2012 and 120 hrs from 2013 onwards, OFCL: Official (+ve represents improvement & -ve represents deterioration).

Table 4.7.2 Homogeneous comparison of OFCL & CLIPER Track Forecast Errors over NIO in 2025 with Averages for 2020-24 and 2015-24

Parameter	Forecast Period (hr)									
	12	**24**	**36**	**48**	**60**	**72**	**84**	**96**	**108**	**120**
2025										
2025 Mean OFCL Forecast Error (km)	42	80	102	120	169	204	245	129		
2025 Mean CLIPER Error (km)	109	234	393	477	572	699	832	792		
2025 Mean OFCL Skill wrt CLIPER (%)	61	66	74	75	70	71	71	84		
2025 No. of cases	58	45	38	30	23	18	12	5		
2020-2024										
2020-24 Mean OFCL Forecast Error (km)	45	72	90	111	128	154	180	210	195	220
2020-24 Mean CLIPER Error (km)	107	208	316	428	530	668	738	846	1107	1299
2020-24 Mean OFCL Skill wrt CLIPER (%)	58	65	71	74	76	77	76	75	82	83
2020-24 No. of cases	398	332	290	236	186	135	81	55	38	26
2015-2024										
2015-24 Mean OFCL Forecast Error (km)	47	77	96	119	139	164	198	230	239	288
2015-24 Mean CLIPER Error (km)	111	213	328	459	566	700	810	1016	1127	1320
2015-24 Mean OFCL Skill wrt CLIPER (%)	57	64	71	74	75	77	76	77	79	78
2015-24 No. of cases	852	732	640	534	436	338	228	168	119	79
Relative Error										
2025 relative to 2020-24 mean (%)	6	-11	-13	-8	-32	-32	-36	39		
2025 CLIPER error relative to 2020-24 mean (%)	-2	-12	-24	-11	-8	-5	-13	6		
2025 Skill relative to 2020-24 mean (%)	5	2	4	1	-8	-8	-7	12		
2025 relative to 2015-24 mean (%)	11	-4	-7	-1	-21	-24	-24	44		
2025 CLIPER error relative to 2015-24 mean (%)	2	-10	-20	-4	-1	0	-3	22		
2025 Skill relative to 2015-24 mean (%)	7	3	4	1	-7	-8	-7	9		

The track forecast was issued upto 24 hrs from 2003 to 2008, upto 72 hrs from 2009 to 2012 and 120 hrs from 2013 onwards, OFCL: Official (+ve represents improvement & -ve represents deterioration).

Table 4.7.3 Homogeneous comparison of OFCL & Persistence Intensity Forecast Errors based on Absolute Error over NIO in 2025 with Averages for 2020-24 and 2015-24

Parameter	Forecast Period (hr)									
	12	**24**	**36**	**48**	**60**	**72**	**84**	**96**	**108**	**120**
2025										
2025 Mean OFCL Forecast Error (kts)	1.7	3.1	4.7	2.7	3.5	3.9	2.9	1.0		
2025 Mean Persistence Error (kts)	4.8	16.7	18	22.2	27.4	40.3	44.2	78.0		
2025 Mean OFCL Skill wrt Persistence (%)	65	81	74	88	87	90	93	99		
2025 No. of cases	58	45	38	30	23	18	12	5		
2020-2024										
2020-24 Mean OFCL Forecast Error (kts)	3.4	5.9	7.4	8.3	8.7	9.8	12.8	15.7	14.5	17.7
2020-24 Mean Persistence Error (kts)	8.0	13.6	20.1	26.9	35.3	47.3	68.7	83.6	67.1	121.6
2020-24 Mean OFCL Skill wrt Persistence (%)	57.6	56.5	62.9	69.3	75.4	79.2	81.4	81.2	78.4	85.4
2020-24 No. of cases	398	332	290	240	186	135	81	55	38	26
2015-2024										
2015-24 Mean OFCL Forecast Error (kts)	4.4	7.5	10.0	10.9	11.8	13.2	15.3	16.7	15.9	16.8
2015-24 Mean Persistence Error (kts)	7.7	15.0	27.9	34.9	42.5	51.8	67.1	79.2	86.4	108.0
2015-24 Mean OFCL Skill wrt Persistence (%)	42.5	49.7	64.0	68.8	72.1	74.6	77.2	78.9	81.6	84.4
2015-24 No. of cases	852	733	641	539	436	338	228	168	119	79
Relative Error										
2025 OFCL error relative to 2020-24 mean (%)	49.6	47.4	36.9	67.3	59.7	60.3	77.3	93.6		
2025 Persistence error relative to 2020-24 mean (%)	39.7	-23.2	10.7	17.4	22.4	14.8	35.7	6.7		
2025 Relative Skill wrt 2020-24	12.1	44.0	17.3	26.8	15.7	14.0	14.8	21.5		
2025 OFCL error relative to 2015-24 mean (%)	61.6	58.8	53.2	75.2	70.4	70.4	81.0	94.0		
2025 Persistence error relative to 2015-24 (%)	37.7	-11.6	35.9	36.3	35.5	22.3	34.1	1.6		
2025 Relative Skill wrt 2015-24	52.1	64.0	15.2	27.7	20.9	21.1	21.0	25.1		

The intensity forecast was issued upto 24 hrs during 2003 to 2008, 72 hrs during 2009-12 and 120 hrs from 2013 onwards, OFCL: Official (+ve represents improvement & -ve represents deterioration).

Table 4.7.4 Homogeneous comparison of OFCL & Persistence Intensity Forecast Errors based on Root Mean Square Error over NIO in 2025 with Averages for 2020-24 and 2015-24

Parameter	Forecast Period (hr)									
	12	**24**	**36**	**48**	**60**	**72**	**84**	**96**	**108**	**120**
2025										
2025 Mean OFCL Forecast Error (km)	2.9	4.2	5.6	4.2	5.1	4.8	3.8	1.4		
2025 Mean Persistence Error (km)	6.9	15.2	24	28.5	35.9	49.5	54.4	81.9		
2025 Mean OFCL Skill wrt Persistence (%)	58	73	77	85	86	90	93	98		
2025 No. of cases	58	45	38	30	23	18	12	5		
2020-2024										
2020-24 Mean OFCL Forecast Error (km)	5.0	7.9	9.7	13.3	11.2	12.6	15.3	17.7	16.3	17.9
2020-24 Mean Persistence Error (km)	12.5	22.4	32.9	40.3	55.5	74.0	85.0	89.8	132.9	121.7
2020-24 Mean OFCL Skill wrt Persistence (%)	60.3	64.7	70.4	67.1	79.9	83.0	82.0	80.3	87.8	85.3
2020-24 No. of cases	398	332	290	240	185	134	81	55	38	26
2015-2024										
2015-24 Mean OFCL Forecast Error (km)	6.2	10.1	12.8	15.7	15.2	16.9	18.7	19.6	18.9	19.4
2015-24 Mean Persistence Error (km)	11.8	22.6	33.2	44.3	61.2	71.0	85.9	99.2	128.5	131.8
2015-24 Mean OFCL Skill wrt Persistence (%)	47.5	55.5	61.4	64.5	75.2	76.2	78.2	80.2	85.3	85.3
2015-24 No. of cases	852	733	641	510	435	337	228	168	119	79
Relative Error										
2025 OFCL error relative to 2020-24 mean (%)	41.5	58.6	56.4	73.3	66.5	71.6	79.7	92.9		
2025 Persistence error relative to 2020-24 mean (%)	44.8	32.9	27.8	35.6	41.3	30.2	36.6	17.5		
2025 Relative Skill wrt 20116-20	-3.9	12.1	8.9	27.1	7.4	8.8	13.4	22.4		
2025 OFCL error relative to 2015-24 mean (%)	-53.2	-58.6	-56.4	-73.3	-66.5	-71.6	-79.7	-92.9		
2025 Persistence error relative to 2015-24 mean (%)	-41.5	-32.9	-27.8	-35.6	-41.3	-30.2	-36.6	-17.5		
2025 Relative Skill wrt 2015-24	22.0	30.6	24.9	32.2	14.2	18.5	19.0	22.5		

The intensity forecast was issued upto 24 hrs during 2003- 2008, 72 hrs during 2009-12 and 120 hrs from 2013 onwards OFCL: Official (+ve represents improvement & -ve represents deterioration)

Acknowledgement

India Meteorological Department (IMD) and RSMC New Delhi duly acknowledge the contribution from various national and international organizations/institutes for their contribution in early warning services against various cyclonic disturbances over the North Indian Ocean during 2024.

- World Meteorological Organisation (WMO) and all the 13 WMO/ESCAP Panel member countries including Bangladesh, Iran, Maldives, Myanmar, Pakistan, Qatar, Sri Lanka, Saudi Arabia, Sultanate of Oman, Thailand, United Arab Emirates, Yemen.
- All sister organisations of Ministry of Earth Sciences including National Centre for Medium Range Weather Forecasting Centre (NCMRWF), Indian Institute of Tropical Meteorology (IITM), Indian National Centre for Ocean Information Services (INCOIS), National Institute of Ocean Technology (NIOT).
- Research institutes including IIT Bhubaneswar, IIT Delhi and Indian Space Research Organisation (ISRO).
- Various international modeling centres including European Centre for Medium Range Weather Forecasting (ECMWF), UK Meteorological Office, National centre for Environmental Prediction (NCEP), USA, Japan Meteorological Agency and Meteo-France
- Various international meteorological satellite groups/institutes providing the cloud imageries and products related to cyclonic disturbances over north Indian Ocean region through open access
- Various central and state disaster management agencies, stakeholders, press & electronic media and general public

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DAMAGE IN SRI LANKA DUE TO CYCLONIC STORM ‘DITWAH’

Image Sources: (a) Reuters, (b) News.un.org, (c) Reuters, and (d) shutterstock.com.