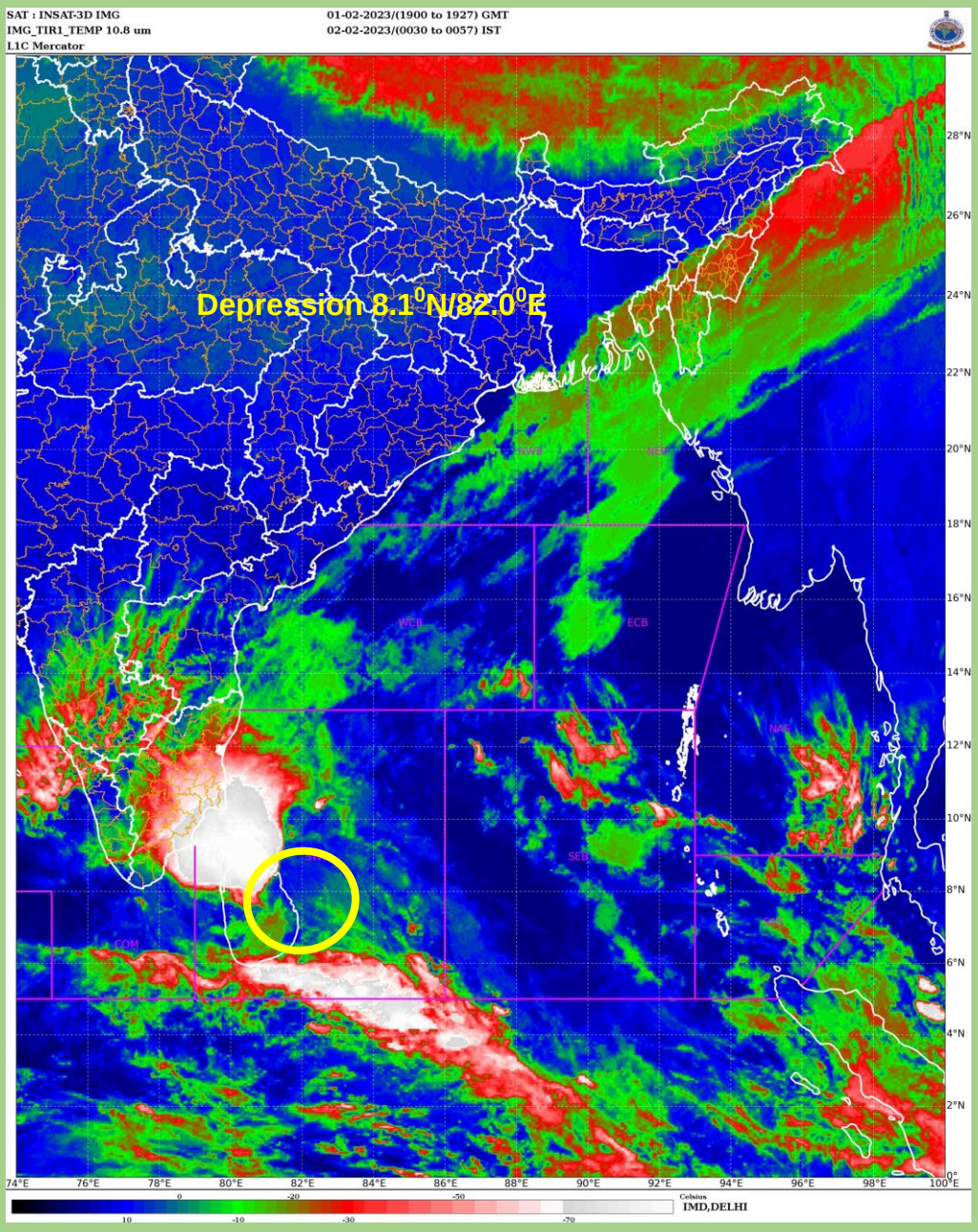
GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
INDIA METEOROLOGICAL DEPARTMENT

Depression over southeast & adjoining southwest Bay of Bengal (30th January – 02nd February 2023): A Report



INSAT-3D Satellite imagery of Depression over Southwest Bay of Bengal at 1800 UTC of 1st February, 2023

Cyclone Warning Division

India Meteorological Department

Depression over Southeast & adjoining Southwest Bay of Bengal during 30th January- 2nd February, 2023

1. Introduction

- A cyclonic circulation developed over East Equatorial Indian Ocean (EEIO) and adjoining southeast Bay of Bengal (BoB) in the forenoon (0830 hrs IST/0300 UTC) of 25th January, 2023.
- It lay as a low pressure area over the same region in the morning (0530 hrs IST/ 0000 UTC) of 27th January, 2023 and as a well marked low pressure area (WML) over southeast BoB and adjoining EEIO in the forenoon (0830 hrs IST/0300 UTC) of 29th January, 2023.
- Under favourable environmental conditions, it concentrated into a depression over southeast and adjoining southwest BoB in the forenoon (0830 hrs IST/ 0300 UTC) of 30th January, 2023.
- It moved west-northwestwards till noon (1130 hrs IST/0600 UTC) of 31st January. Thereafter, it recurved southwestwards and crossed Sri Lanka coast between Batticaloa and Trincomalee near latitude 7.8°N and longitude 81.6°E during 0330 to 0430 hrs IST of 2nd February, 2023 (between 2200 & 2300 UTC of 1st February).
- Continuing to move further southwestwards, it weakened into a well marked low pressure area over Comorin and adjoining Gulf of Mannar and west coast of Sri Lanka during midnight (around 2330 hrs IST/1800 UTC) of 2nd February, 2023.
- The observed track of the system (depression to depression) is presented in Fig. 1

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

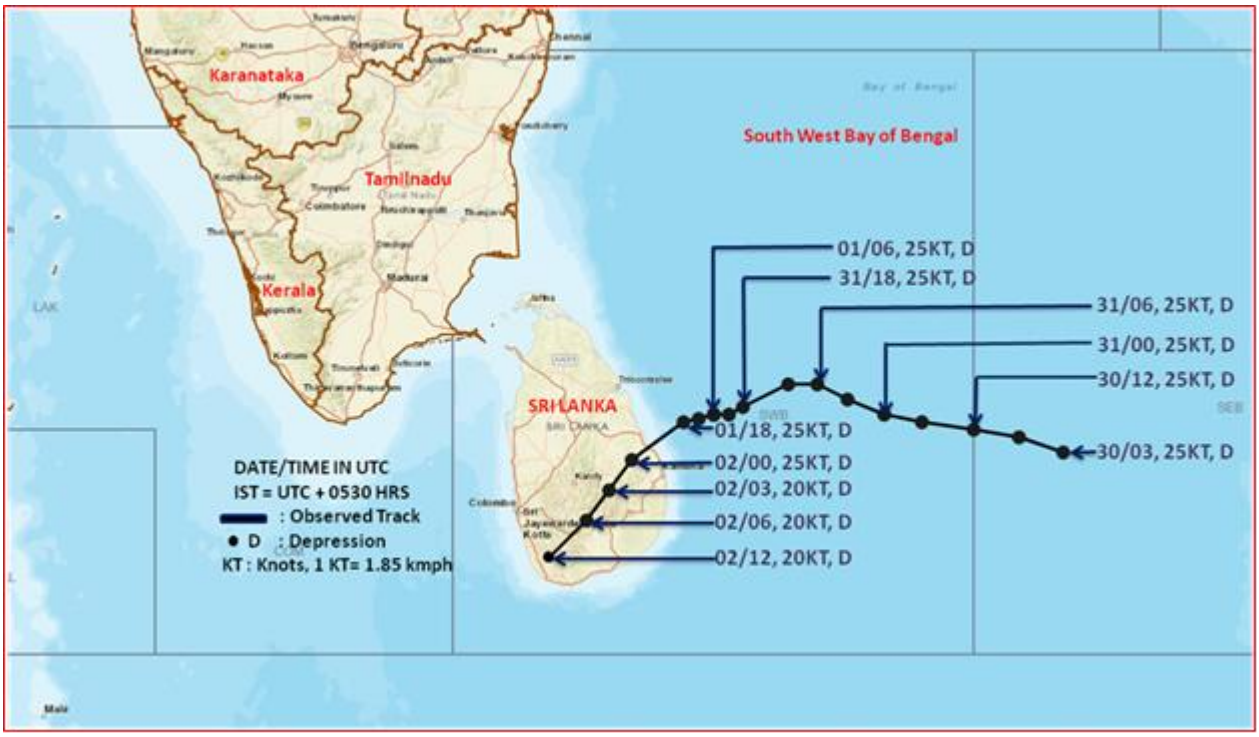


Fig. 1: Observed track of Depression over Southwest Bay of Bengal during 30 January - 02 February, 2023

Table1: Best track positions and other parameters of the Depression over Southwest Bay of Bengal during 30 January - 02 February, 2023.

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
30.01.23	0300	7.7	87.2	1.5	1004	25	4	D
	0600	7.9	86.6	1.5	1004	25	4	D
	1200	8.0	86.0	1.5	1004	25	4	D
	1800	8.1	85.3	1.5	1004	25	4	D
31.01.23	0000	8.2	84.8	1.5	1004	25	4	D
	0300	8.4	84.3	1.5	1004	25	4	D
	0600	8.6	83.9	1.5	1004	25	4	D
	1200	8.6	83.5	1.5	1004	25	4	D
	1800	8.3	82.9	1.5	1004	25	4	D
01.02.23	0000	8.2	82.7	1.5	1004	25	4	D
	0300	8.2	82.5	1.5	1004	25	4	D
	0600	8.2	82.5	1.5	1004	25	4	D
	1200	8.2	82.3	1.5	1004	25	4	D
	1800	8.1	82.1	1.5	1004	25	4	D
	Crossed Sri Lanka coast between Batticaloa and Trincomalee near latitude 7.8°N and longitude 81.6°E during 0330 to 0430 hours IST of the 2nd February as a depression with the estimated maximum sustained wind speed of 25 knots gusting to 35 knots (45-55 kmph gusting to 65 kmph).							
02.02.23	0000	7.6	81.4	-	1004	25	4	D
	0300	7.2	81.1	-	1004	20	4	D
	0600	6.8	80.8	-	1006	20	4	D
	1200	6.3	80.3	-	1006	20	4	D
	1800	Weakened into a well marked low pressure area over Comorin and adjoining Gulf of Mannar & west coast of Sri Lanka						

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

2. Salient features of the system

- The depression developed under the influence of active phase of Madden Julian Oscillation (MJO), strong easterly winds, enhanced westerly winds and various equatorial waves including Rossby waves (RW) and Kelwin waves (KW) over South BoB and adjoining EIO. It was a rare activity in the month of January. Last such activity over BoB was observed in 2019 with emergence of

cyclonic storm Pabuk from South China Sea into Andaman Sea. Similarly, a depression also developed on 4th January, 2014 which crossed Sri Lanka coast and weakened over Comorin area.

- The system exhibited recurving track. It moved west-northwestwards till 1200 UTC of 30th January and thereafter recurved west-southwestwards. The system was mainly steered west-northwestwards by the east-southeasterly winds prevailing in the periphery of upper tropospheric ridge near 15°N. Thereafter, the system showed slight weakening and thus the steering level changed to middle tropospheric levels. The system was thus steered west-southwestwards under the influence of east-northeasterly winds in the lower-middle tropospheric levels.
- The system exhibited very slow movement prior to landfall, as there was a phase lock between the westerly trough with axis near 82°E & extension upto 15°N and another trough in easterly across the centre of depression with axis near 82°E & extension upto 13°N. After the passage of westerly trough, the system moved with faster speed.
- The life period of the system was 3 days and 15 hours against normal of 2 days and 2 hours for depressions over BoB during the year as a whole.

3. Brief life history - Genesis Intensification and movement

3.1 Genesis

Under the influence of the cyclonic circulation over EEIO and adjoining southeast BoB, a low pressure area formed over the same region in the morning (0530 hrs IST/ 0000 UTC) of 27th January, 2023. It lay as a WML over southeast BoB adjoining EEIO at 0300 UTC of 29th January, 2023. The system developed under the influence of active phase & enhanced amplitude of MJO, strong easterly winds, enhanced westerly winds and various equatorial waves including RW and KW over South BoB and adjoining EIO.

Under favourable environmental conditions, it concentrated into a depression over southeast and adjoining southwest BoB at 0300 UTC of 30th January, 2023. At 0300 UTC of 30th January, the Madden Julian Oscillation (MJO) index was in phase 3 with amplitude more than 1. MJO index was thus conducive for enhancement of convective activity over BOB and intensification of the system. The CFS based forecast for equatorial waves indicated strong easterly winds (5-7 mps) over south BOB, strong westerly winds (5-7 mps) over Equatorial Indian Ocean (EIO) and adjoining south BOB along with Kelvin waves, MJO and equatorial Rossby waves over EIO and adjoining south BOB on 30th January. All these waves contributed towards organization of circulation and enhancement of convection over southeast & adjoining southwest BOB.

The sea surface temperature (SST) was around 27-28°C over south BOB and adjoining EIO. Total Precipitable Water (TPW) imagery indicated warm moist air incursion into the core of the system. Low level Vorticity was 100 $x10^{-6}$ s^{-1} around the system center. Low level convergence was around 5 $x10^{-5}$ s^{-1} to the northeast of the system center. Upper Level Divergence was 10 $x10^{-5}$ s^{-1} to the northwest of the system center. Wind shear was low to moderate (10-15 knots) over southeast & adjoining southwest BoB. The upper tropospheric ridge was seen along 15.0 °N over the BOB. The east-southeasterly winds at middle & lower tropospheric level indicated west-northwestwards movement of system.

3.2 Intensification and movement

At 1200 UTC of 30th January, similar sea and environmental conditions continued. Thus, the system maintained its intensity and continued to move west-northwestwards under the influence of east-southeasterly winds prevailing along the periphery of the ridge.

At 0300 UTC of 31st January, the MJO index continued in phase 3 with amplitude around 2 and was highly conducive for enhancement of convective activity over BOB and maintenance of intensity of the system. The CFS based forecast for equatorial waves indicate strong easterly winds (5-7 mps) over South BoB, strong westerly winds (5-7 mps) over EIO and adjoining south BOB along with Kelvin waves, MJO and Equatorial Rossby Waves over EIO and adjoining South BoB on 31st January. All these equatorial waves contributed towards maintenance of intensity of the system. The SST was around 27-28 °C over South BoB and adjoining EIO. TPW imagery indicated warm moist air incursion into the core of the system. Low level vorticity was 100 $x10^{-6}$ s^{-1} to the south of system center. Low level convergence increased and was around 20 $x10^{-5}$ s^{-1} to the southwest of the system center. Upper level divergence also increased and was around 30 $x10^{-5}$ s^{-1} to the southwest of the system center. Wind shear was moderate (15-20 knots) around system centre over southwest Bay of Bengal. The upper tropospheric ridge was seen along 15.0 °N over the BOB. The system continued to be steered west-northwestwards under the influence of east-southeasterly winds along the periphery of ridge.

At 1200 UTC of 31st January, the MJO index was in phase 3 with amplitude around 2. It was likely to continue in same phase with similar increased amplitude during next 7 days. MJO index was thus conducive for enhancement of convective activity over BOB and maintenance of intensity of the system. The CFS based forecast for equatorial waves indicated strong easterly winds (5-7 mps) over south BOB, strong westerly winds (5-7 mps) over EIO and adjoining south BOB along with Kelvin waves, MJO and Equatorial Rossby waves over EIO and adjoining south BOB on 31st January. All these equatorial waves contributed towards maintenance of intensity of the system. The SST was around 27-28°C over south BOB and adjoining EIO. TPW imagery indicated warm moist air incursion into the core of the system. Low level vorticity was 150 $x10^{-6}$ s^{-1} to the south of system center. Low level convergence was 10 $x10^{-5}$ s^{-1} to the southwest of the system center. Upper level divergence was 20 $x10^{-5}$ s^{-1} to the southwest of the system center. Wind shear was moderate (15-20 knots) around system centre over southwest Bay of Bengal. The upper tropospheric ridge was seen along 15.0 °N over the BoB. As the vertical extent of the system decreased due to weakening of the system as shown in the dynamical parameters, the system was steered by the lower-mid level mean northeasterly winds. These winds were likely to recurve the system southwestwards towards Sri Lanka coast. Near the coast, dry cold air was likely to intrude into the system area from south and easterly wind shear was likely to prevail. These features were likely to weaken of the system.

At 0300 UTC of 1st February, similar sea conditions prevailed with enhanced MJO and presence of various equatorial waves over the region. Low level vorticity was 100 $x10^{-6}$ s^{-1} around the system center. Low level convergence was 10 $x10^{-5}$ s^{-1} around the system center. Upper level divergence was 20 $x10^{-5}$ s^{-1} to the west of the system center. Wind shear was low (10 knots) around system centre over southwest BoB, with an increasing tendency (20-30 knots) along predicted track. The upper tropospheric ridge was seen along 15.0 °N over the BoB. The system was steered southwestwards by the lower-mid level mean northeasterly winds. However, near the

coast, the system was likely to weaken due to dry cold air intrusion into the system area from south and easterly wind shear.

At 1200 UTC of 1st February, similar sea and environmental conditions prevailed. SST was around 27 °C over Southwest BoB and adjoining EIO. Total precipitable water imagery indicated warm moist air incursion into the core of the system. Low level vorticity was around 100 $x10^{-6}$ s^{-1} to the southwest of the system center. Low level convergence was about 10 $x10^{-5}$ s^{-1} around the system center. Upper level divergence decreased and was around 10 $x10^{-5}$ s^{-1} towards north of the system center. Wind shear was moderate (15-20 knots) around system centre over southwest BoB, and was increasing along forecast track (20-30 knots). The upper tropospheric ridge was seen along 11.0 °N over the BOB. The system was exhibiting slow movement and was steered nearly westwards. The vorticity fields indicated that the vertical extension of the system was upto 500 hPa level. IMD GFS analysis field of winds at 400 hPa level indicated, presence of a trough in westerly with axis running along 82°E upto 15°N. The trough from the centre of depression was running northwards along 82 °E upto 13 °N. There was a phase locking between the troughs in westerlies and trough in easterlies, leading to slow movement of the system. The system thus moved very slowly, maintaining the intensity of depression.

At 0300 UTC of 2nd February, the MJO index lay in phase 3 with amplitude around 2. MJO index was still very conducive for enhancement of convective activity over BOB and maintenance of intensity of the system. The CFS based forecast for equatorial waves indicate easterly winds (5-7 mps) over South BoB, westerly winds (3-5 mps) to the south Sri Lanka and adjoining Comorin area, along with Kelvin Waves, MJO and Equatorial Rossby Waves over east EIO and adjoining south BOB on 2nd February. All these equatorial waves were contributing towards maintenance of intensity of the system and slow weakening after landfall. The SST was around 27 ° C over southwest BOB and adjoining EIO. Low level vorticity was about 100 $x10^{-6}$ s^{-1} to the northwest of the system center. Low level convergence was 15 $x10^{-5}$ s^{-1} near system center. Upper level divergence was around 10 $x10^{-5}$ s^{-1} to northwest of the system center. Wind shear was moderate (15-20 knots) around system centre and was increasing along forecast track (30-40 knots). The upper tropospheric ridge was seen along 12.0 °N over the BOB.

At 1200 UTC of 2nd February, the MJO index lay in phase 3 with amplitude around 2. The CFS based forecast for equatorial waves indicate easterly winds (5-7 mps) over south BOB, westerly winds (3-5 mps) to the south Sri Lanka and adjoining Comorin area, along with Kelvin waves, MJO and Equatorial Rossby Waves over east EIO and adjoining south BOB on 2nd February. All these equatorial waves contributed towards maintenance of intensity of the system and slow weakening after landfall. Low level vorticity decreased and was about 50 $x10^{-6}$ s^{-1} to the south of the system center. Low level convergence was 20 $x10^{-5}$ s^{-1} to the west of system centre. Upper level divergence was around 05 $x10^{-5}$ s^{-1} to northwest of the system center. Wind shear was moderate (15-20 knots) around system centre and was increasing along forecast track (25-30 knots). The upper tropospheric ridge was seen along 12.0 °N over the BOB. The system thus gradually weakened into a WML over Comorin & adjoining Gulf of Mannar and west coast of Sri Lanka around 1800 UTC of 2nd February, 2023.

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 **19th January**. The extended range outlook issued on 19th January indicated likely

formation of a cyclonic circulation around 25th January over southeast BoB (**about 6 days prior to formation of cyclonic circulation over EEIO and adjoining southeast BoB and about 11 days prior to formation of depression on 30th January**). 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 from Sri Lanka 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.

4.1. Features observed through satellite

Satellite monitoring of the system was mainly done by using half hourly INSAT-3D and 3DR imageries. Satellite imageries of other international geostationary satellites, high resolution polar orbiting satellites and scatterometer imageries from ASCAT were also considered for monitoring of the system. Typical INSAT-3D enhanced colored imageries, visible/ IR, brightness temperature and water vapour imageries are presented in **Fig.2 (a) to 2 (e)**. During the entire life cycle, the clouds were organsied in shear pattern. The detailed features from the satellite pictures are discussed in this section.

At 0300 UTC of 30th January, 2023 clouds were organised in shear pattern. Most of the cloud mass was sheared to the north of system centre. Intensity of the system was characterized as T1.5. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over south BoB between latitude 7.0N to 12.0N & longitude 83.0E to 91.5E and over south Andaman Sea. Minimum Cloud Top Temperature (CTT) was -93°C. Multi satellite based winds indicated stronger winds in the northern sector.

At 1200 UTC of 30th January, most of the cloud mass was sheared to the north of system centre. Intensity of the system was characterized as T1.5. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over south BoB between latitude 7.0N to 13.0N & longitude 82.5E to 89.0E. Minimum CTT was -93°C.

At 0300 UTC of 31st January, clouds were sheared to the northeast of system centre. Intensity of the system was characterized as T1.5. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over south & adjoining central BoB between latitude 6.5N to 14.0N longitude 81.0E to 87.5E. Minimum Cloud Top Temperature was -93°C. As per multisatellite based winds, stronger winds were seen in the northeast sector. The intense cloud mass was also seen in northern sector

At 1200 UTC of 31st January, intensity of the system was characterized as T1.5. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over south & adjoining central BoB between latitude 5.2N to 16.0N long 78.0E to 85.5E. Minimum Cloud Top Temperature was -93°C. As per multisatellite based winds, stronger winds were seen in the northern sector. The intense cloud mass was also sheared in northern sector.

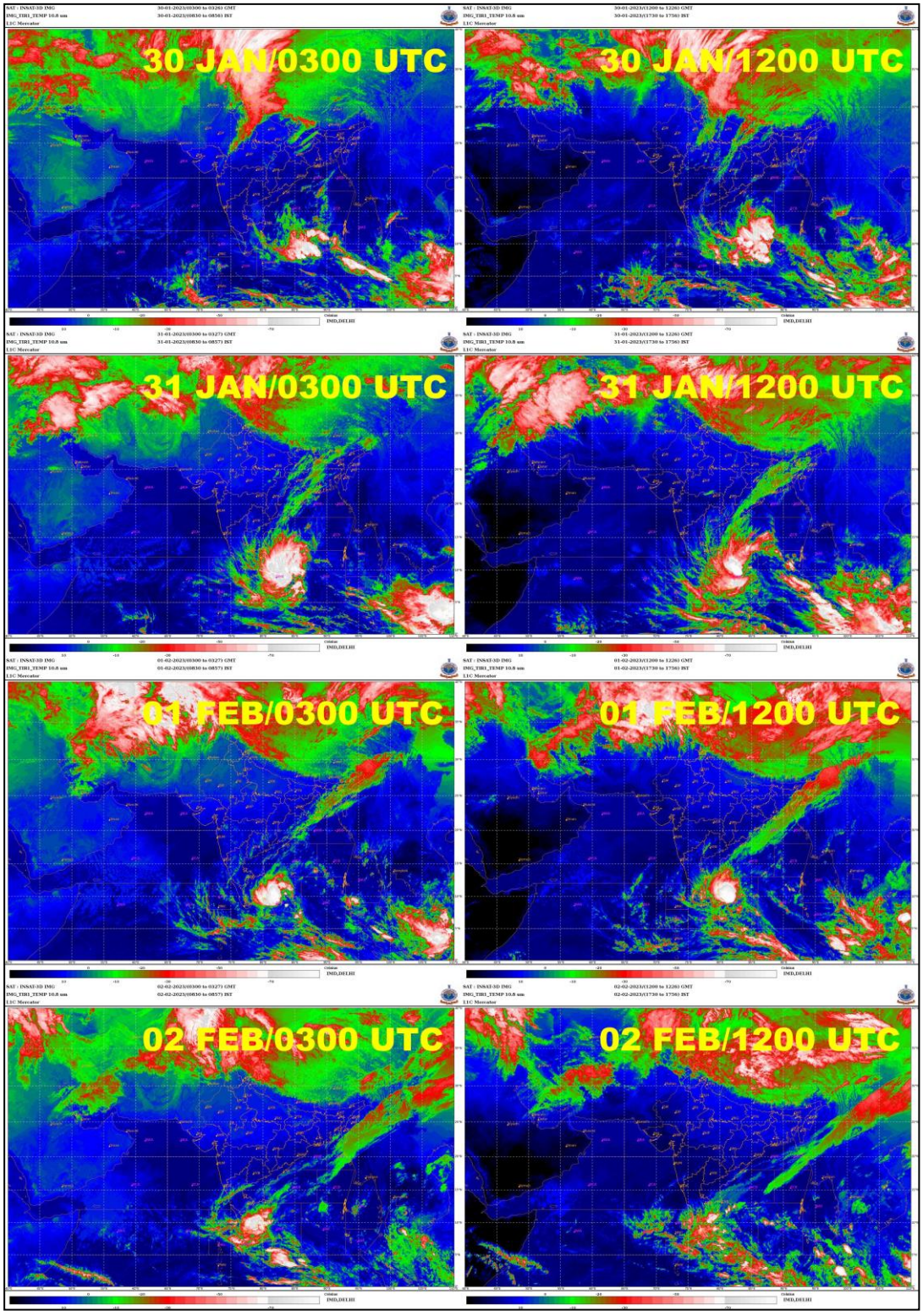


Fig.2(a): INSAT-3D enhanced colored imageries during life cycle of Depression southwest & adjoining southeast Bay of Bengal during 30Jan -02 Feb, 2023

At 0300 UTC of 1st Feb, intensity of the system was characterized as T 1.5. Clouds were sheared in the northeast sector. Scattered to broken low and medium clouds with embedded intense to very intense convection lay over southwest & adjoining westcentral BoB between latitude 8.5N to 13.0N long 80.0E to 85.0E and

north Sri Lanka, Palk strait and Gulf of Mannar. Minimum Cloud Top Temperature was -93°C.

At 1200 UTC of 1st Feb, intensity of the system was characterized as T1.5. Clouds were organised in shear pattern. Intense convection was sheared to the northwest of system centre. Intense convective cloud mass was observed off northeast Sri Lanka coast. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over southwest west BoB between latitude 8.5N to 12.5N longitude 79.0E to 83.0E and moderate to intense convection lay over Tamilnadu, north Sri Lanka and Palk strait. Moderate to intense convection was seen over Gulf of Mannar. Minimum Cloud Top Temperature was -93°C.

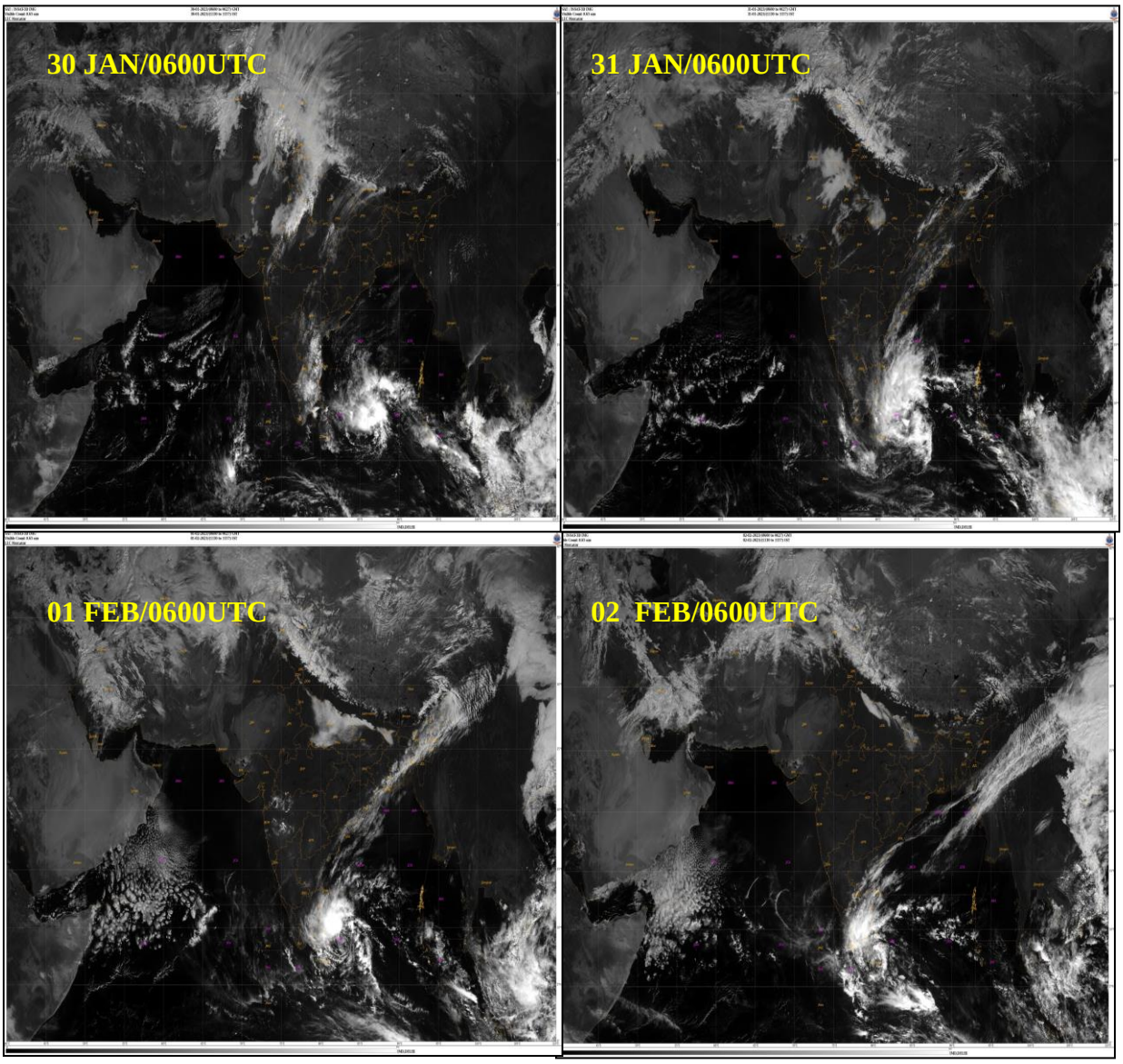


Fig.2(b): INSAT-3D Visible imageries during life cycle of Depression southwest & adjoining southeast Bay of Bengal during 30Jan -02 Feb, 2023

At 0300 UTC of 2nd Feb, scattered to broken low and medium clouds with embedded intense to very intense convection lay over south Tamilnadu, Palk strait, Gulf of Mannar and north Sri Lanka.

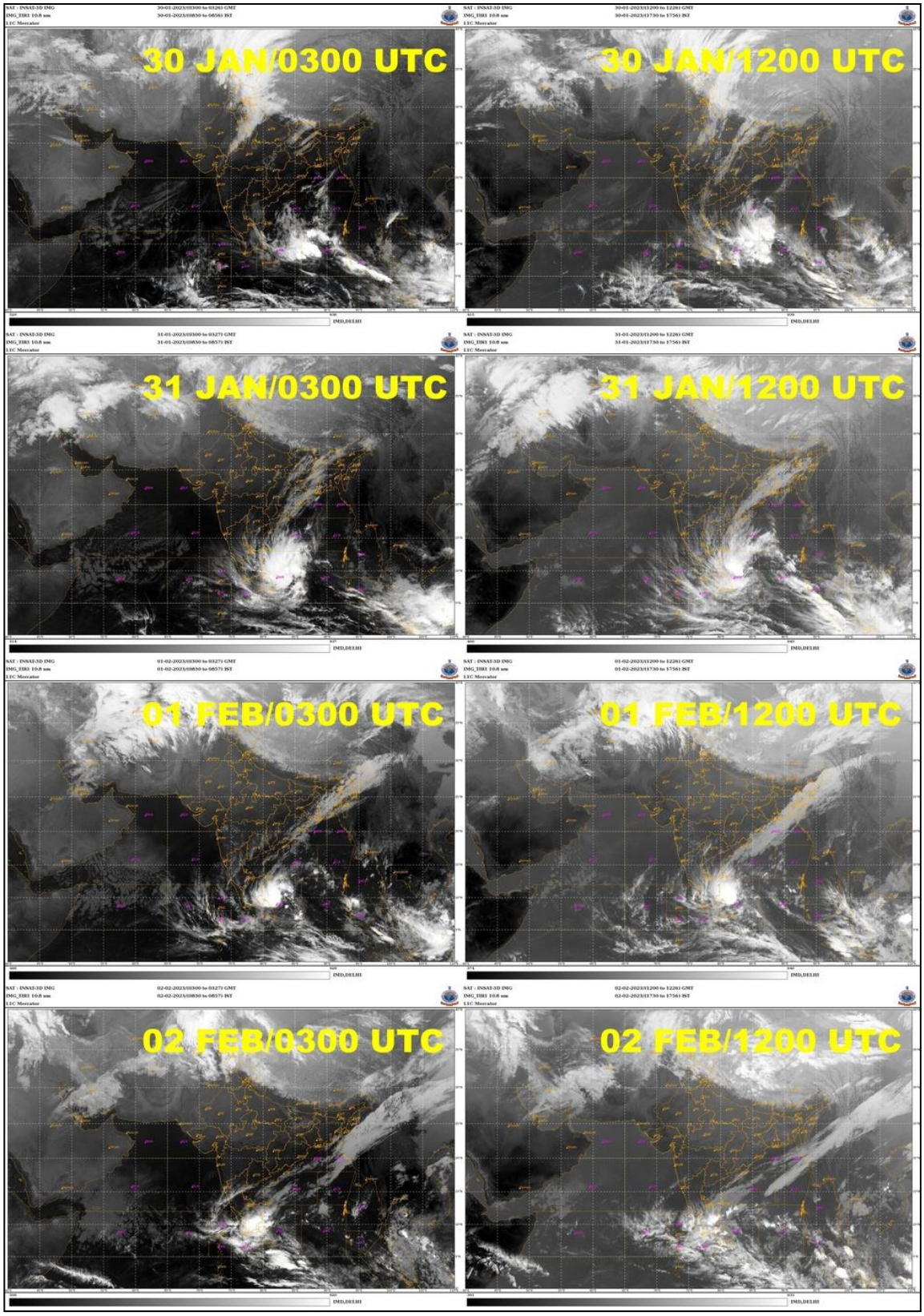


Fig.2(c): INSAT-3D IR imageries during life cycle of Depression southwest & adjoining southeast Bay of Bengal during during 30Jan -02 Feb, 2023

Minimum Cloud Top Temperature was minus 90°C. Scattered to broken low and medium clouds with embedded moderate to intense convection lay over south Kerala and Comorin area.

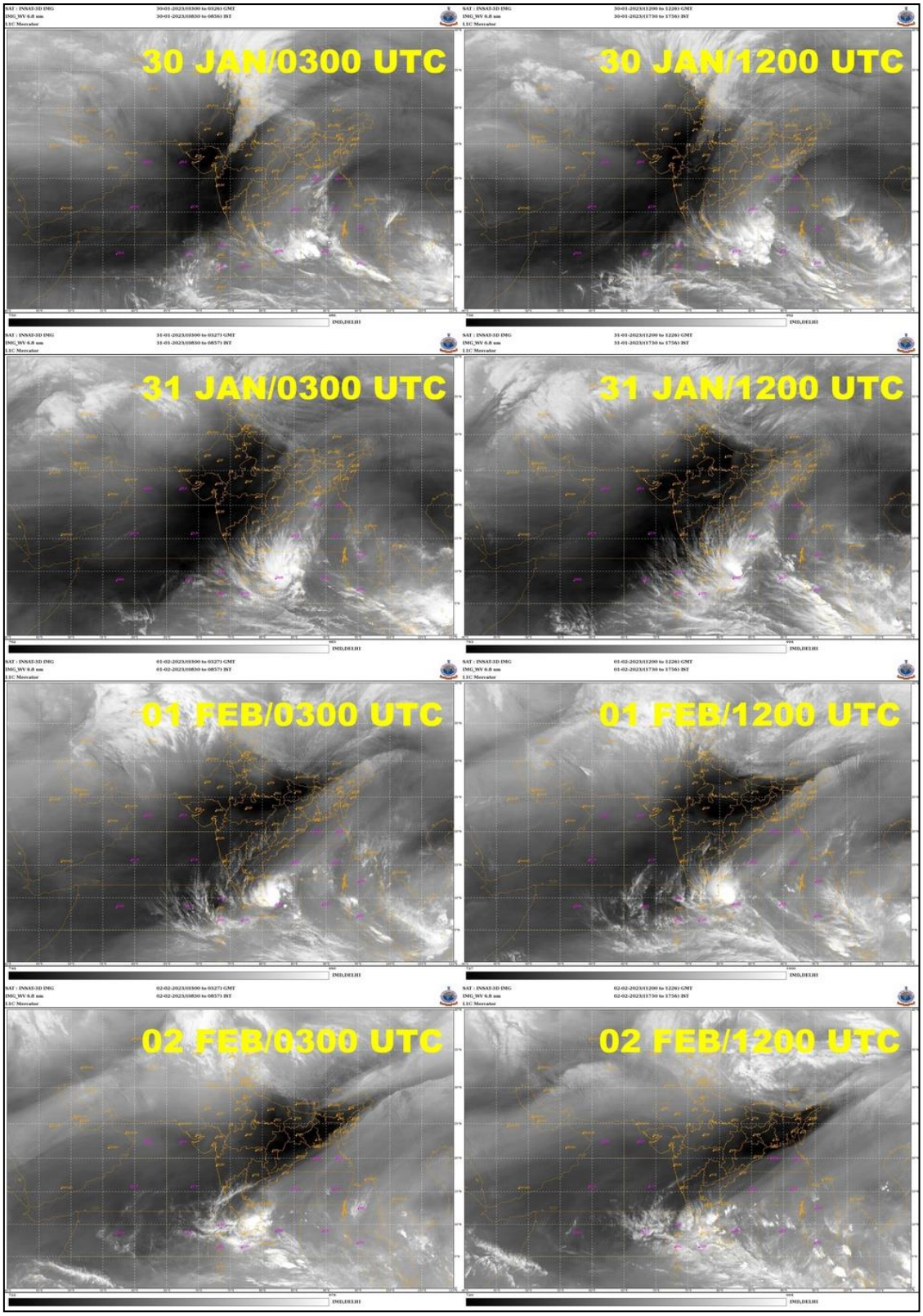


Fig.2(d): INSAT-3D Water Vapour imageries imageries during life cycle of Depression southwest & adjoining southeast Bay of Bengal during during 30Jan -02 Feb, 2023

At 1200 UTC of 2nd Feb, scattered to broken low and medium clouds with embedded intense to very intense convection lay over south Tamilnadu, Palk strait, Gulf of Mannar and west Sri Lanka. Minimum Cloud Top Temperature was - 75°C. Scattered to broken low and medium clouds with embedded moderate to intense convection lay over north Sri Lanka, Kerala and Comorin area.

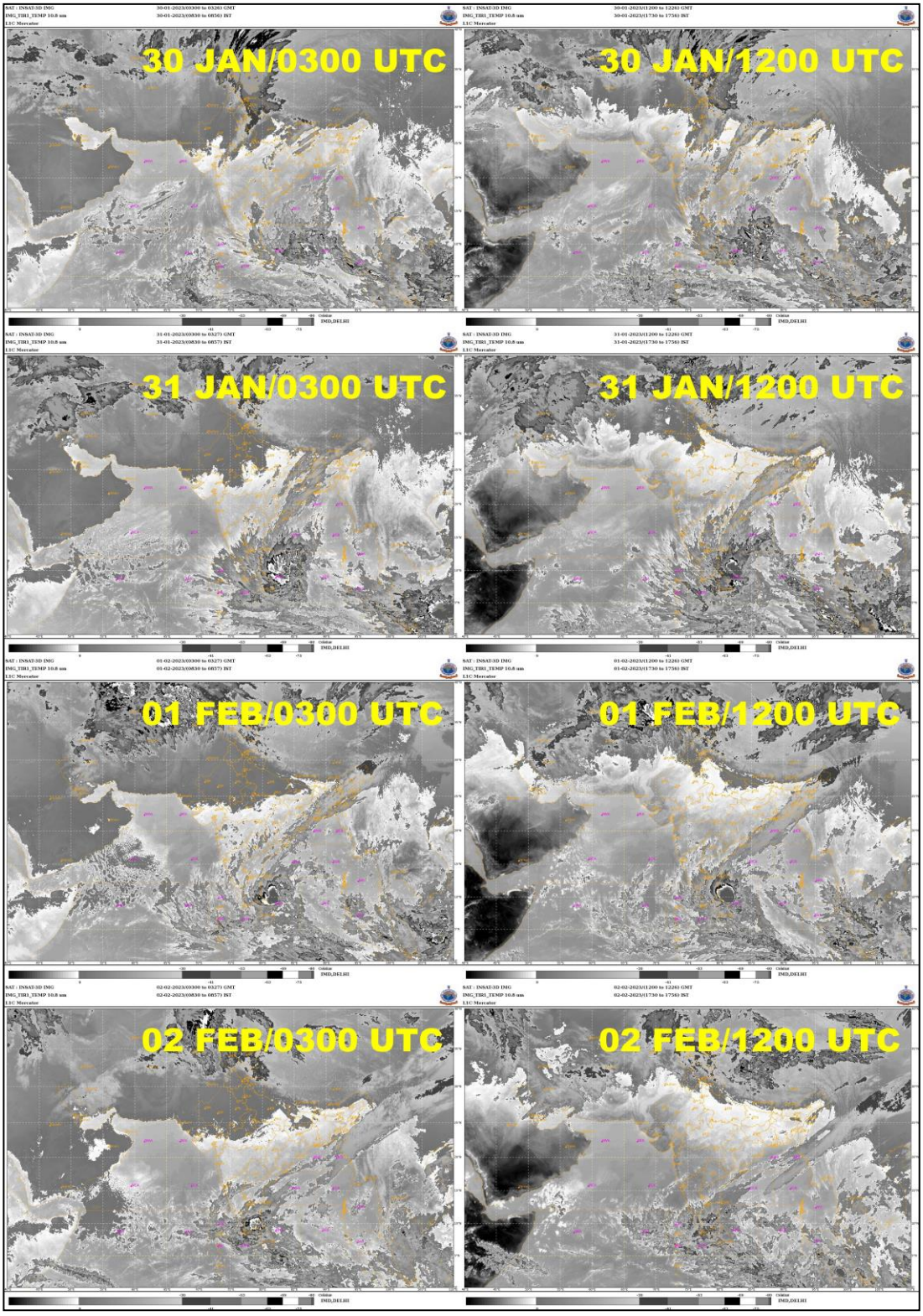


Fig.2 (e): INSAT-3D Brightness Temperature imageries during life cycle of Depression southwest & adjoining southeast Bay of Bengal during 30Jan -02 Feb, 2023

4.2. Synoptic Observations from Sri Lanka

The plotted surface charts from Sri Lanka are presented in Fig. 2 (f). These observations helped in better monitoring of the system on the day of landfall and after landfall, when the system was over land. When the system was near to coast these observations were given more weightage over satellite based observations in fixing the centre.

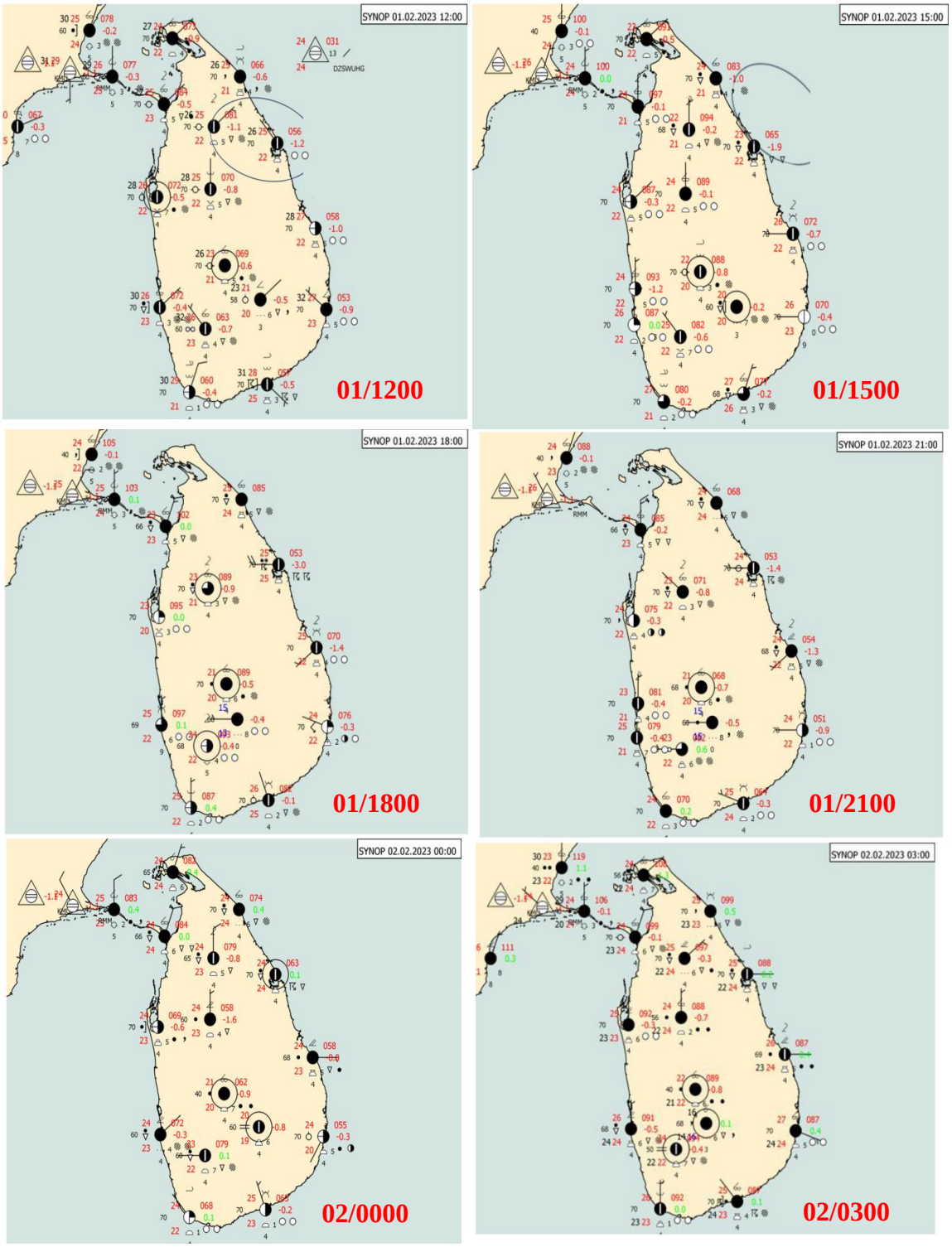


Fig. 2(f): Synoptic observations from Sri Lanka during 1200 UTC of 1st January to 0300 UTC of 2nd February

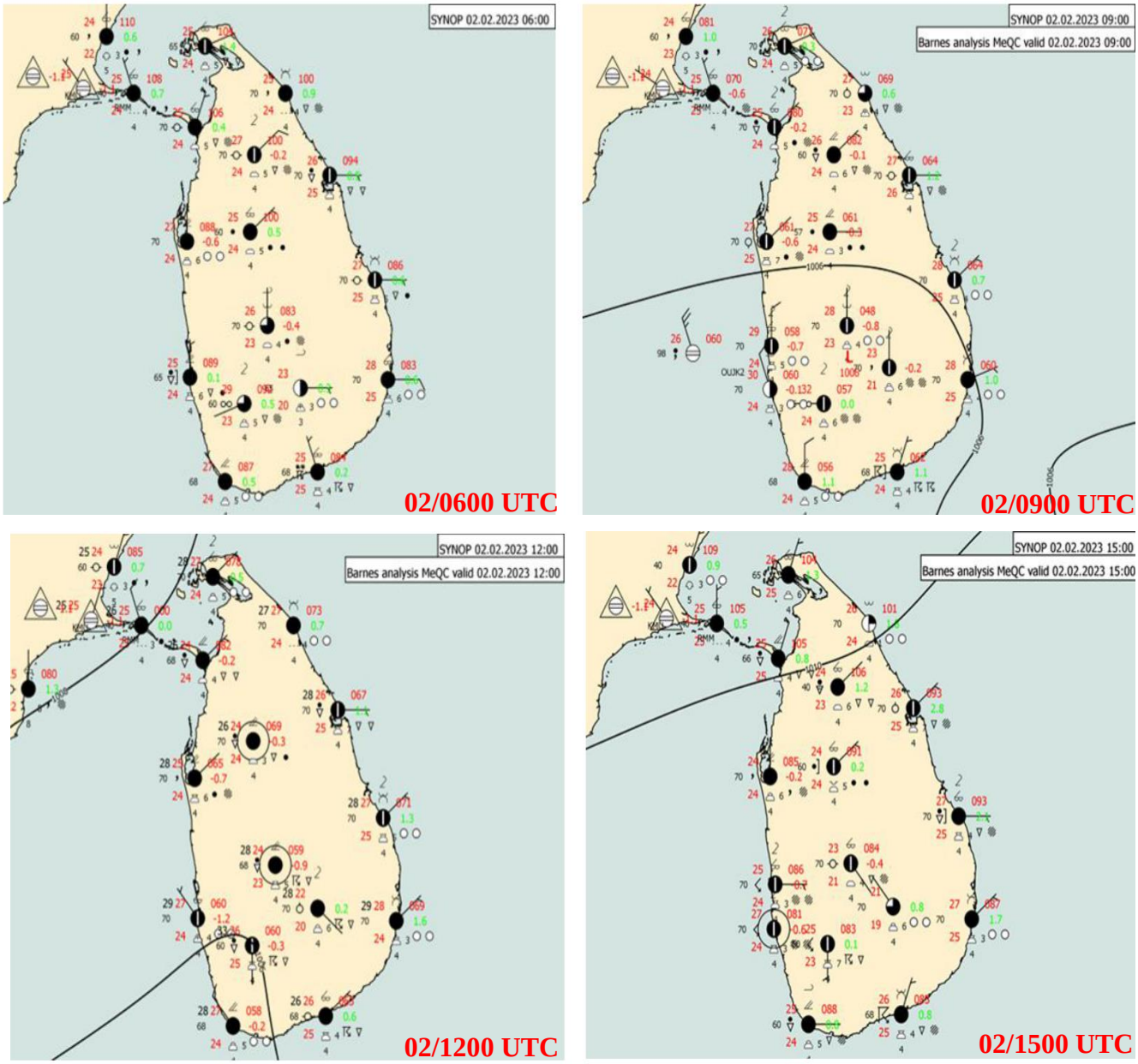


Fig. 2(f) contd: Synoptic observations from Sri Lanka during 0600 UTC of 2nd February to 1500 UTC of 2nd February

5. Dynamical Features

IMD GFS (T1534) daily analyses at 0000 UTC of mean sea level pressure (MSLP), winds at 10 m, 850, 500 and 200 hPa levels from 30th January to 2nd February are presented in **Fig. 3(a) to 3(d)** respectively.

The MSLP analysis field indicated a depression over southeast & adjoining southwest BoB near 7.0°N/86.5°E. Actually the system was located near 7.7°N/87.2°E at 0300 UTC. Thus, GFS was correctly capturing the initial conditions on 30th January. The model showed that vertically, the system extended upto 500 hpa level. Ridge was seen near 15°N.

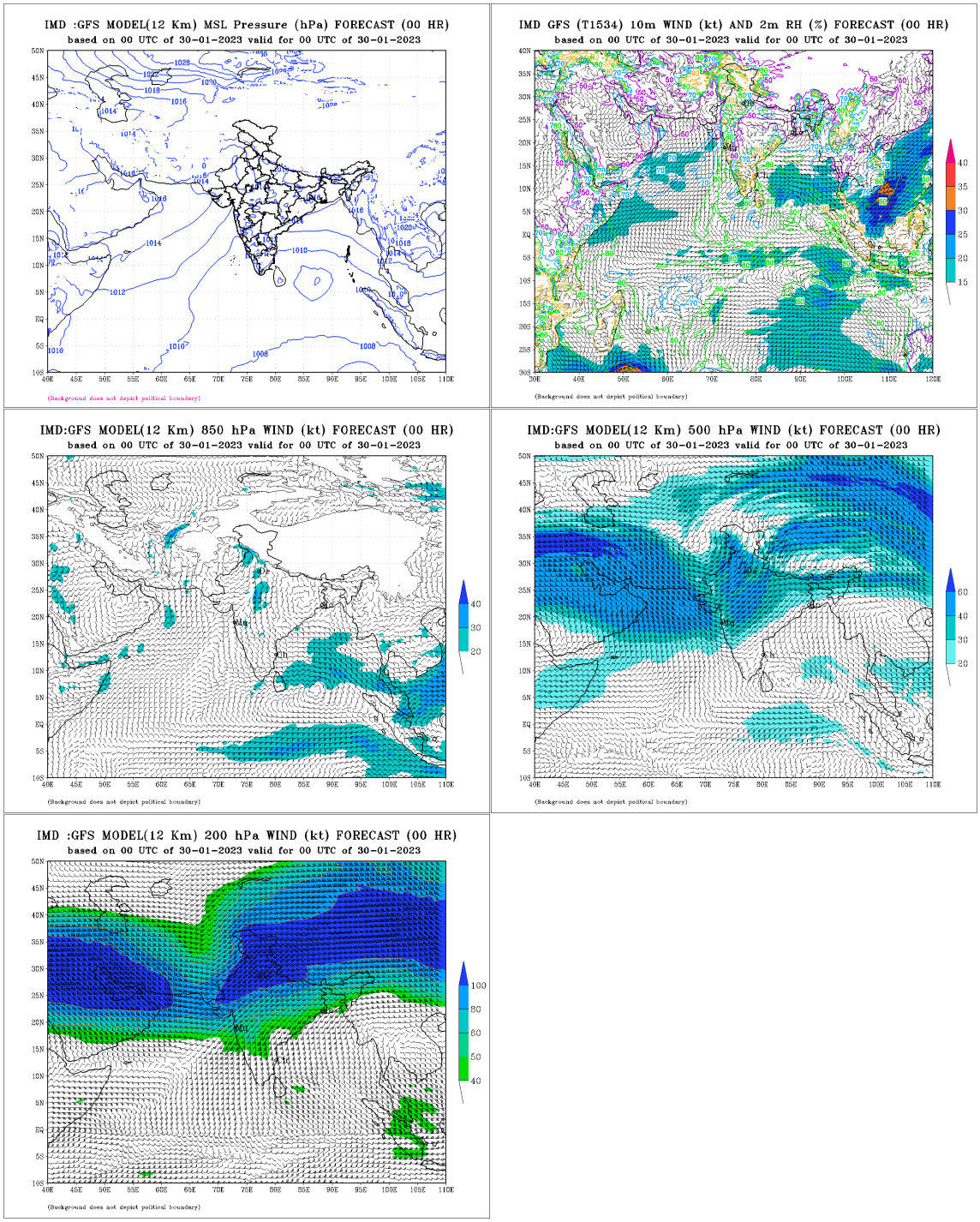


Fig. 3(a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 30th Jan 2023

At 0000 UTC of 31st January, the MSLP analysis field indicated a depression over southwest BoB near 8.0°N/85.0°E. Actually the system was located near 8.2°N/84.8°E at 0000 UTC. The east-southeasterly winds in upper levels indicated west-northwestwards movement of the system.

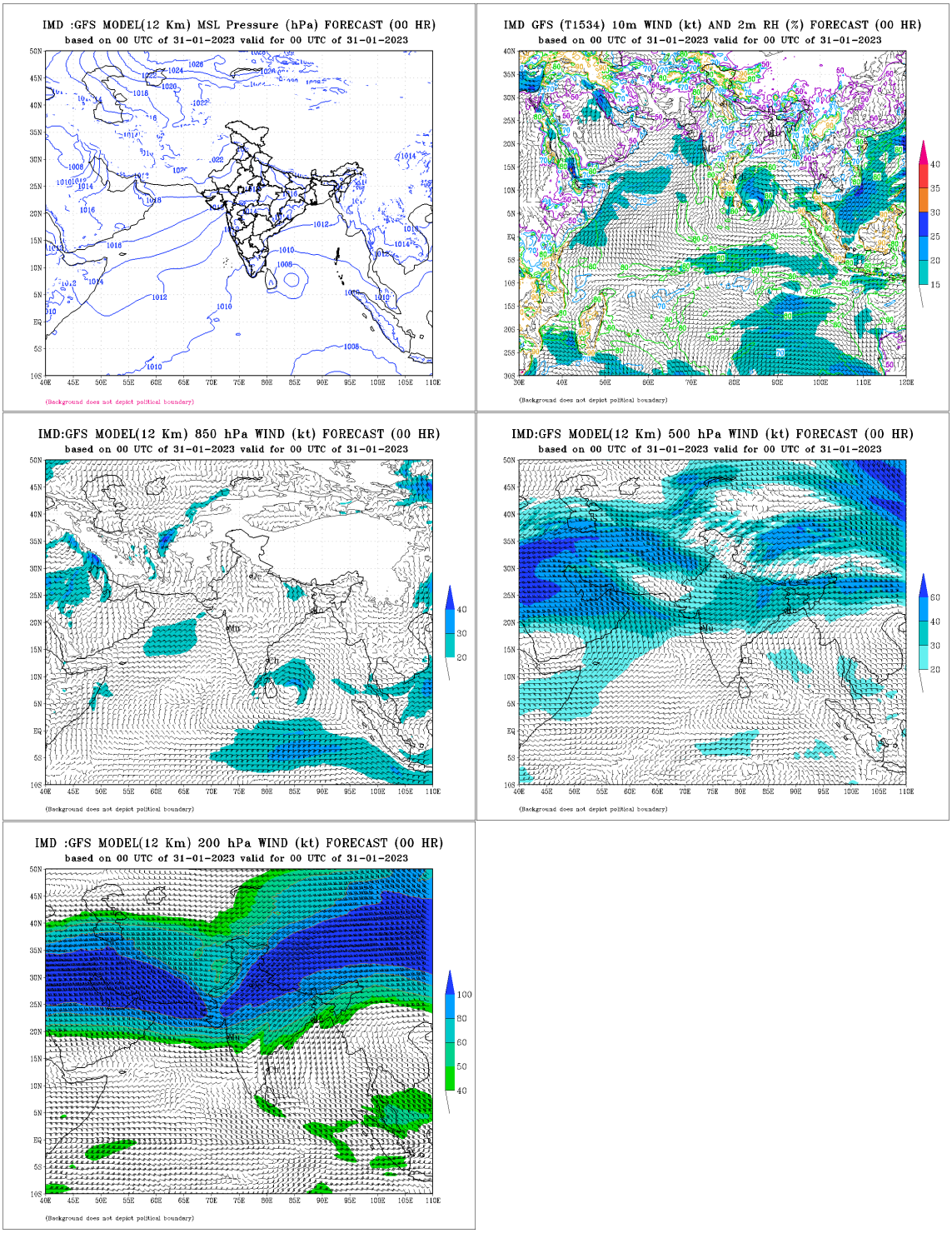


Fig. 3(b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 31st Jan 2023

At 0000 UTC of 1st February, the system was seen over southwest BoB close to Sri Lanka coast near 8.5°N/83.0°E. Actually, the system lay near 8.2°N/82.7°E. The southwestwards movement was not captured by the model.

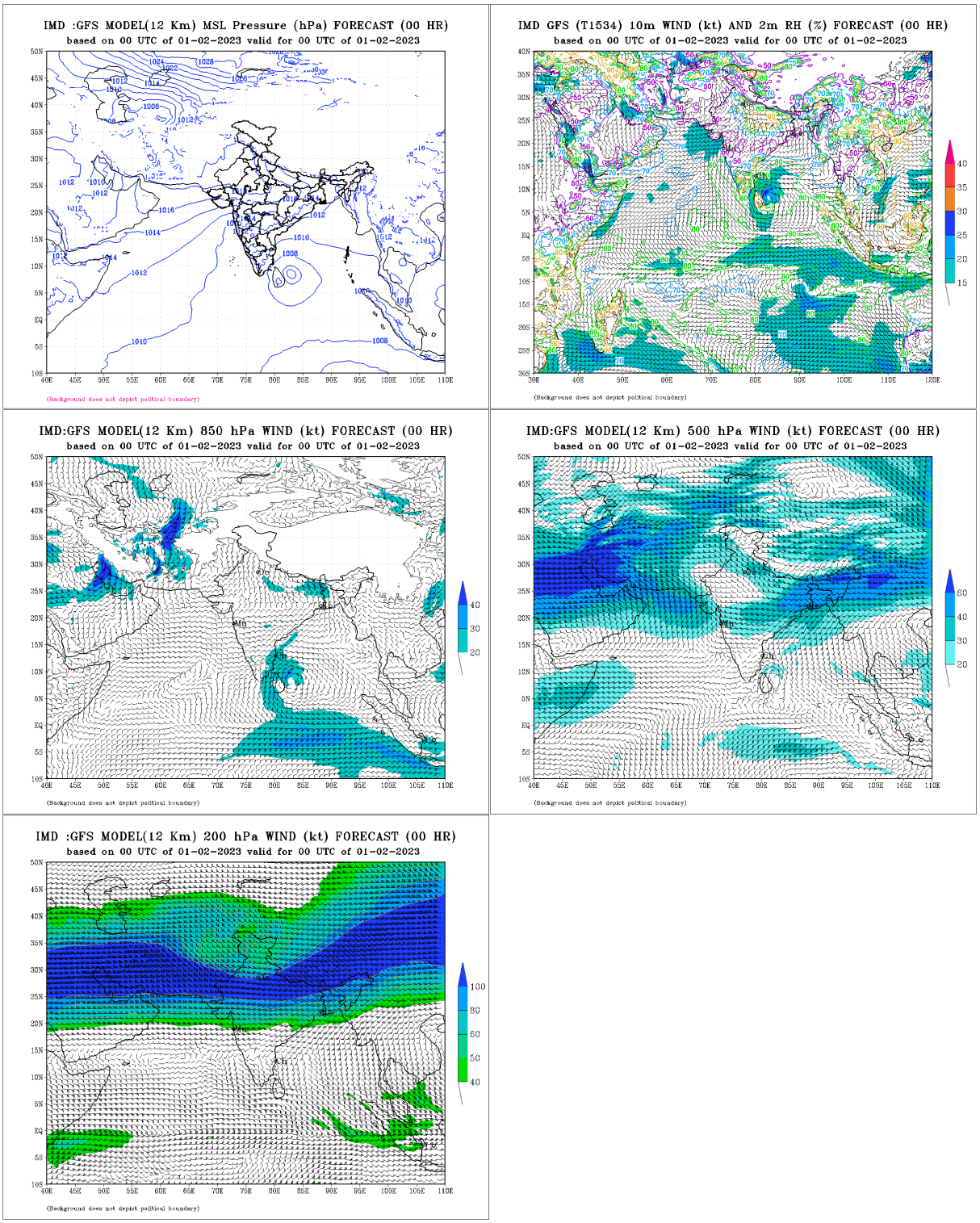


Fig. 3(c): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 1st Feb 2023

At 0000 UTC of 2nd February, the model indicated a low pressure area over south Sri Lanka. Actually, at 0000 UTC, the system lay as a depression over South Sri Lanka. IMD GFS underestimated the intensity of the system on 2nd February.

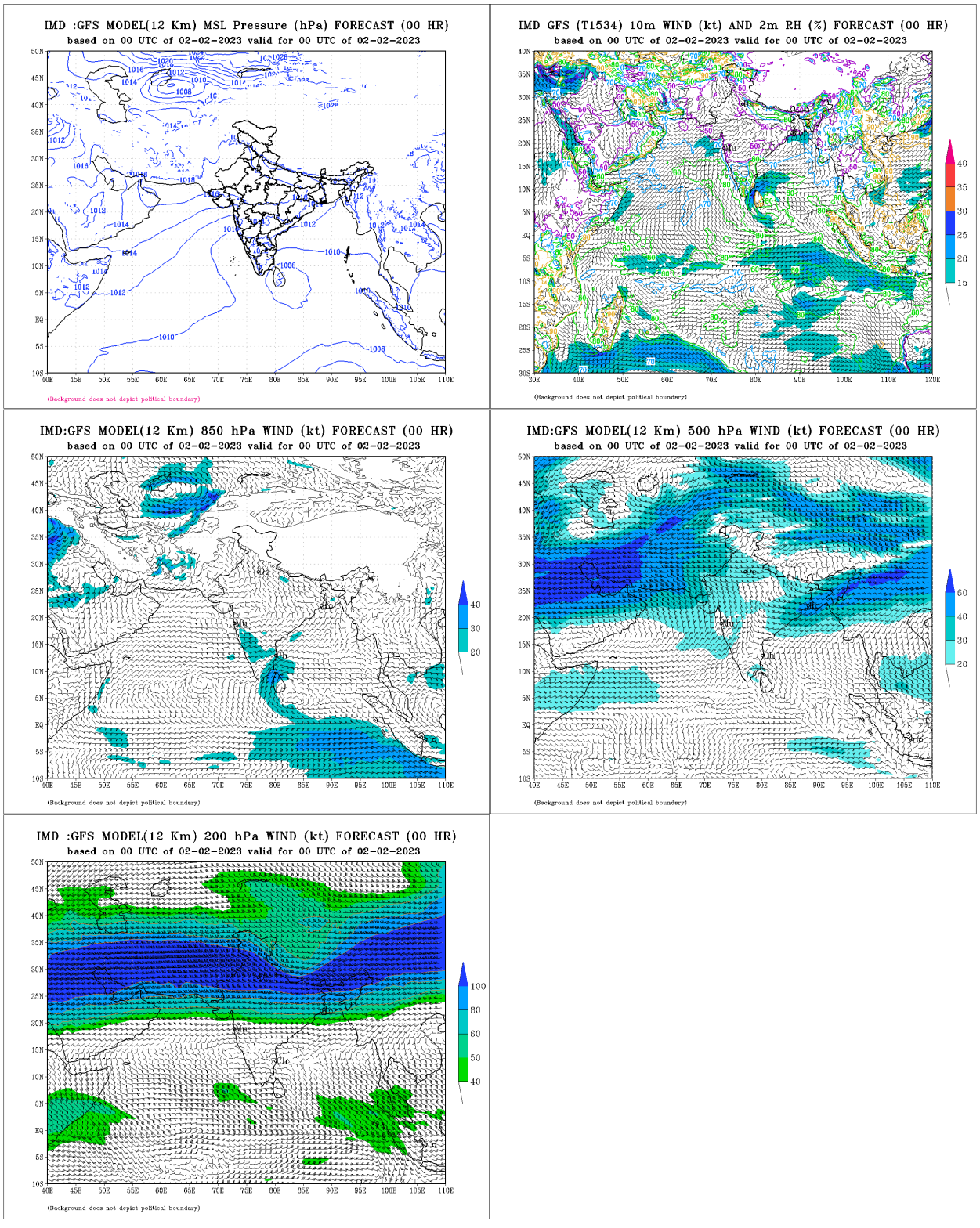


Fig. 3(d): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 2nd Feb 2023

6. Realized Weather

Rainfall associated with the depression based on IMD-NCMRWF satellite gauge merged data are depicted in Fig 4a respectively. The 24 hour cumulative rainfall recorded at different stations is presented in Fig. 4(b). It is seen that light to moderate rainfall occurred at isolated places & heavy rainfall at isolated places over costal Tamil Nadu on 1st February. Light to moderate rainfall at a few places with heavy to very heavy rainfall at isolated places occurred over south Tamil Nadu and adjoining south Kerala on 2nd February.

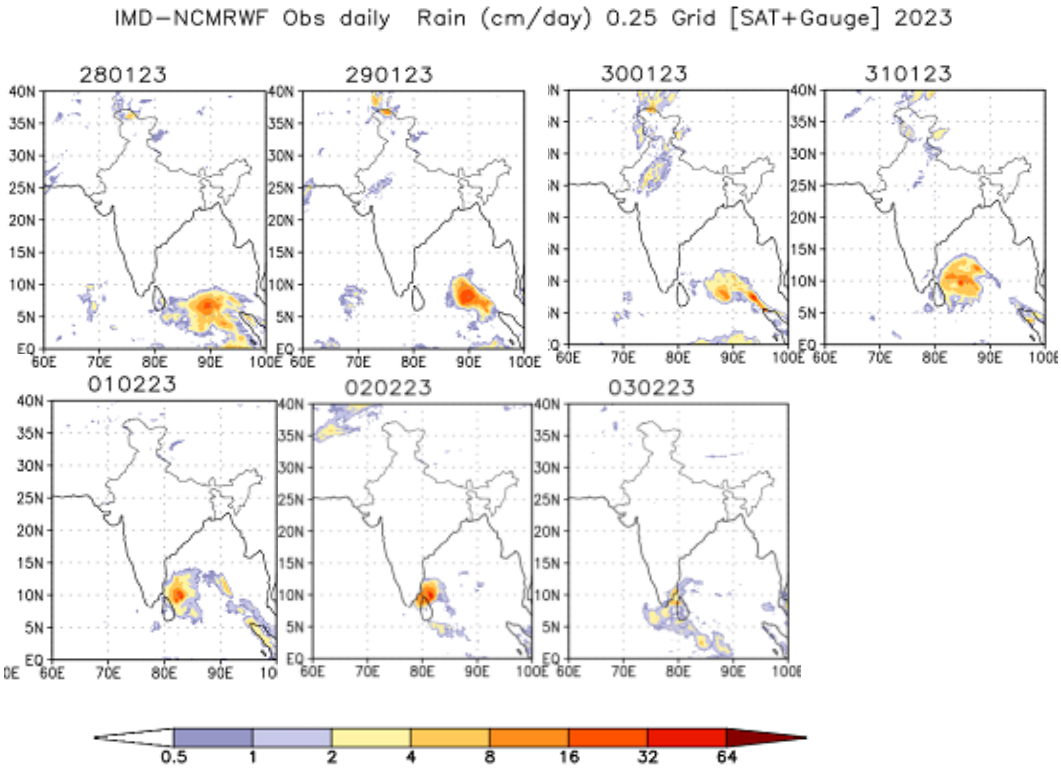


Fig. 4(a): IMD-NCMRWF Rain gauge and satellite merged rainfall plots ending at 0300 UTC of 28th Jan to 3rd Feb, 2023 (cm/day)

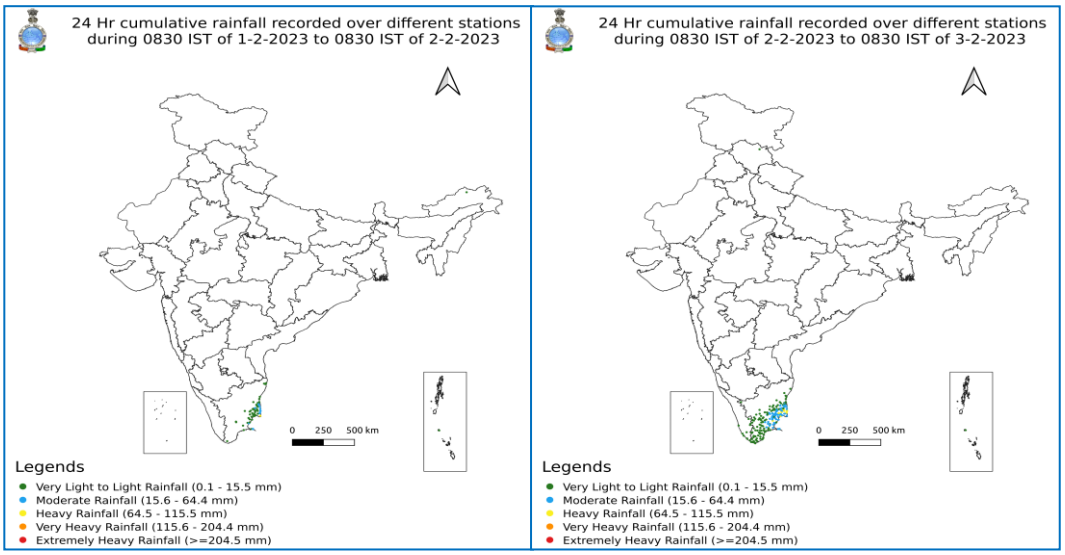


Fig. 4(b): Daily 24 hr cumulative rainfall distribution recorded over different stations of IMD during 1st – 2nd February, 2023

5.1 Rainfall forecast verification

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

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

Date/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
30.01.2023/ 0300UTC	Isolated heavy rainfalls over south Tamil Nadu on 1st and 2nd February	**2nd February, 2023** **Tamil Nadu:** Vedaranyam-7 **3rd February, 2023** **Tamil Nadu, Puducherry and Karaikal:** Oothu (Dist Tirunelveli) 16, Nalumukku (Dist Tirunelveli) 13, Kakkachi (Dist Tirunelveli) 12, Velankanni & Needamangalam 10 each, Nannilam, Nagapattinam & Tiruvarur 9 each, Tirupoondi 8 & Thirukuvalai each and Mannargudi, Adirampatnam, Vettikadu, Kodavasal, Neivasal Thenpathi, Ayyampettai, Orthanad & Devakottai 7 each.
31.01.2023/ 0300UTC	Isolated heavy rainfalls over south Tamil Nadu during 31st January to 2nd February	
01.02.2023/ 0300UTC	Isolated heavy rainfall over south Tamil Nadu on 1st and 2nd February	
02.02.2023/ 0300UTC	Isolated heavy to very heavy rainfall over south Tamil Nadu and isolated heavy rainfall over Kerala over Kerala on 2nd February	

7. Damage due to the system

No damage was reported in association with this system over Sri Lanka and Tamil Nadu, India.

8. Operational Forecast Performance

- First information about formation of a cyclonic circulation over southeast BoB was released in the extended range outlook issued on 19th January about **about 6 days prior to formation of cyclonic circulation over EEIO and adjoining southeast BoB on 25th January and about 11 days prior to formation of depression on 30th January.**
- Subsequent extended range outlook issued on 26th January indicated moderate probability of cyclogenesis (formation of depression) over southeast & adjoining southwest BoB around 31st January (about 4 days prior to formation of depression over southeast & adjoining southwest BoB on 30th January).
- The daily Tropical Weather Outlook issued on 27th January indicated that the depression would move westwards and reach near Sri Lanka around 1st February.
- The first bulletin issued on formation of depression on 30th January indicated that the system would move initially west-northwestwards till 1200 UTC of 31st

January and thereafter recurve gradually southwestwards and cross Sri Lanka coast on 1st morning (around 0000 UTC). However, actually the system moved west-northwestwards till 1800 UTC of 31st and thereafter recurved southwestwards & crossed Sri Lanka coast in the early morning hours of 2nd February. Actually, the phase locking between the westerly trough and easterly trough over southwest BoB near 82°E in the mid tropospheric level (around 400 hPa level) inhibited the movement of the depression on 1st February, thereby delaying the landfall of the system.

- Thus, it is seen that except the landfall time, other parameters including the track, intensity and landfall point were well predicted by IMD/RSMC New Delhi.

9. Bulletins issued by IMD

- Track, intensity and landfall forecast: IMD continuously monitored, predicted and issued bulletins containing track & intensity forecast from the stage of depression till the system weakened into a low pressure area. The forecast of these parameters were issued from the 30th January onwards along with the cone of uncertainty every six hourly for 00, +12, +24, +36 and +48 hours lead period.
- Adverse weather warning bulletins: The tropical cyclone forecasts along with expected adverse weather like heavy rain were issued with every six hourly update to central, state and district level disaster management agencies including MHA NDRF, NDMA for all Tamilnadu, Puducherry and Kerala. The bulletins also contained the suggested action for disaster managers and general public in particular for fishermen. These bulletins were also issued to Defence including Indian Navy & Indian Air Force, NDRF, Indian Coast Guard, ports, Shipping, Fishery, Railways, Surface Transport & Aviation Authorities.
- Warning graphics: The graphical display of the observed and forecast track with cone of uncertainty was disseminated by email and uploaded in the RSMC, New Delhi website (http://rsmcnewdelhi.imd.gov.in/) regularly. The adverse weather warnings related to heavy rain were also presented in graphics along with colour codes in the website.
- Warning and advisory for marine community: The six hourly bulletins under Global Maritime Distress Safety System (GMDSS) were issued by the Marine Weather Services Division at New Delhi and bulletins for maritime interest were issued by Area Cyclone Warning centre of IMD at Kolkata & Chennai and Cyclone Warning Centres at Visakhapatnam to ports, fishermen, coastal and high sea shipping community.
- Fishermen Warning: Regular warnings for fishermen for deep sea of BoB and the states of Tamilnadu, Puducherry, Andhra Pradesh and Kerala were issued since 26th January onwards.
- Warning and advisory through social media: Daily updates (every six hourly or whenever there was any significant change in intensity/track) were uploaded on facebook and tweeter regularly during the life period of the system from 9th morning onwards, updates were posted on facebook and tweeter.
- Diagnostic and prognostic features of Depression: The prognostics and diagnostics of the system were described in the RSMC bulletins.

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

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

S. No.	Bulletins	No. of Bulletins	Issued to
1	National Bulletin	19	1. IMD's website 2. FAX and e-mail to Control Room NDM, Ministry of Home affairs, Control Room NDMA, Cabinet Secretariat, Minister of Sc. & Tech, Secretary MoES, DST, HQ Integrated Defence Staff, DG Doordarshan, All India Radio, DG-NDRF, Director Indian Railways, Indian Navy, IAF, Chief Secretary: Andaman & Nicobar Islands, Tamil Nadu, Puducherry and Kerala
2	RSMC Bulletin	19	1. IMD's website 2. All WMO/ESCAP member countries including Sri Lanka through GTS and E-mail. 3. Indian Navy, IAF by E-mail
3	GMDSS Bulletins	19	1. IMD website, RSMC New Delhi website 2. Transmitted through WMO Information System (WIS) to Joint WMO/IOC Technical Commission for Ocean and Marine Meteorology (JCOMM)
4	Warnings through SMS	Frequently	SMS to (i) disaster managers at national level and concerned states (every time when there was change in track, intensity and landfall characteristics) by IMD Headquarters, (ii) to General Public registered through RSMC website by IMD Headquarters and RMC Chennai office (iii) to fishermen through INCOIS network.
5	Warnings through Social Media	Daily	Cyclone Warnings were uploaded on Social networking sites (Face book and Tweeter) since inception to weakening of system (every six hourly).

10. Summary

Under the active phase of MJO and equatorial waves over south BoB, a cyclonic circulation developed over EEIO and adjoining southeast BoB on 25th January (0300 UTC). It lay as an LPA over the same region on 27th January (0000 UTC). Under favourable environmental conditions, it concentrated into a depression over southeast and adjoining southwest BoB in the forenoon (0300 UTC) of 30th January. It crossed Sri Lanka coast during early morning hours of 2nd February, 2023. It weakened into a WML over Comorin area in the midnight of 2nd February, 2023. No damage was reported in association with this system. The system was well monitored since 19th January.

11. Acknowledgement

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