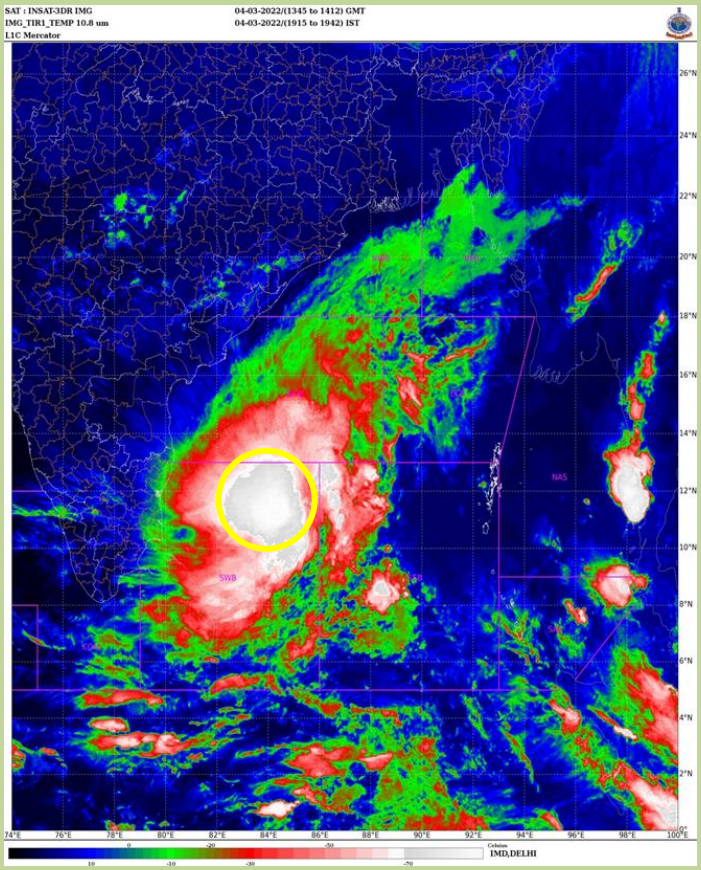
GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
INDIA METEOROLOGICAL DEPARTMENT

Deep Depression over southwest Bay of Bengal and adjoining Equatorial Indian Ocean (3^{rd}-6^{th} March, 2022): A Report



INSAT-3D enhanced Colored IR imagery based on 1345 UTC of 4^{th} March

Cyclone Warning Division

India Meteorological Department

New Delhi

March 2022

Deep depression over southwest Bay of Bengal and adjoining Equatorial Indian Ocean during 3-6 March, 2022

1. Introduction

A cyclonic circulation formed over the south Andaman Sea & adjoining Equatorial Indian Ocean (EIO) concentrated into a low pressure area over southeast Bay of Bengal (BOB) and adjoining areas at 1200 UTC of 28 February, 2022. At 0300 UTC of 1st March, 2022, it lay over southeast BoB and adjoining EIO and over central parts of south BOB and adjoining EIO at 0300 UTC 2nd march, 2022 and became well marked. The Well - Marked Low Pressure Area then moved west-northwestwards and concentrated into a Depression and lay centered at 0000 UTC (0530 hrs IST) of 3rd March 2022, over southwest BoB and adjoining equatorial Indian Ocean. It then moved northwestwards and subsequently north-northwestwards and intensified into a deep depression over southwest BoB at 1200 UTC (1730 hrs IST) of 4th March 2022. It moved nearly northwards till 5th morning and then nearly southwestwards, weakened into a Depression and lay centered at 1800 UTC of 4th (2330 hrs IST of 5th March). Continuing to move southwestwards, it weakened into a depression over southwest BoB at 0000 UTC (0530 hrs IST) of 6th March 2022. It further weakened into a well marked low pressure area at 0300 UTC (0830 IST) of 6th March over the same region.

The observed track and best track parameters of the system are presented in Fig. 1a and table 1. The direction and movement of the system is depicted in fig. 1b.

2. The salient features of the system were as follows:

- Considering climatological guidance, 8 cyclonic disturbances developed over NIO with 2 over Arabian Sea and 6 over BoB during 1891-2020. Out of these 1 crossed north Tamil Nadu as a cyclonic storm & other crossed Sri Lanka as a severe cyclonic storm and 6 weakened over sea. Fig.2 shows the cyclonic disturbance developed over NIO and b) cyclonic storms crossing Tamil Nadu coast during March of 1891-2020. Hence, the cyclogenesis is not frequent during March and probability of landfall is very less as per the climatology. Hence, this system exhibited climatological behavior.

- On 24th February, enhanced convective activity leading to formation of cyclonic circulation or a low pressure area was predicted over south Andaman Sea and adjoining southeast BoB around 28th February with westwards movement towards Sri Lanka during later half of the week. Actually, a low pressure area formed over southeast Bay of Bengal (BoB) and adjoining areas of south Andaman Sea & Equatorial Indian Ocean (EIO) on 28th and it concentrated into a depression over southwest & adjoining EIO on 3rd March. Hence, formation of low pressure area and enhanced convective activity over south Andaman Sea was well predicted one week in advance.
- The Velocity Flux, Accumulated Cyclone Energy (a measure of damage potential) and Power Dissipation Index (a measure of loss) were 3.5 X10^2 knots, 9.5 X 10^3 knots2 and 2.6 X10^6 knots3 respectively.
- The track length of the deep depression was 804.77 km.
- The life period (D to D) of the system was 72 hours.

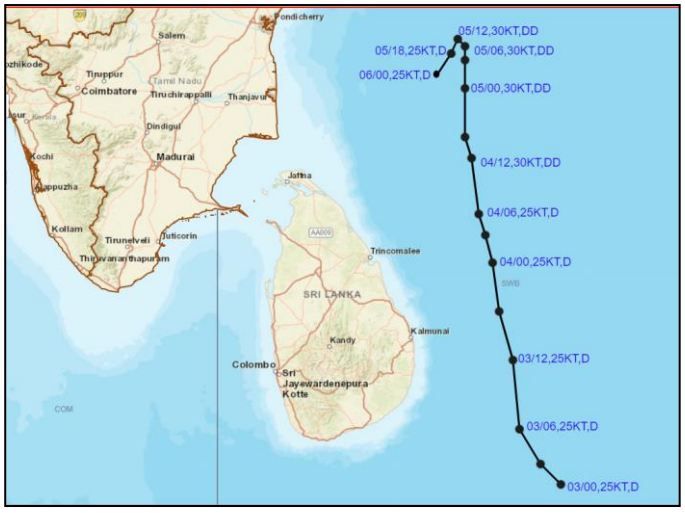


Fig.1a: Observed track of deep depression over Southwest BoB during 3rd -6th March, 2022

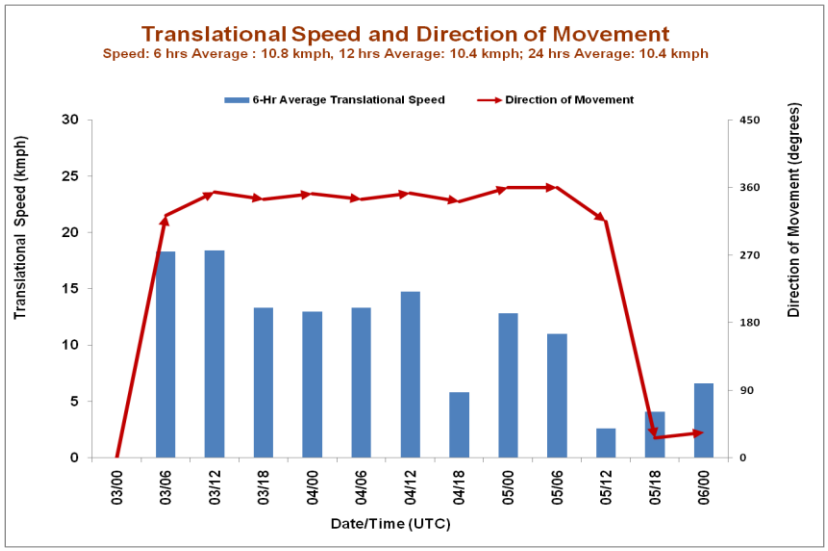


Fig.1b: The direction and movement of deep depression over Southwest BoB during 3rd -6th March, 2022

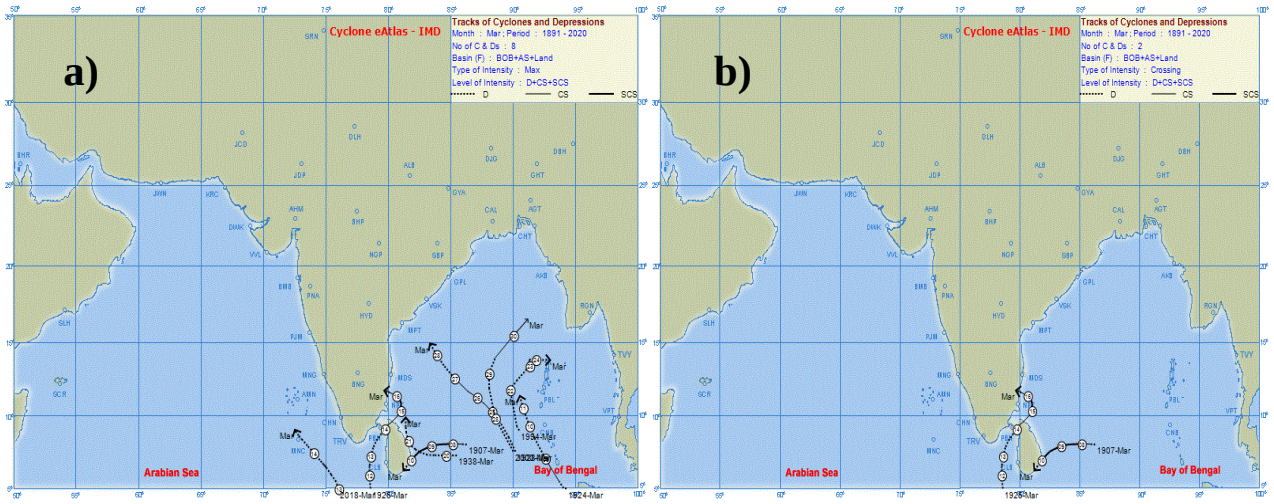


Fig. 2: Track of a) cyclonic disturbance and b) cyclonic storms crossing during March 1891-2020

3. Brief life history

3.1. Genesis

A cyclonic circulation formed over the south Andaman Sea & adjoining Equatorial Indian Ocean (EIO) on 28th Feb. 2022. It concentrated into a low pressure area over southeast Bay of Bengal (BOB) and adjoining areas at 1200 UTC of 28th February. At 0300 UTC of 1st march, 2022, it lay over southeast BoB and adjoining equatorial Indian Ocean (EIO). It became well marked over central parts of south BoB and adjoining EIO on 2nd March morning.

On 3rd March, the sea surface temperature (SST) was around 28^{O}C over south BoB. Tropical Cyclone heat potential (TCHP) was around 60-80 kj/cm2 over the same region. The Madden Julian Oscillation (MJO) index lay in phase 5 with amplitude less than 1. The low level vorticity was around 150 x10^{-6} s^{-1} in the northeast sector. Vertically it extended up to 500 hPa level. The low level convergence was around 20 x10^{-5} s^{-1} to the northeast of system center. The upper-level divergence was around 20 x10^{-5} s^{-1} in the northeast sector. The vertical wind shear (VWS) was moderate to high (20-30 knots). Under these conditions, the well marked low pressure area over central parts of south BoB and adjoining EIO moved west-northwestwards and concentrated into a depression and lay centered at 0000 UTC of the 3rd march 2022, over southwest BoB and adjoining EIO near latitude 5.3°N and longitude 84.0°E.

3.2. Intensification and movement:

The depression over southwest BoB and adjoining EIO moved initially west-northwestwards and then northwestwards on 3rd March and then moved northwards on 4th March under the similar environmental conditions. However, with slight increase in upper-level divergence, it intensified into a deep depression at 1200 UTC of 4th march 2022 and lay centered over southwest BoB at latitude 10.0^{O} N and longitude 82.7^{O} E. The positive low level vorticity (150x10-6s-1), moderate to high VWS (25-30 kts), and favorable upper-level divergence (30 x10^{-5} s^{-1}) helped in maintenance of active convection over the region and intensify. Upper tropospheric ridge ran along latitude 13^{O}N to the north of system area. Hence, east-south-easterly winds persist over the system region in upper tropospheric levels.

The deep depression then moved northwestwards with a speed of 13 kmph till 4th March midnight and then moved northwards till early morning of 5th March and lay centered at 0000 UTC of 5th March 2022 near latitude 11.0^{O} N and 82.6^{O} E. The SST at that time was around 28-29^{O}C over southwest and west-central BoB. TCHP was around 60-80 kj/cm^{2} over the same region. The MJO index lay in phase 5 with amplitude less than 1. Low level vorticity was around 150 x10^{-6} s^{-1} to the south of the system center. Vertically, it was extending up to 500 hPa level. Low level convergence was around 20 x10^{-5} s^{-1} to the south of the system center. Upper-level divergence was about 20 x10^{-5} s^{-1} around the system center. Wind shear decreased and was moderate (10-15 knots) around the system center and increased westwards towards Tamil Nadu coast. Upper tropospheric ridge ran along latitude 13^{o} N. Hence, east south-easterly winds prevailed over the system region at upper troposphere. However, the system moved northward under the influence of middle tropospheric anticyclonic circulation lying to the east of the system center and the system lay in the western periphery of the anti-cyclone.

The deep depression then continued to moved northward with a speed of 14 kmph and lay centered at 1200 UTC of 5th March 2022 near latitude 11.7^{o} N and longitude 82.5^{o} E. The MJO index lay in phase 5 with amplitude less than 1, while the other environmental conditions remained same. The low-level vorticity is decreased to 100 x10^{-6} s^{-1} around the system center. The low-level convergence was around 20 x10^{-5} s^{-1} to the northeast of the system center. Upper-level divergence was decreased and was about 10 x10^{-5} s^{-1} east of the system center. VWS is moderate (15-20 knots) around the system center and increases westwards towards Tamil Nadu coast. There was an anti-cyclonic in mid-tropospheric level over south peninsular India, to the northwest of the system center.

As a result, the deep depression over BoB moved nearly southwestwards with a speed of about 04 kmph and weakened into a depression and lay centered at 1800 UTC of 5th March 2022, over the same region near latitude 11.5°N and longitude 82.4°E. Continuing to move southwest wards, it further weakened into a well-marked low-pressure area over southwest BoB at 0300 UTC of 6th March 2022.

Table 1: Best track positions and other parameters of the Deep Depression over the Bay of Bengal during 3rd -6th March, 2022

Date	Time (UTC)	Centre lat.^{0} N/ long.^{0} E		C.I. NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
03.03.22	0000	5.3	84.0	1.5	1004	25	4	D
	0300	5.6	83.7	1.5	1004	25	4	D
	0600	6.1	83.4	1.5	1004	25	4	D
	1200	7.1	83.3	1.5	1004	25	4	D
	1800	7.8	83.1	1.5	1004	25	4	D
04.03.22	0000	8.5	83.0	1.5	1004	25	4	D
	0300	8.9	82.9	1.5	1003	25	5	D
	0600	9.2	82.8	1.5	1003	25	5	D
	1200	10.0	82.7	2.0	1002	30	6	DD
	1800	10.3	82.6	2.0	1002	30	6	DD
05.03.22	0000	11.0	82.6	2.0	1002	30	6	DD
	0300	11.4	82.6	2.0	1002	30	6	DD
	0600	11.6	82.6	2.0	1002	30	6	DD
	1200	11.7	82.5	2.0	1002	30	6	DD
	1800	11.5	82.4	1.5	1003	25	5	D
06.03.22	0000	11.2	82.2	1.5	1004	25	4	D
	0300	Weakened into a Well-Marked Low Pressure Area over Southwest Bay of Bengal						

Knots: kt, 1 kt = 1.85 kmph, Time in IST= Time in UTC + 0530 hrs

4. Monitoring through satellite and radar:

India Meteorological Department (IMD) maintained round the clock watch over the NIO and the system was monitored since 2nd September, about 9 days prior to the formation of LPA over east-central & adjoining northeast BoB on 11th and 10 days prior to formation of depression on 12th. The cyclone was monitored with the help of available satellite observations from INSAT 3D and 3DR, polar orbiting satellites and available ships & buoy observations in the region. The system was also monitored by Doppler Weather

RADAR (DWR) Paradip (Odisha). 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.

4.1 Detailed feature observed through Satellites:

Typical INSAT-3D IR, visible, enhanced colored and cloud top brightness temperature imageries during life cycle of the system are presented in Fig. 3. As per INSAT 3D imagery at 0300 UTC, the 27th February 2022, Scattered to broken low and medium clouds with embedded intense to very intense convection lay over southeast BoB south of latitude 10.0^{o}N, south Andaman sea and strait of Malacca. Minimum Cloud Top Temperature was minus 75^{o}C. As per INSAT-3D imagery at 0300 UTC, the 01st March 2022, scattered to broken low and medium clouds with embedded intense to very intense convection lay over south BOB, south of latitude 11.0^{o}N & adjoining EIO and Andaman Sea. Minimum Cloud Top Temperature is minus 93^{o} C.

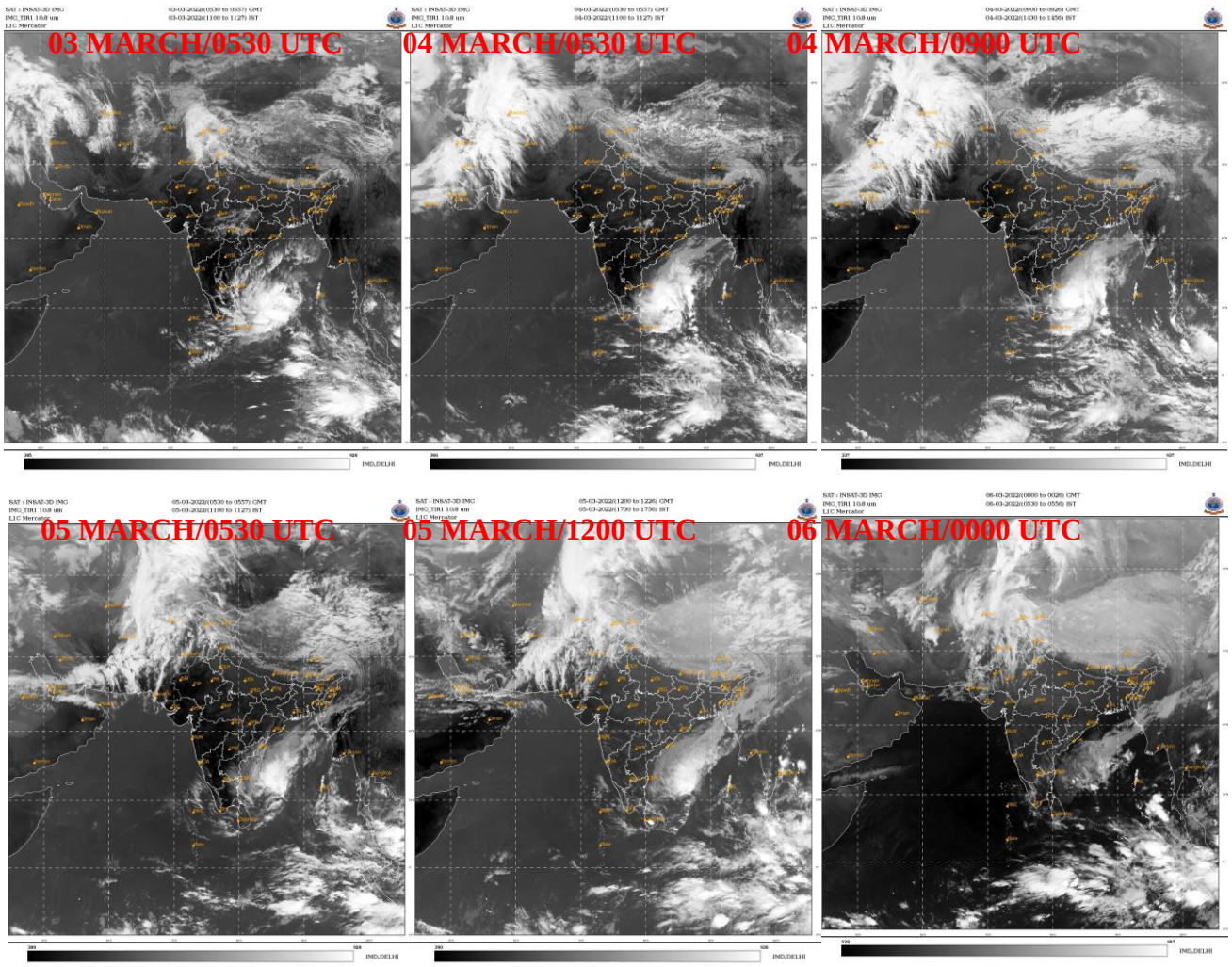


Fig. 3(i): INSAT-3D Visible imageries during 3rd -6th March, 2022

As per INSAT-3D imagery at 0300 UTC of 3rd March, associated broken low and medium clouds with embedded intense to very intense convection lay over area between lat 5.0°N to 12.0°N and long 80.0°E to 91.0°E & Sri Lanka. Minimum Cloud Top Temperature is minus 93°C. Convection is more in the northern sector of the system. As per INSAT-3D imagery at 1200 UTC of 04.03.2022, Associated broken low and medium clouds with embedded intense to very intense convection lay over area between lat 6.0°N & 16.5°N and long 80°E to 88.5°E & Sri Lanka. The minimum CTT was minus 93° C.

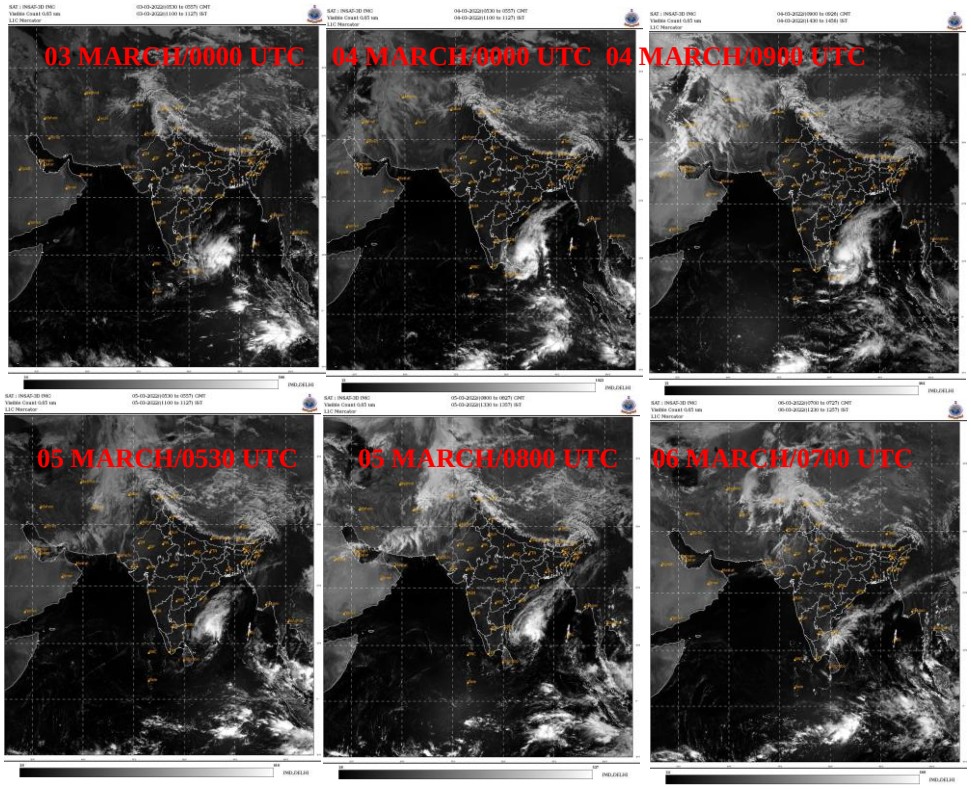


Fig. 3(ii): INSAT-3D IR imageries during 3rd -6th March, 2022

As per INSAT-3D imagery at 1800 UTC of 05th March 2022, intense convective cloud mass has sheared to the northeast of the system centre. Intensity of this convection has also decreased marginally in previous 3 hrs. Associated broken low/med clouds with embedded intense to very intense convection lay over area between lat 10.5° N & 16.5° N and long 82°E to 90.0°E. Minimum Cloud Top Temperature is minus 93 Deg C. Intense convection lies over northeast sector of the system center. As per INSAT-3D imagery at 0300 UTC of 06th March 2022, Low level circulation centre was clearly exposed in visible imagery. However, the convection became further disorganized. The system continued to move in south-west direction. Associated scattered low and medium clouds with embedded moderate to intense convection lay over southwest BoB & neighbourhood. Minimum Cloud Top Temperature is minus 93°C.

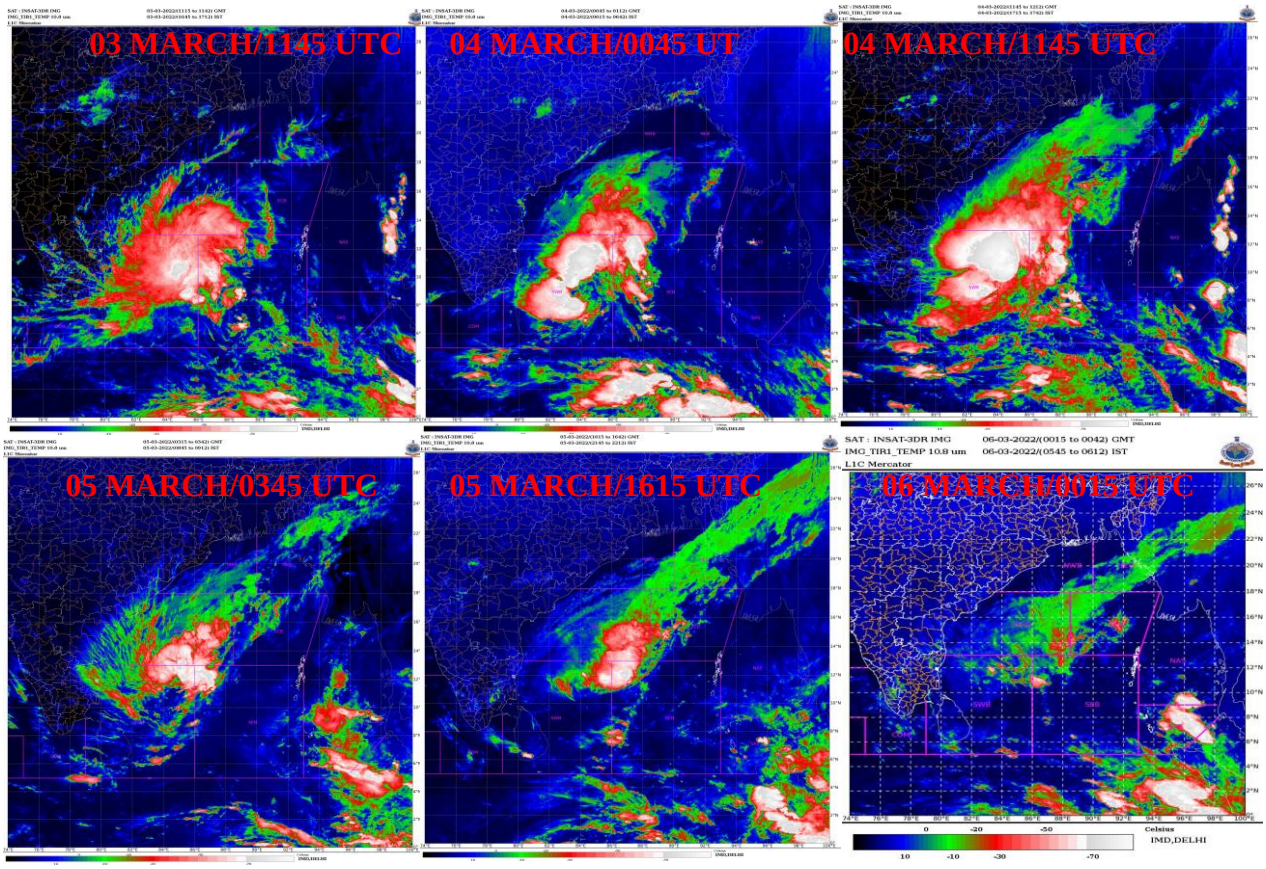


Fig. 3(iii): INSAT-3D NHC imageries during 3rd -6th March, 2022

The total perceptible water (TPW) imagery during 03-06 March 2022 is provided in Fig. 4. From the figure, TPW indicates warmer advection into the system centre during genesis and intensification phase.

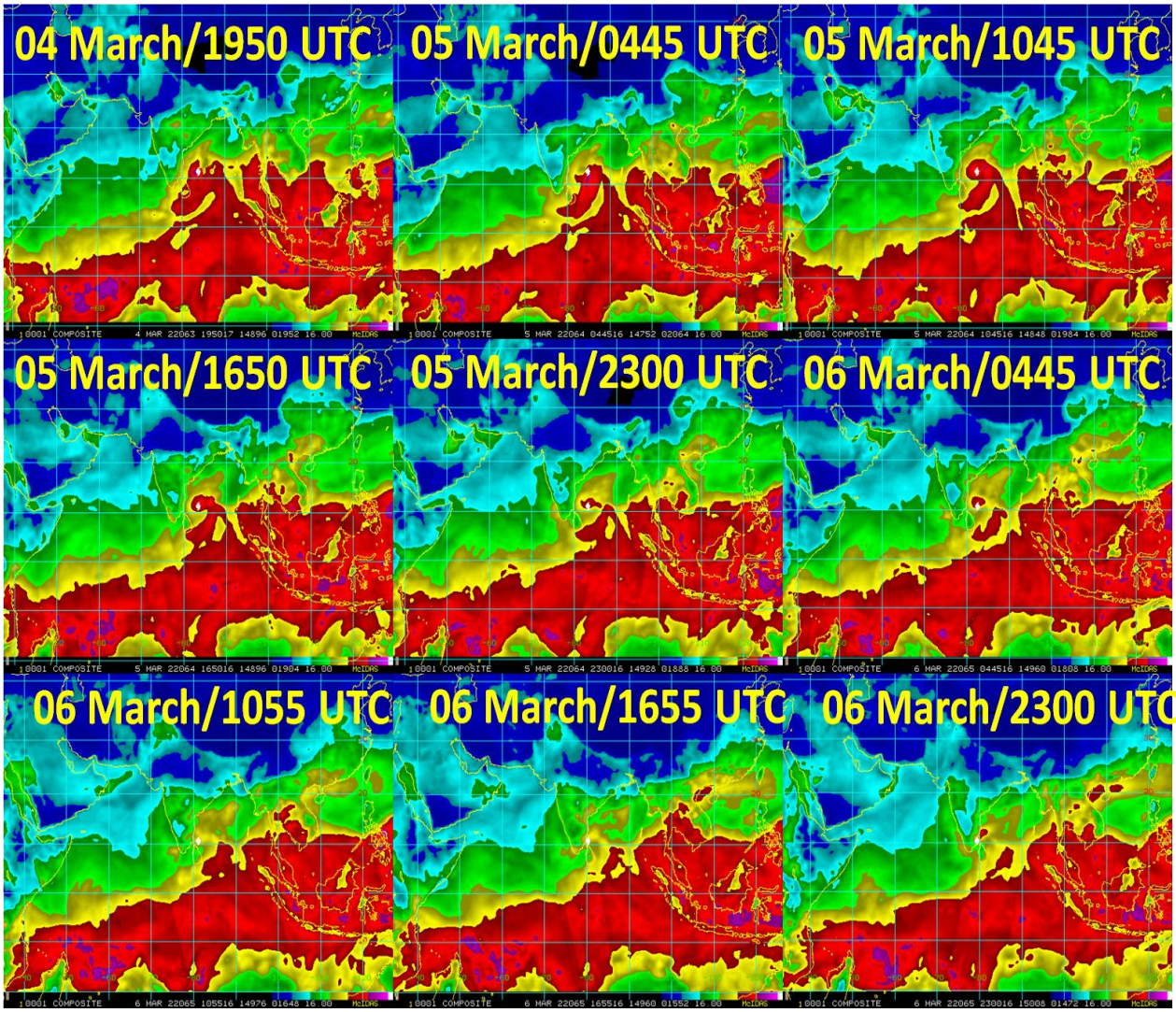


Fig 4:TPW imageries with respect to Deep Depression over the southwest Bay of Bengal and adjoining Equatorial Indian Ocean during 03 March- 06 March, 2022

The SCATSAT (METOP-B) imageries during 03-06 March 2022 is provided in fg.5. These SCAT imageries indicate stronger wind in the northern sector of the system. These winds were in agreement with the intensity of the system.

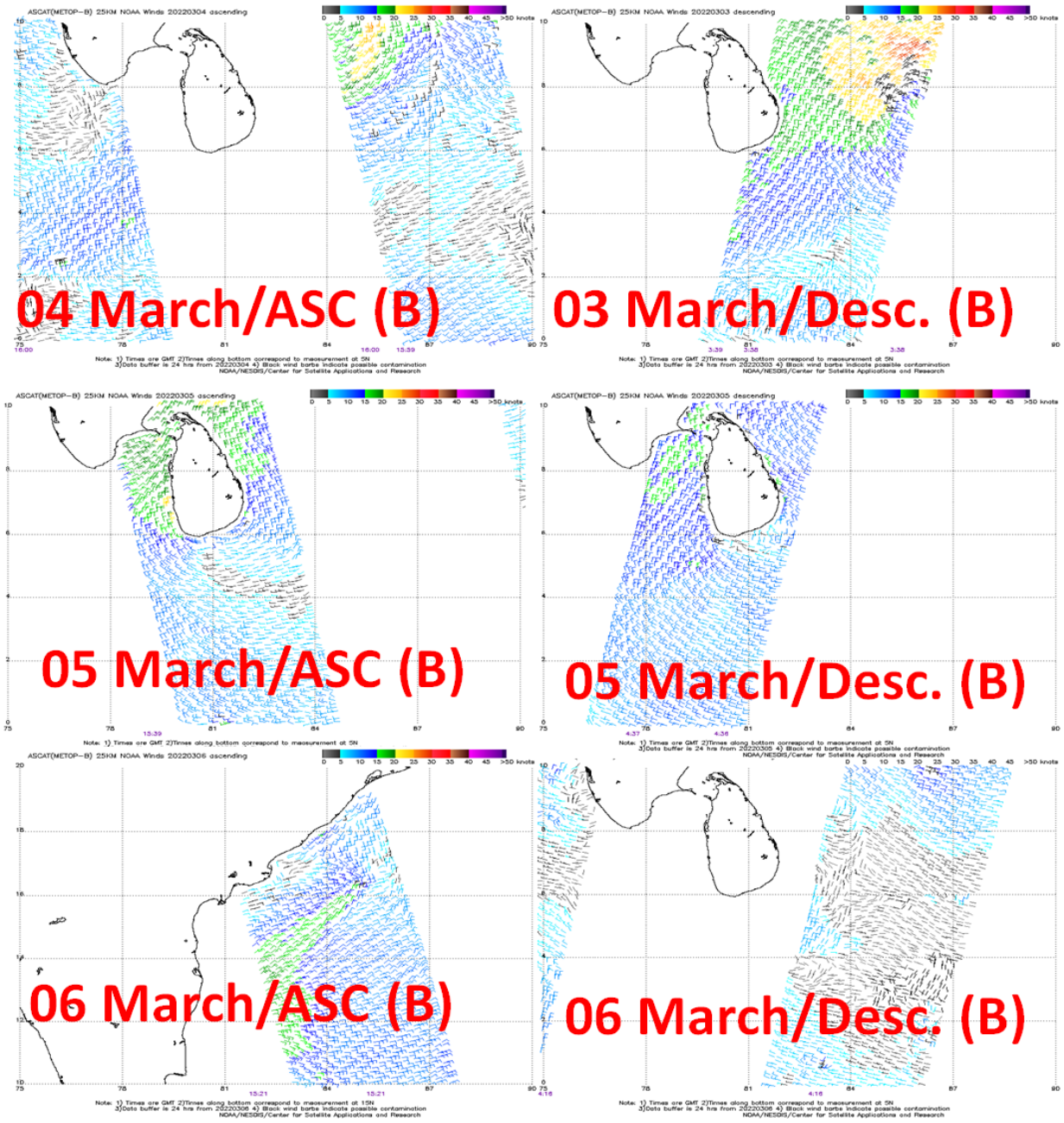


Fig 5: SCATSAT (METOP-B) imageries with respect to Deep Depression over the southwest Bay of Bengal and adjoining Equatorial Indian Ocean during 03 March- 06 March, 2022

5. Dynamical features

IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10 m, 850, 500 and 200 hPa levels are presented in Fig.6. The analysis field of IMD GFS at 0000 UTC of 03rd March indicated a depression over central part of south BoB with vertical extension upto 500 hPa level. East-southeasterly winds prevailed in the upper level indicating west-northwestwards movement.

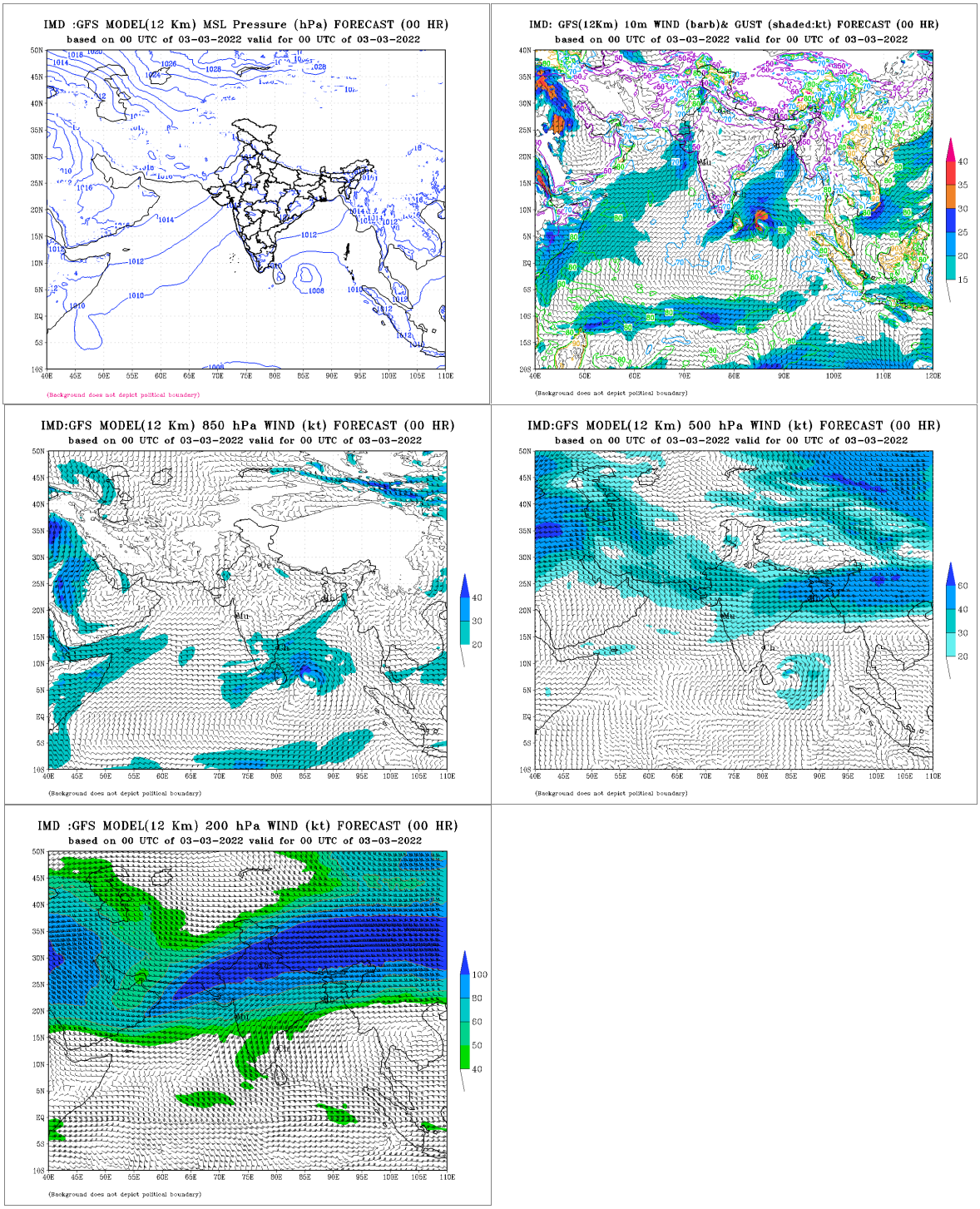


Fig 6 (i): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 3rd March 2022

The analysis field of IMD GFS at 0000 UTC of 4th March indicated depression over southwest BoB with vertical extension upto 500 hPa level. However, GFS reasonably estimated the intensity at 0000 UTC of 4th March.

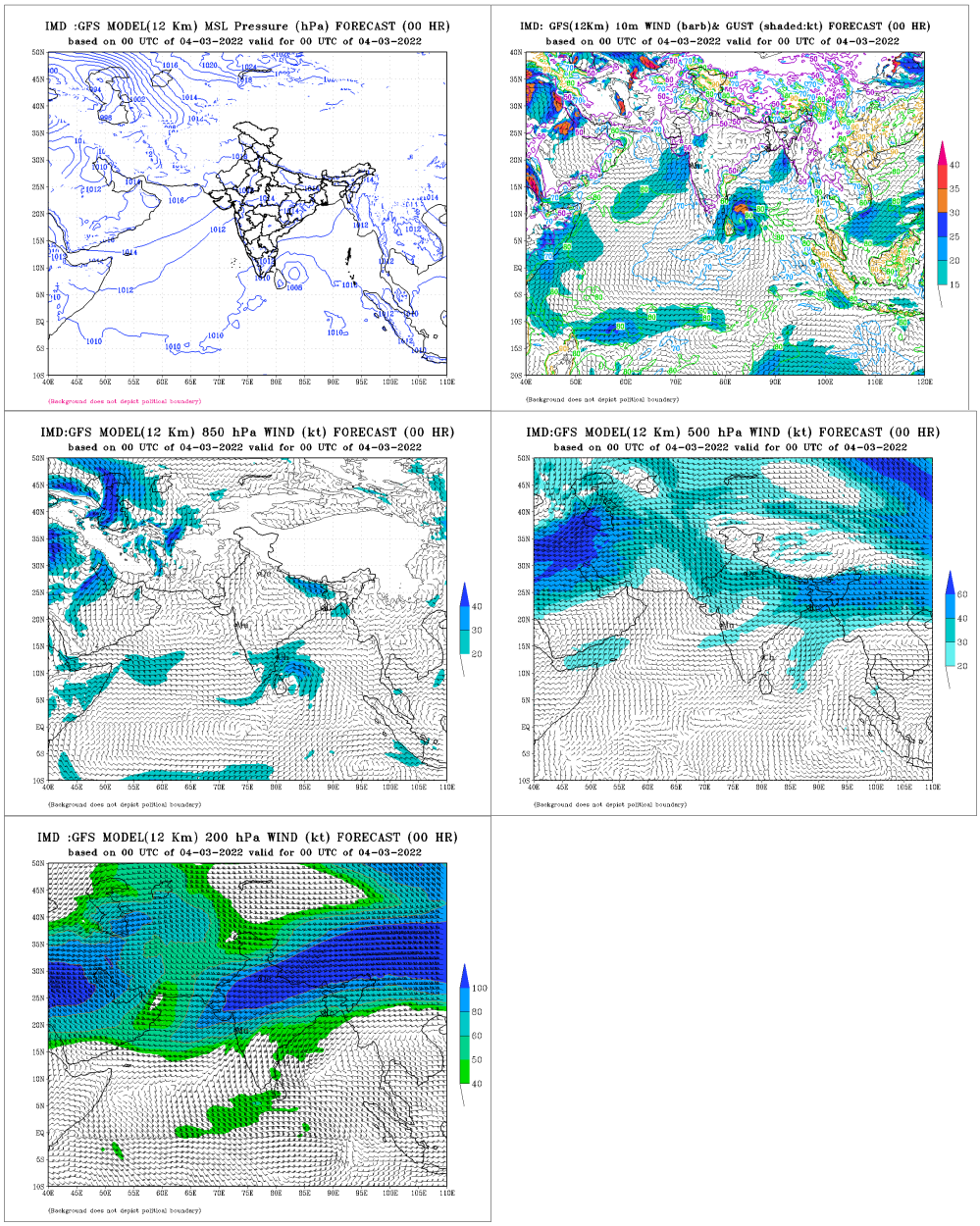


Fig 6 (ii): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 4th March 2022

The analysis field of IMD GFS at 0000 UTC of 5th March indicated intensification of the system into a cyclonic storm against the actual intensity of deep depression, thus overestimating the intensity.

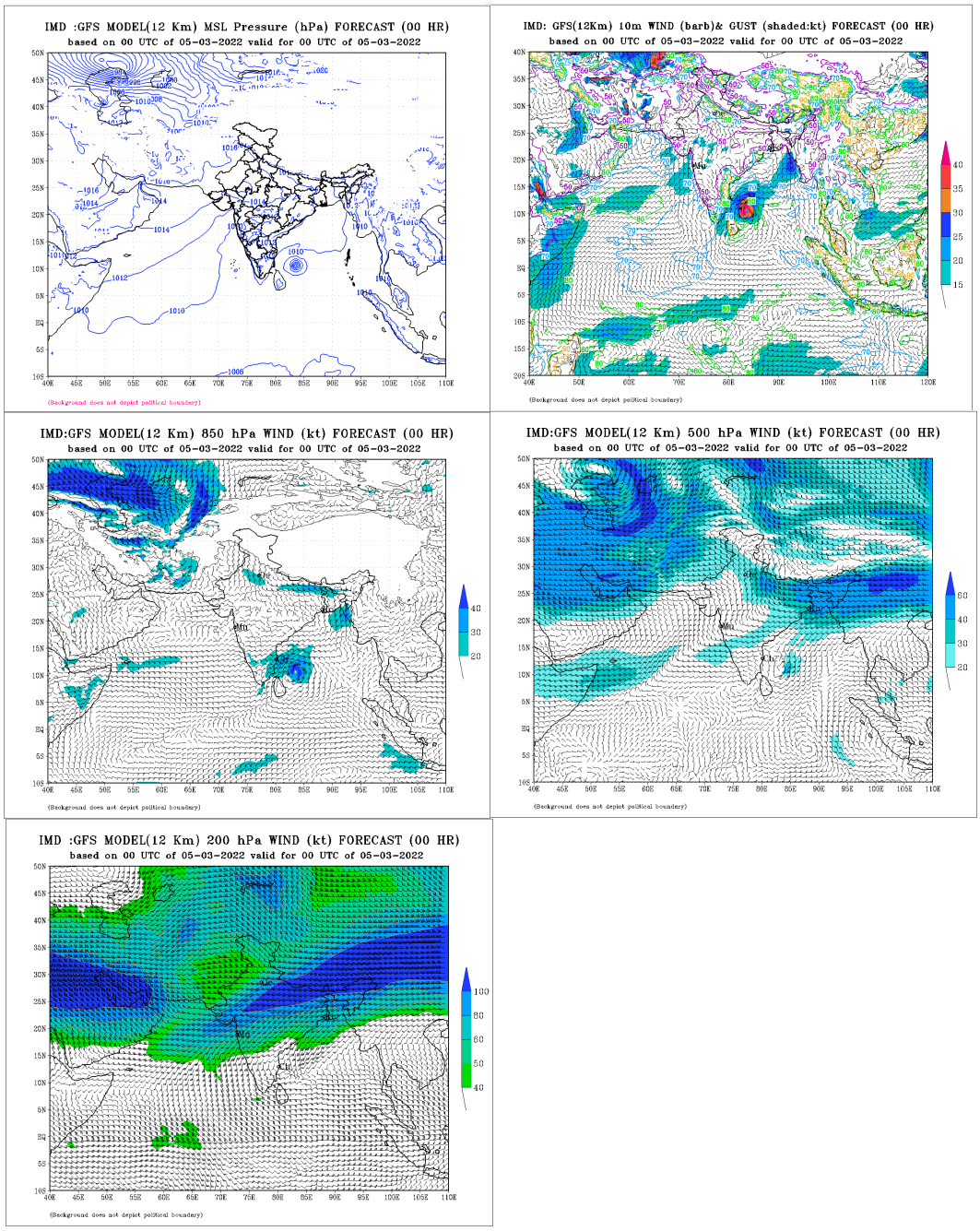


Fig 6 (iii): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 5th March 2022

The analysis field of IMD GFS at 0000 UTC of 6th March indicated weakening of the system into a depression against the actual intensity of well marked low at 0300 UTC of 6th March.

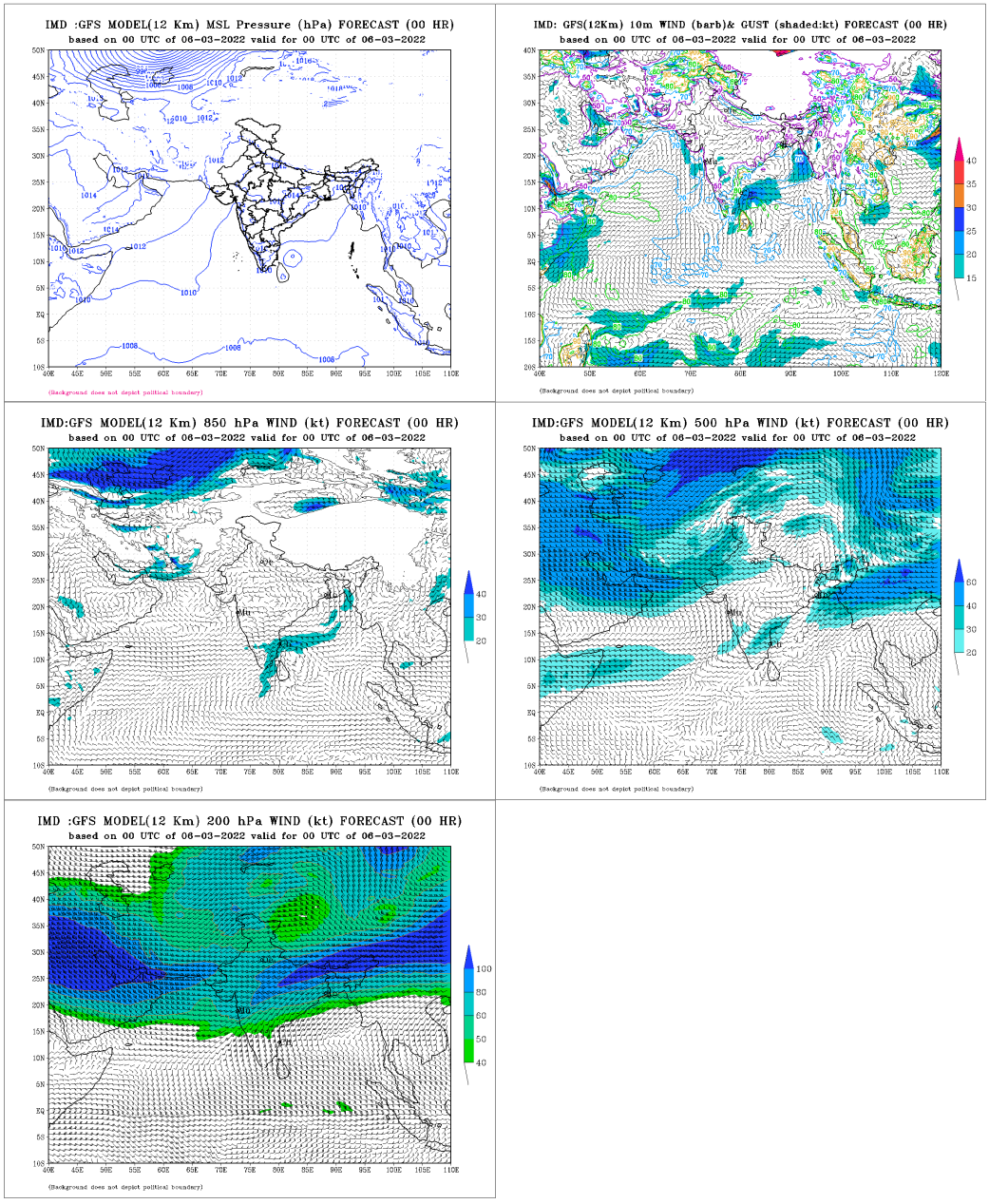


Fig 6 (iv): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 6th March 2022

Thus, IMD GFS could capture the genesis and movement correctly. However, it over estimated the intensity of the system.

6. Realized Weather:

6.1 Rainfall:

Under the influence of deep depression, rainfall occurred mainly over the sea area throughout the life period. However widespread rainfall with isolated heavy rainfall occurred over eastern Sri Lanka on 3rd and 4th and light to moderate rainfall over east coastal Sri Lanka on 5th March. Light to moderate rainfall occurred over Tamil Nadu and Puducherry on 4th and 5th March. Daily rainfall distribution based on merged grided rainfall data of IMD/NCMRWF during 03 March - 06 March, 2022 is shown in fig.7 and 24 hr cumulative rainfall distribution recorded over different stations of IMD during 03 March- 06 March, 2022 is shown in fig.8.

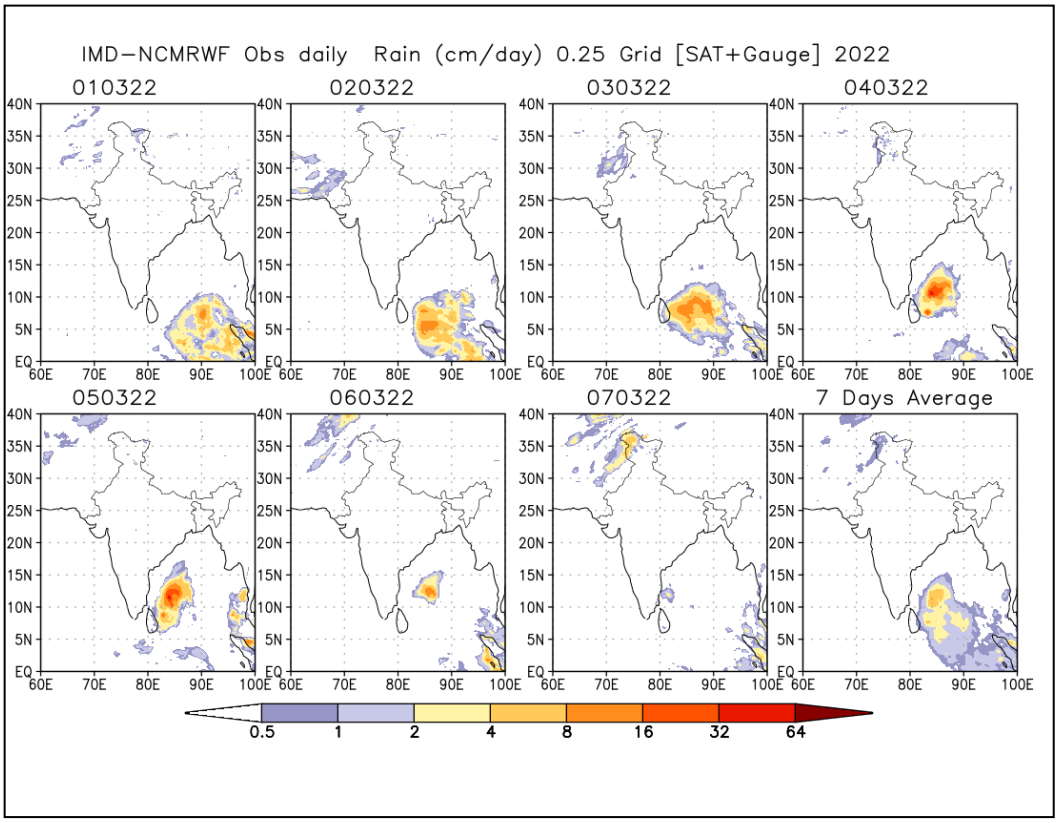


Fig 7: Daily rainfall distribution based on merged grided rainfall data of IMD/NCMRWF during 03 March- 06 March, 2022

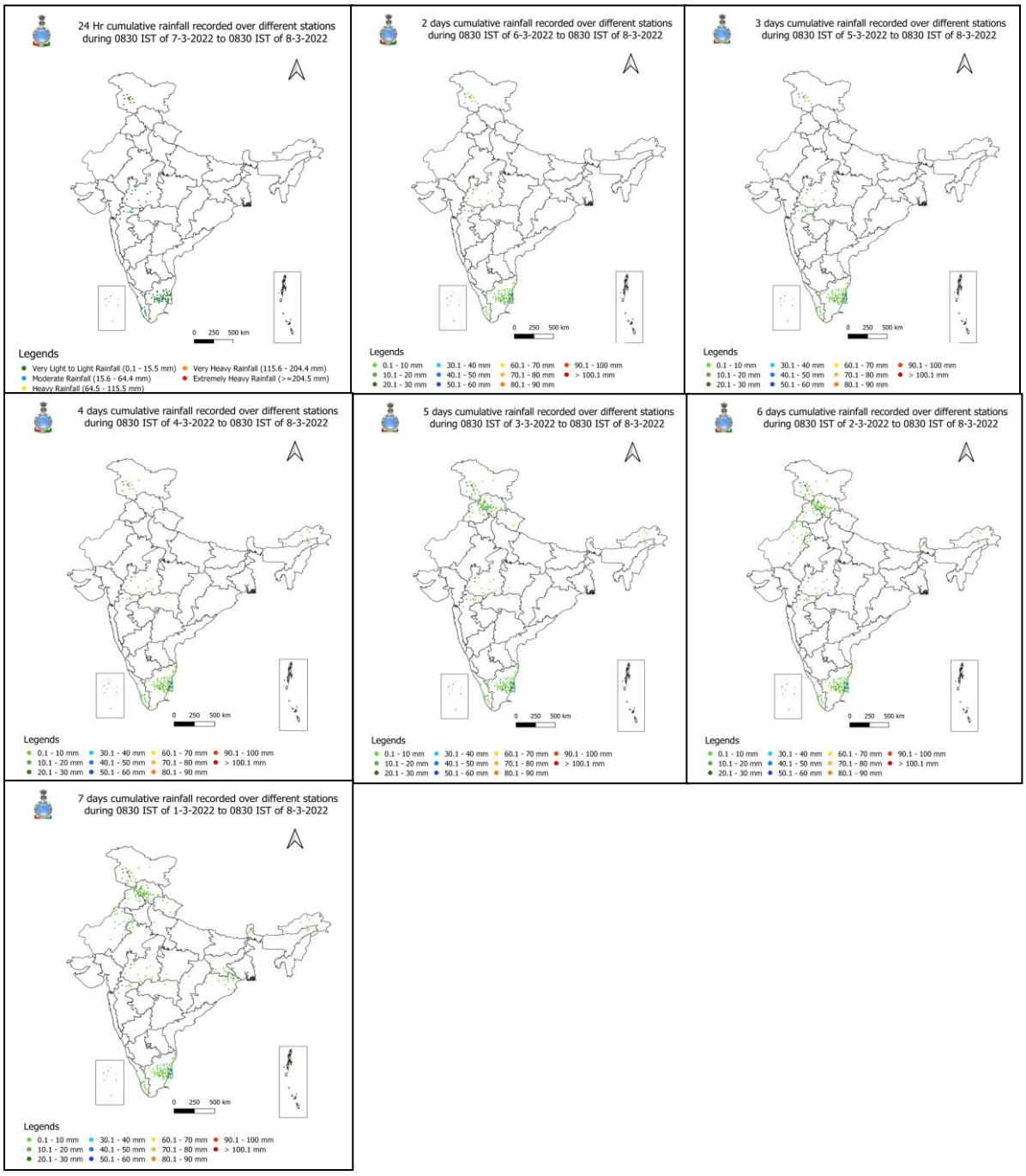


Fig 8: 24 hr cumulative rainfall distribution recorded over different stations of IMD during 03 March- 06 March, 2022

7. Performance of NWP models

7.1 Track prediction

The track forecast errors by the models and the operational track forecast errors are shown in fig. 9.

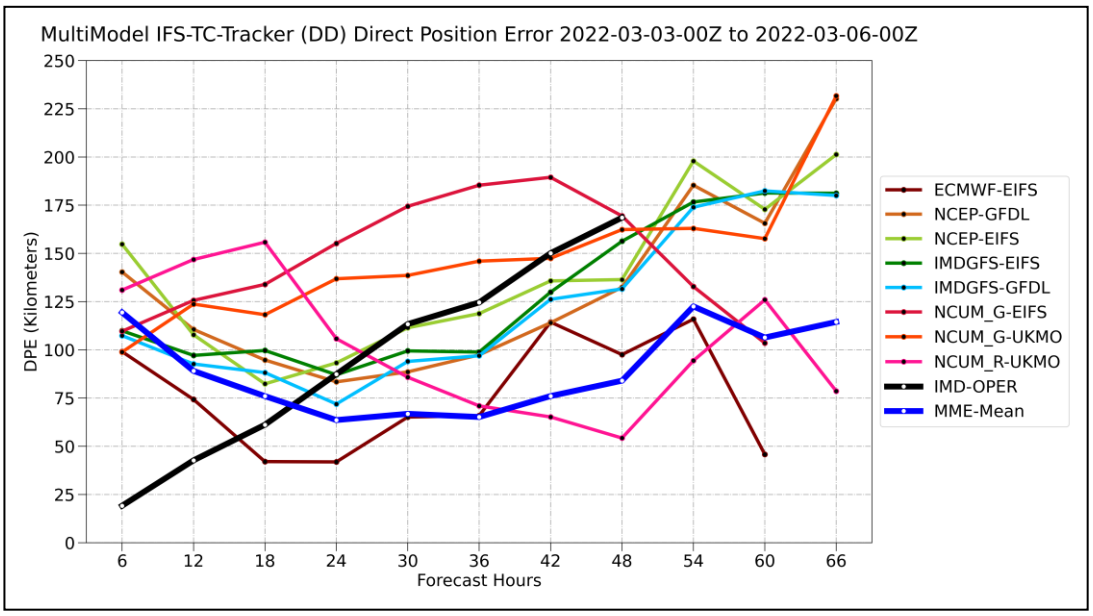


Fig 9: Track forecast errors by the models and the operational track forecast errors in case of Deep Depression (3-6 March 2022).

Fig. 10 shows ensemble tracks and strike probability of DD passing through 65nm along with IMD tracks, GFS(control i.e. AC00), ensemble mean (AEMN) based on different initial conditions such as 00UTC 3 March, 00UTC 4March and 00UTC 05 March. Initially with 00UTC 3March IC, both GFS wasn't able to track the system, whereas GEFS was showing high probability of crossing the east coast of India. But from 12UTC 3March the tracks are very well predicted by both models.The strike probabilty(probabilty of storm passing with 65nm) is more than 50% around the observed track.

7.2 Intensity Prediction:

Fig 11 Show the intensity forecast in terms of Maximum sustained wind speed (MSW) in knots at various initial conditions. For most of the ICs, intensity is overestimated by both models.

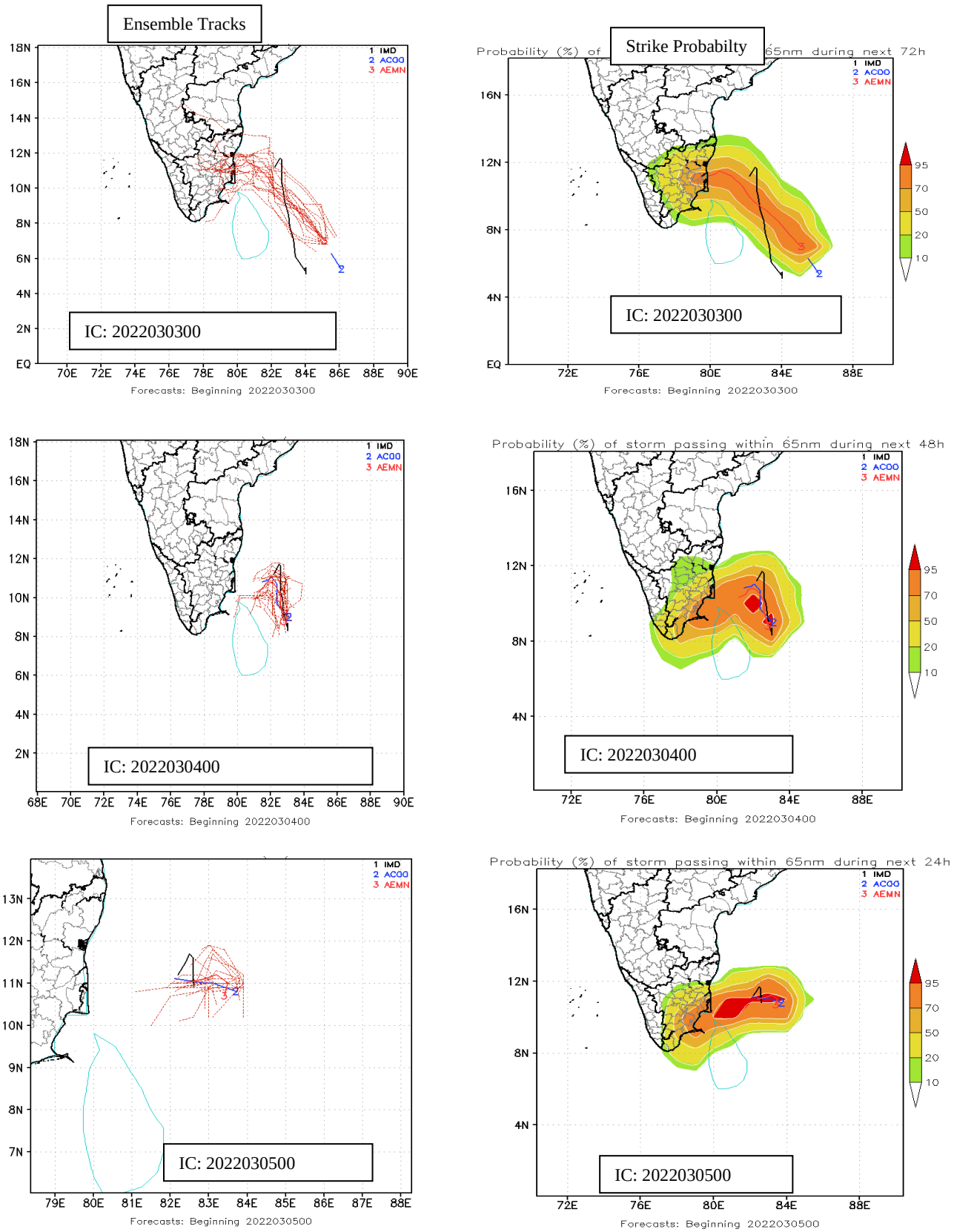


Fig 10: Left Panel: GEFS Ensemble Tracks for ICs : 2022030300, 2022030400 and 2022030500 respectively. Right Pannel: Strike Probability (Probability of storm passing within 65nm) for ICs: 2022030300, 2022030400 and 2022030500 respectively.

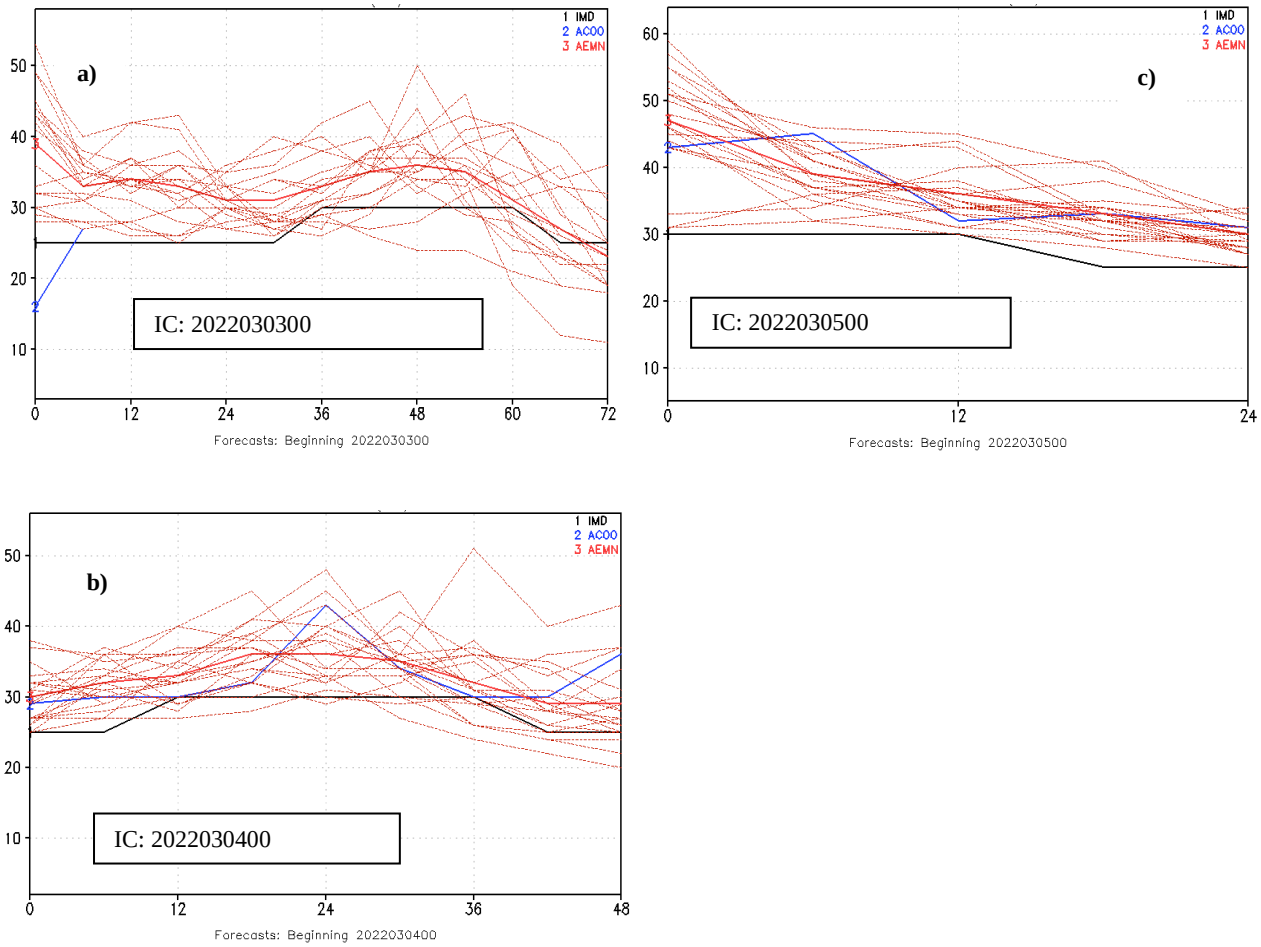


Fig 11: Intensity in terms of Maximum Sustained Wind Speed (MSW) in knots based on ICs a) 2022030300, b) 2022030400 and c) 2022030500 respectively.

The average track forecast errors (Direct Position Error) in km at different lead period (hrs) for GEFS (Control (CNTL) and Ensemble mean (ENS_MEAN) models are presented in Table 2.1. The Track error is less in ENS_MEAN than control. The tracks errors for 48hrs for CNTL and ENS_MEAN are lower than 150km. Table 2.2 represents intensity forecast errors of maximum sustained wind in knots. The CNTL and ENS_MEAN both overestimate the intensity of cyclone throughout its life period. Root Mean Square (RMSE) errors of maximum sustained wind (kts) and of track (km) from GEFS model are given in Table 2.3 and Table 2.4 respectively. Table 2.5 represents the Average Absolute errors (AAE) of wind for control and ensemble mean. RMSE and AAE for wind are found to be almost same in both the models.

Table 2.1. Average track forecast errors (Direct Position Error (DPE)) in km (Number of forecasts verified is given in the parentheses)

Lead Time	12H	24H	36H	48H	60H
CNTL	61(5)	61(4)	89(3)	133(2)	187(1)
ENS_MEAN	77(6)	79(5)	112(4)	147(3)	187(2)

Table 2.2. Average Intensity Forecast Errors of maximum sustained wind in knots (Number of forecasts verified is given in the parentheses). Negative sign indicates underestimation of intensity and vice versa

Lead Time	12H	24H	36H	48H	60H
CNTL	4(5)	7(4)	5(3)	4(2)	-1(1)
ENS_MEAN	6(6)	5(5)	3(4)	5(3)	3(2)

Table 2.3. Root Mean Square (RMSE) errors of maximum sustained wind in knots of CNTL and ENS_MEAN from GEFS model (Number of forecasts verified is given in the parentheses)

Lead Time	12H	24H	36H	48H	60H
CNTL	7(5)	8(4)	7(3)	8(2)	1(1)
ENS_MEAN	7(6)	5(5)	4(4)	5(3)	3(2)

Table 2.4. Root Mean Square (RMSE) errors of track in km of CNTL and ENS_MEAN from GEFS model (Number of forecasts verified is given in the parentheses)

Lead Time	12H	24H	36H	48H	60H
CNTL	67(5)	71(4)	89(3)	140(2)	187(1)
ENS_MEAN	90(6)	87(5)	114(4)	147(3)	190(2)

Table 2.5 Average absolute errors (AAE) of maximum sustained wind in kts of CNTL and ENS_MEAN from GEFS model (Number of forecasts verified is given in the parentheses)

Lead Time	12H	24H	36H	48H	60H
CNTL	4(5)	7(4)	5(3)	7(2)	1(1)
ENS_MEAN	6(6)	5(5)	3(4)	5(3)	3(2)

8. Operational Forecast Performance

8.1. Genesis, track, landfall and intensity forecast performance:

On 24th February, enhanced convective activity leading to formation of cyclonic circulation or a low pressure area was predicted over south Andaman Sea and adjoining southeast BoB around 28th February with westwards movement towards Sri Lanka during later half of the week. Actually, a low pressure area formed over southeast Bay of Bengal (BoB) and adjoining areas of south Andaman Sea & Equatorial Indian Ocean (EIO) on 28th and it concentrated into a depression over southwest & adjoining EIO on 3rd March. Hence, formation of low pressure area and enhanced convective activity over south Andaman Sea was well predicted one week in advance.

The operational track forecast error is given in Table 3. The error was about 91 km.

Table 3. Operational track forecast error of the Deep Depression (3-6 March 2022)

Lead Period	N	Operational Track forecast error	Operational Track Forecast Skill
12	11	48.1	50.9
24	9	91.4	60.4
36	7	130.1	69.7
48	5	187.0	72.1

9. Bulletins issued by IMD

IMD continuously monitored the BoB region and issued warnings to all concerned at central and state level since 24th February, 2022. Regular bulletins were issued including 16 national bulletins, 16 RSMC bulletins to WMO/ESCAP Panel member countries, regular Press Release, six hourly SMS to coastal population including fishermen and farmers were issued. Warnings and advisories for fishermen were issued since 16th September. Frequent updates on social networking sites were also issued with the formation of low pressure area. Regular bulletins were issued at National level by Cyclone Warning Division and at State level by concerned Meteorological Centres of IMD for the states of Odisha, Tamil Nadu , Puducherry ,Andhra Pradesh, West Bengal, Kerala & Andaman & Nicobar. IMD issued regular warning bulletins to the concerned central and state disaster management authorities and press & media. Bulletins issued by Cyclone Warning Division of IMD in association with the system are given in Table 4.

Table 4: Bulletins issued by Cyclone Warning Division, IMD, New Delhi

S. No.	Bulletins	No. of Bulletins	Issued to
1	National Bulletin	16	1. IMD's website 2. FAX and e-mail to Control Room NDM, Ministry of Home affairs, Control Room NDMA, Cabinet Secretariat, Minister of Sc. & Tech, Secretary MoES, DST, HQ Integrated Defence Staff, DG Doordarshan, All India Radio, DG-NDRF, Director Indian Railways, Indian Navy, IAF, Administrator, Andaman & Nicobar Islands, Chief Secretary: Odisha, Tamil Nadu , Puducherry ,Andhra Pradesh, West Bengal, Kerala
2	RSMC Bulletin	16	1. IMD's website 2. All WMO/ESCAP member countries through GTS

			and E-mail. 3. Indian Navy, IAF by E-mail
3	Press Release	5	1. Disaster Managers, Media persons by email and uploaded on website
4	Facebook /Twitter	Frequently	Highlights uploaded on facebook/twitter since formation of low pressure area.
5	SMS	Frequently	Sent to general public and fishermen and farmers

10. Summary and Conclusions:

A cyclonic circulation formed over the south Andaman sea & adjoining Equatorial Indian Ocean (EIO) concentrated into a low pressure area over southeast Bay of Bengal (BOB) and adjoining areas at 1200 UTC of 28 February, 2022. At 0300 UTC of 1st March, 2022, it lay over southeast BoB and adjoining EIO and over central parts of south BOB and adjoining EIO at 0300 UTC 2nd march, 2022 and became well marked. The Well - Marked Low Pressure Area then moved west-northwestwards and concentrated into a Depression and lay centered at 0000 UTC (0530 hrs IST) of 3rd March 2022, over southwest BoB and adjoining equatorial Indian Ocean. It then moved northwestwards and subsequently north-northwestwards and intensified into a deep depression over southwest BoB at 1200 UTC (1730 hrs IST) of 4th March 2022. It moved nearly northwasrds till 5th morning and then nearly southwestwards, weakened into a Depression and lay centered at 1800 UTC of 4th (2330 hrs IST of 5th March). Continuing to move southwestwards, it weakened into a depression over southwest BoB at 0000 UTC (0530 hrs IST) of 6th March 2022. It further weakened into a well marked low pressure area at 0300 UTC (0830 IST) of 6th March over the same region. It was monitored and predicted well in advance with reasonable accuracy and warnings were issued regularly. There was no damage over land area as it did not cross the coast and dissipated over the Sea.

11. Acknowledgements:

India Meteorological Department (IMD) and RSMC New Delhi duly acknowledge the contribution from all the stake holders and disaster management agencies who contributed to the successful monitoring, prediction and early warning service of system. We acknowledge the contribution of all sister organisations of Ministry of Earth Sciences including National Centre for Medium Range Weather Forecasting Centre (NCMRWF), Indian National Centre for Ocean Information Services (INCOIS), National Institute of Ocean Technology (NIOT), Indian Institute of Tropical Meteorology (IITM) Pune, research institutes including Indian Space Research Organisation for their valuable support. The support from various Divisions/Sections of IMD including Area Cyclone Warning Centre (ACWC) Chennai, Kolkata, Cyclone Warning Centre (CWC) Bhubaneswar, Visakhapatnam, The contribution from Numerical Weather Prediction Division, Satellite and Radar Division, Surface & Upper air instruments Divisions, New Delhi and Information System and Services Division at IMD is also duly acknowledged.