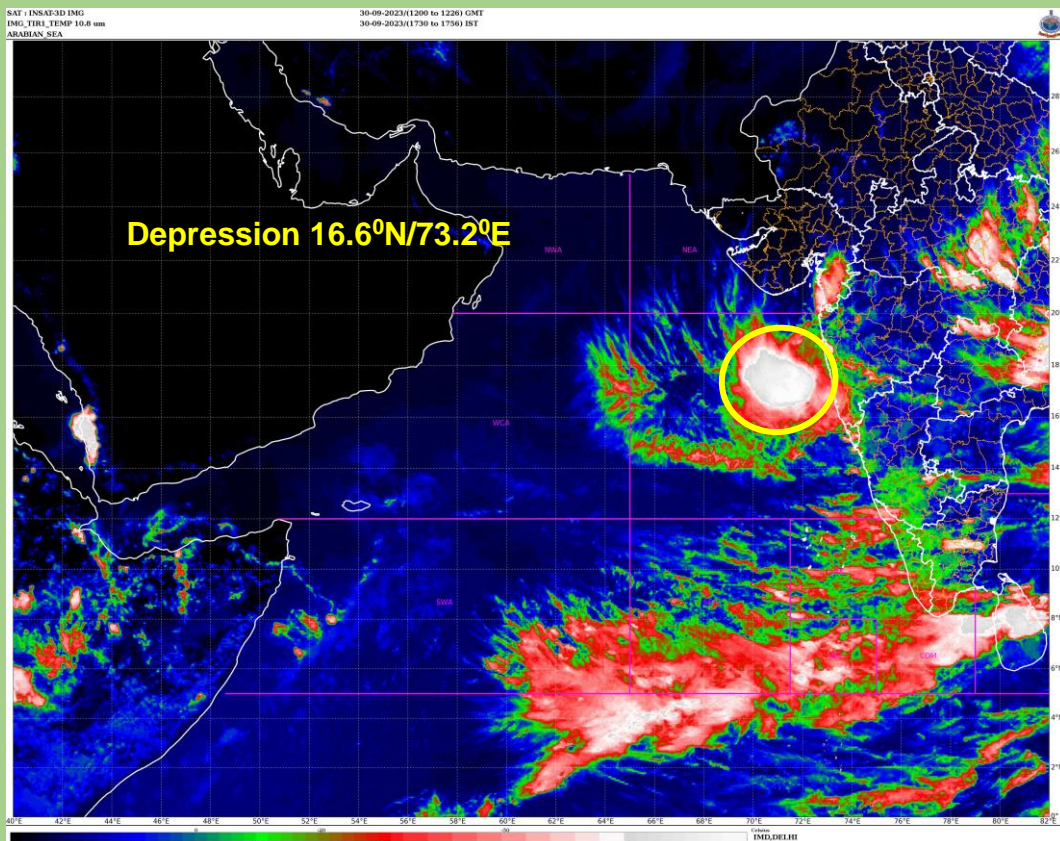**GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
INDIA METEOROLOGICAL DEPARTMENT**

**Depression over Eastcentral Arabian Sea
(30th September – 01st October 2023): A Report**

INSAT-3D Satellite imagery of Depression over Eastcentral Arabian Sea at 1200 UTC of 30th September, 2023

Cyclone Warning Division

India Meteorological Department

New Delhi

September, 2023

Depression over Eastcentral Arabian Sea during 30th September- 1st October, 2023

1. Introduction

> - Under the influence of the cyclonic circulation over North coastal Karnataka & neighbourhood, a low pressure area formed over Eastcentral Arabian Sea off South Konkan-Goa coasts in the early morning (0530 hours IST/0000 UTC) of the 29th September, 2023.
> - It lay as a Well Marked Low Pressure Area (WML) over the same region in the early morning (0530 hours IST/ 0000 UTC) of 30th September, 2023.
> - It concentrated into a depression over the same region in the morning (0830 hours IST/0300 UTC) of 30th September.
> - It moved northeastwards and crossed south Konkan coast between Panjim (Goa) and Ratnagiri (Maharashtra) during 2030-2230 hours IST of 30th September.
> - Thereafter, it moved east-northeastwards and weakened into a well marked low pressure area over south Maharashtra in the morning (0830 hours IST/ 0300 UTC) of 1st October.
> - 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 presented in Fig. 1.
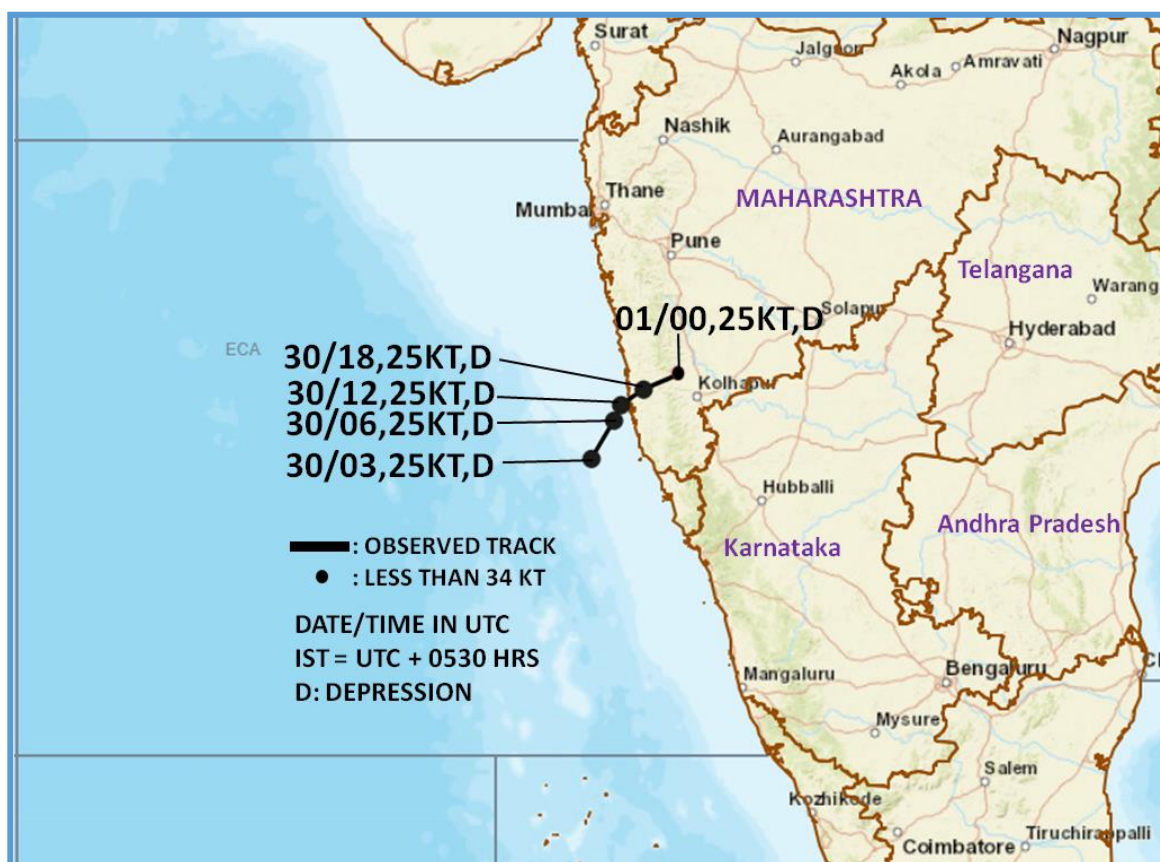

Fig. 1: Observed track of Depression over Eastcentral Arabian Sea during 30th Sep - 01st October, 2023 KT: Knots(nautical mile per hour), 1 KT=1.85 kmph, D: Depression

Table1: Best track positions and other parameters of the Depression over Eastcentral Arabian Sea during 30th Sep - 01st October, 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
30.09.2023	0300	15.9	72.8	1.5	1002	25	4	D
	0600	16.4	73.1	1.5	1002	25	4	D
	1200	16.6	73.2	1.5	1000	25	4	D
	1800	16.8	73.5	1.5	1002	25	4	D
		Crossed South Konkan coast between Panjim and Ratnagiri during 1500-1700 UTC.						
01.10.2022	0000	17.0	74.0	-	1003	25	4	D
	0300	Weakened into a well-marked low pressure area over south Madhya Maharashtra and neighbourhood.						

2. Salient features of the system:

➢ Climatologically, based on the data during September of 1891-2020, 13 cyclonic disturbances developed over the southeast and eastcentral Arabian Sea and out of these three systems crossed the west coast of India.

➢ The track length of the depression during 30 September - 1st October 2023 was 170 km with brief life period. It moved with average translational speed of 9 km/hour.

➢ It developed very close to southwest of South Konkan-Goa coast.

3. Brief life history - Genesis Intensification and movement

3.1. Genesis

Under the influence of the cyclonic circulation over North coastal Karnataka & neighbourhood, a low pressure area formed over Eastcentral Arabian Sea off South Konkan-Goa coasts in the early morning (0530 hours IST / 0000 UTC) of the 29th September, 2023. It lay as a Well Marked Low Pressure Area (WML) over the same region in the early morning (0530 hours IST / 0000 UTC) of 30th September, 2023. Under favorable environmental conditions, it concentrated into a depression over the same region in the morning (0830 hours IST / 0300 UTC) of 30th September.

At 0300 UTC of 30th September 2023, Sea surface temperature was around 28°C over eastcentral Arabian Sea. The equatorial waves forecast indicated strong westerly winds (5-7 mps) over southeast & adjoining eastcentral Arabian Sea, easterly winds (1-3 mps) over northeast Arabian Sea and equatorial rossby waves over southeast Arabian Sea. The environmental features indicated positive low level vorticity ($100 \times 10^{-6} s^{-1}$) around system centre with extension up to 500 hPa. The system was being steered east-northeastwards by the mean wind flow in the lower to middle tropospheric levels in association with large scale southwest monsoon flow. The positive convergence was about $10 \times 10^{-5} S^{-1}$ to the southwest of system centre

and positive upper level divergence was about $30 \times 10^{-5} S^{-1}$ to the southwest of system centre. Wind shear was moderate over system area (10-20 knots) and to the northeast of system area.

3.2. Intensification and movement:

Similar environmental conditions continued on 30th September and 1st October over the eastcental Arabian Sea. Further the system lay close to coast, there was land interaction. Hence the depression did not intensify further. It moved northeastwards and crossed South Konkan coast between Panjim and Ratnagiri during 1500-1700 UTC (2030-2230 IST) of 30th September 2023. After landfall it moved east-northeastwards and weakened into a well marked low pressure area over south Maharashtra in the morning (0830 hours IST / 0300 UTC) of 1st October, 2023.

### 4. Monitoring and prediction of the depression:

India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean (NIO) and the systems are monitored well in advance. The system 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. 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.

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 visible/ IR imageries, enhanced colored imageries are presented in **Fig.2(a) to 2(e)**. The organized cloud mass sheared characteristics was tracked and observed during the life cycle of the depression. The detailed features from the satellite pictures are discussed in this section.

At 0300 UTC of 30th September 2023, 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 Arabian Sea between latitude 14.0N to 20.0N and longitude 68.0E to 74.0E. Minimum Cloud Top Temperature was -85°C and moderate to intense convection lay over Konkan Goa. Multi-satellite winds indicated stronger winds in the southwest sector

At 1200 UTC of 30th September 2023, 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 Arabian Sea between latitude 15.0N to 19.0N and longitude 69.0E to 73.0E. Minimum Cloud Top Temperature was -93°C and moderate to intense convection lay over south Konkan and Goa. Multi-satellite winds indicated stronger winds in the southeast sector as the system came closer to western ghats leading to increased wind convergence in the southeast sector.
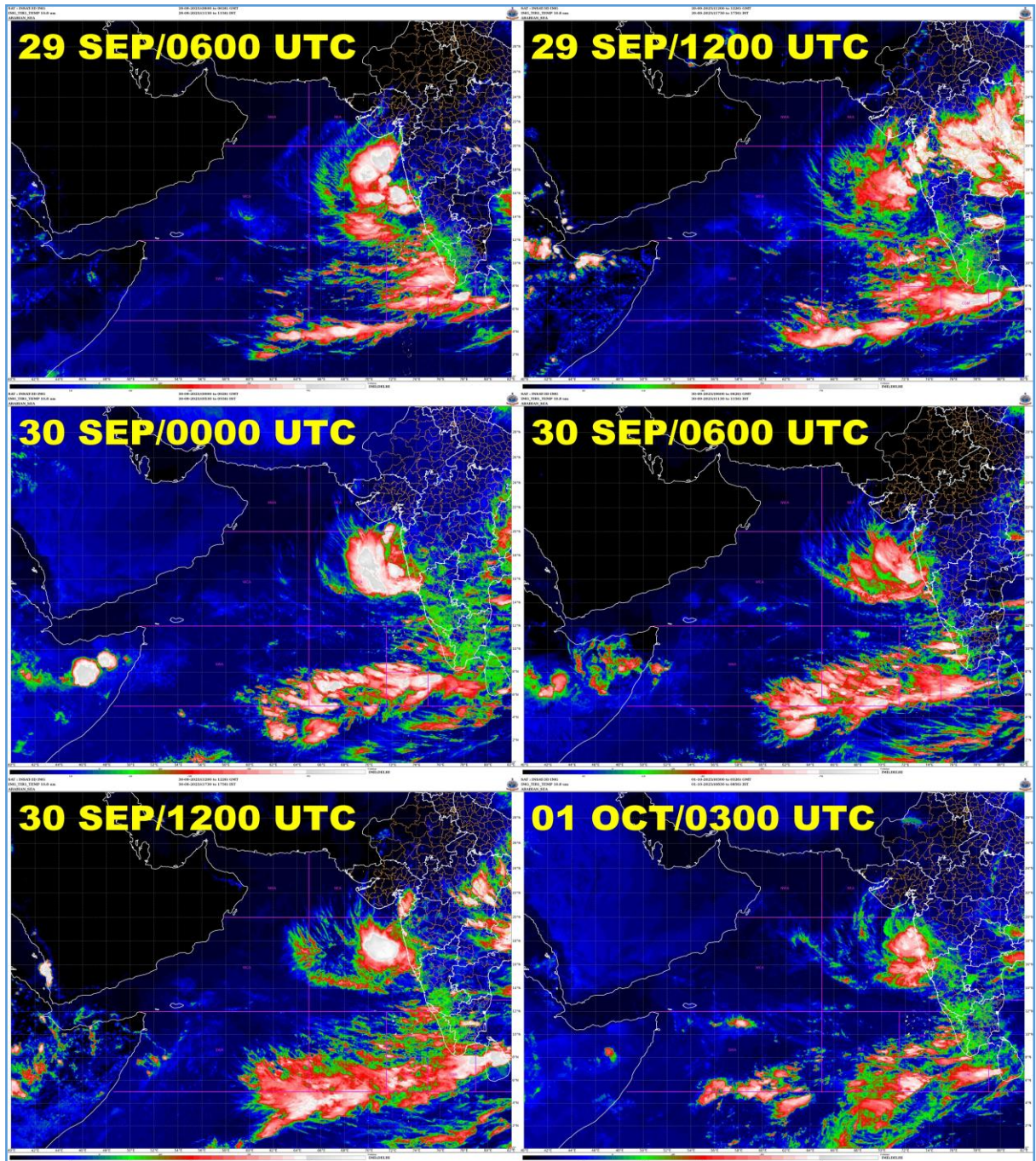
Fig.2(a): INSAT-3D enhanced colored imageries during life cycle of Depression over Eastcentral Arabian Sea during 30th Sep – 01st Oct, 2023

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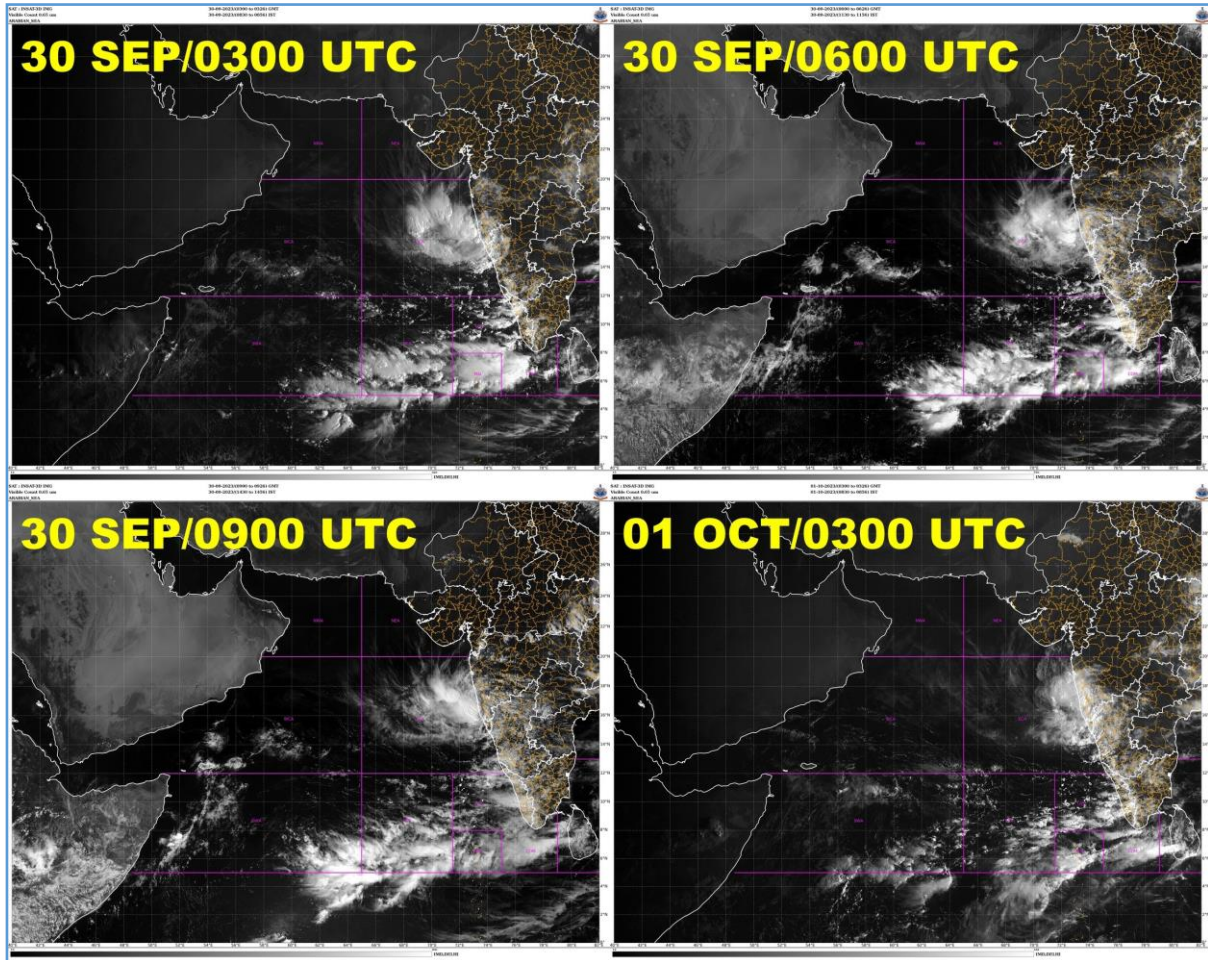
Fig.2(b): INSAT-3D Visible imageries during life cycle of Depression over Eastcentral Arabian Sea during 30th Sep – 01st Oct, 2023

At 0000 UTC of 1st October 2023, vortex lay over south Konkan adjoining south Madhya Maharashtra & neighbourhood. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over eastcentral Arabian Sea off Maharashtra coast (Cloud Top Temperature was -93°C), north Konkan coast (Cloud Top Temperature was -80°C).
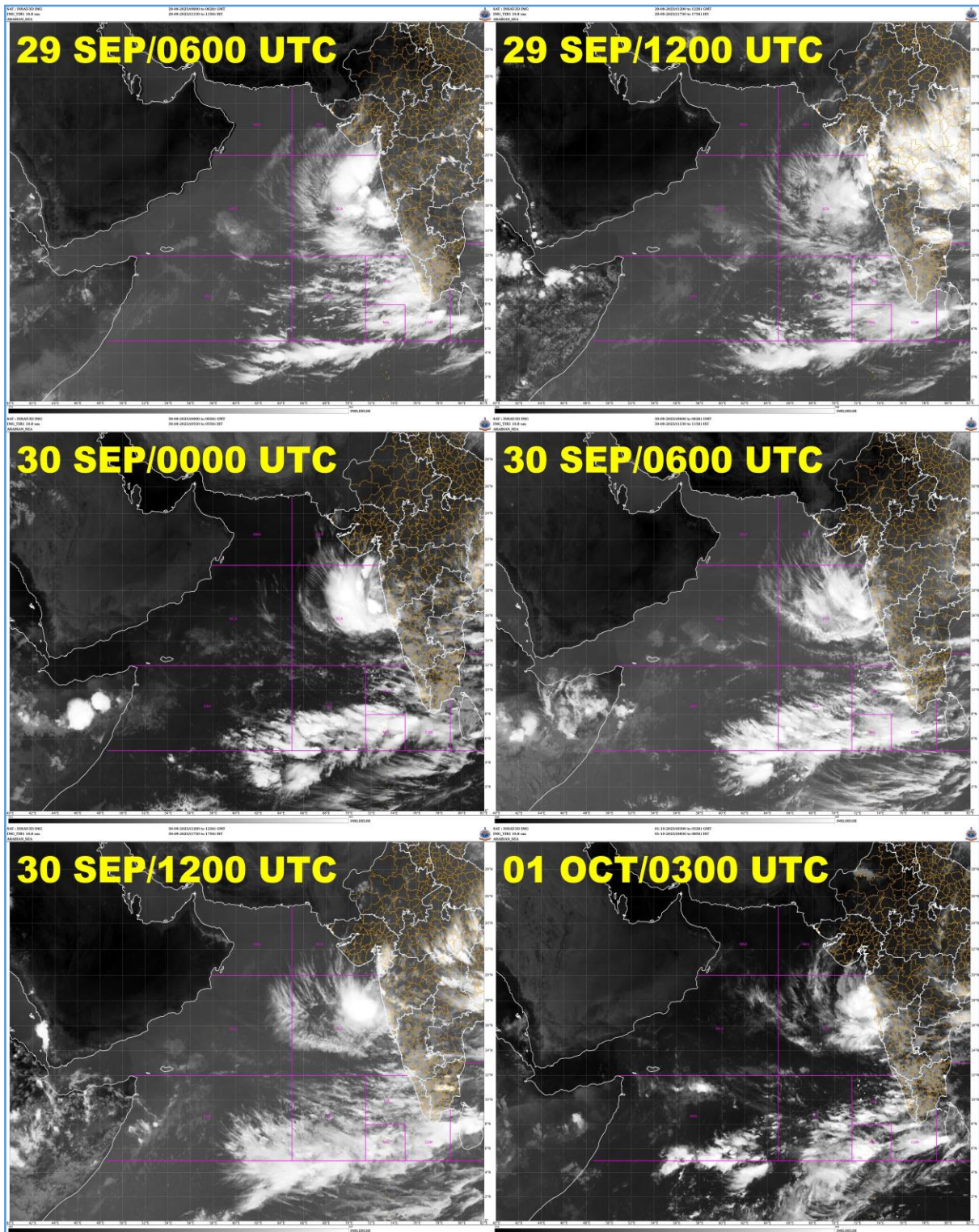
Fig.2(c): INSAT-3D IR imageries life cycle of Depression over Eastcentral Arabian Sea during 29th Sep – 01st Oct, 2023

At 0300 UTC of 1st October 2023, vortex over south Konkan and adjoining south Madhya Maharashtra & neighbourhood was centered near 17.0N / 74.0E. Centre was poorly defined in satellite imageries. Associated broken low and medium clouds with embedded moderate to intense convection lay over south Konkan adjoining eastcentral Arabian Sea and adjoining eastcentral Arabian Sea. Minimum

Cloud Top Temperature was -70 °C. Moderate convection lay over north Konkan, adjoining south Madhya Maharashtra & Goa.
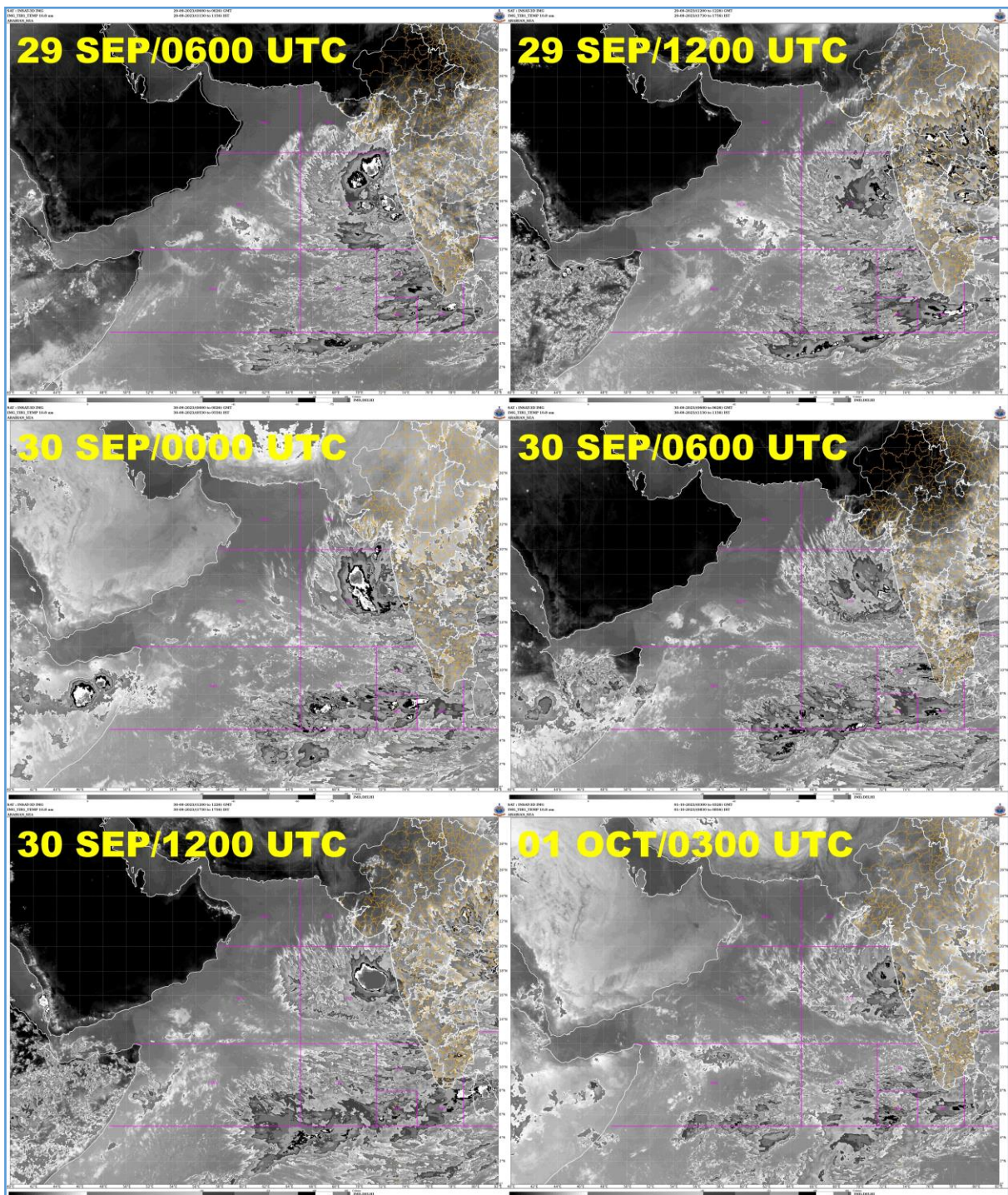
Fig.2(d): INSAT-3D BD imageries during life cycle of Depression over Eastcentral Arabian Sea during 30th Sep – 01st Oct, 2023

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 29th September to 1st October are presented in **Fig. 3(a) to 3(c)** respectively.

The MSLP analysis at 0000 UTC of 29th September clearly indicated the formation of low pressure area over Eastcentral Arabian sea off Konkan-Goa coast.
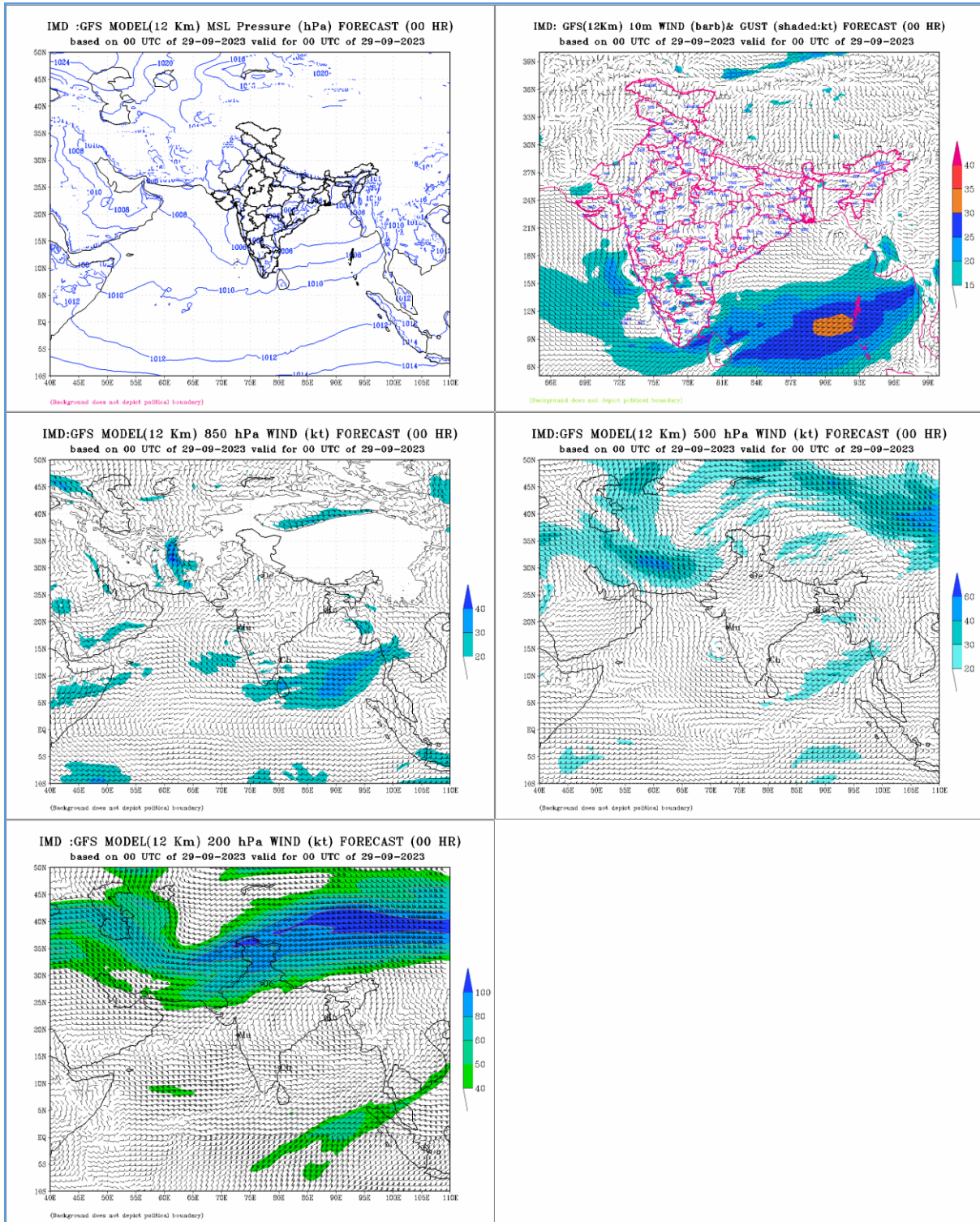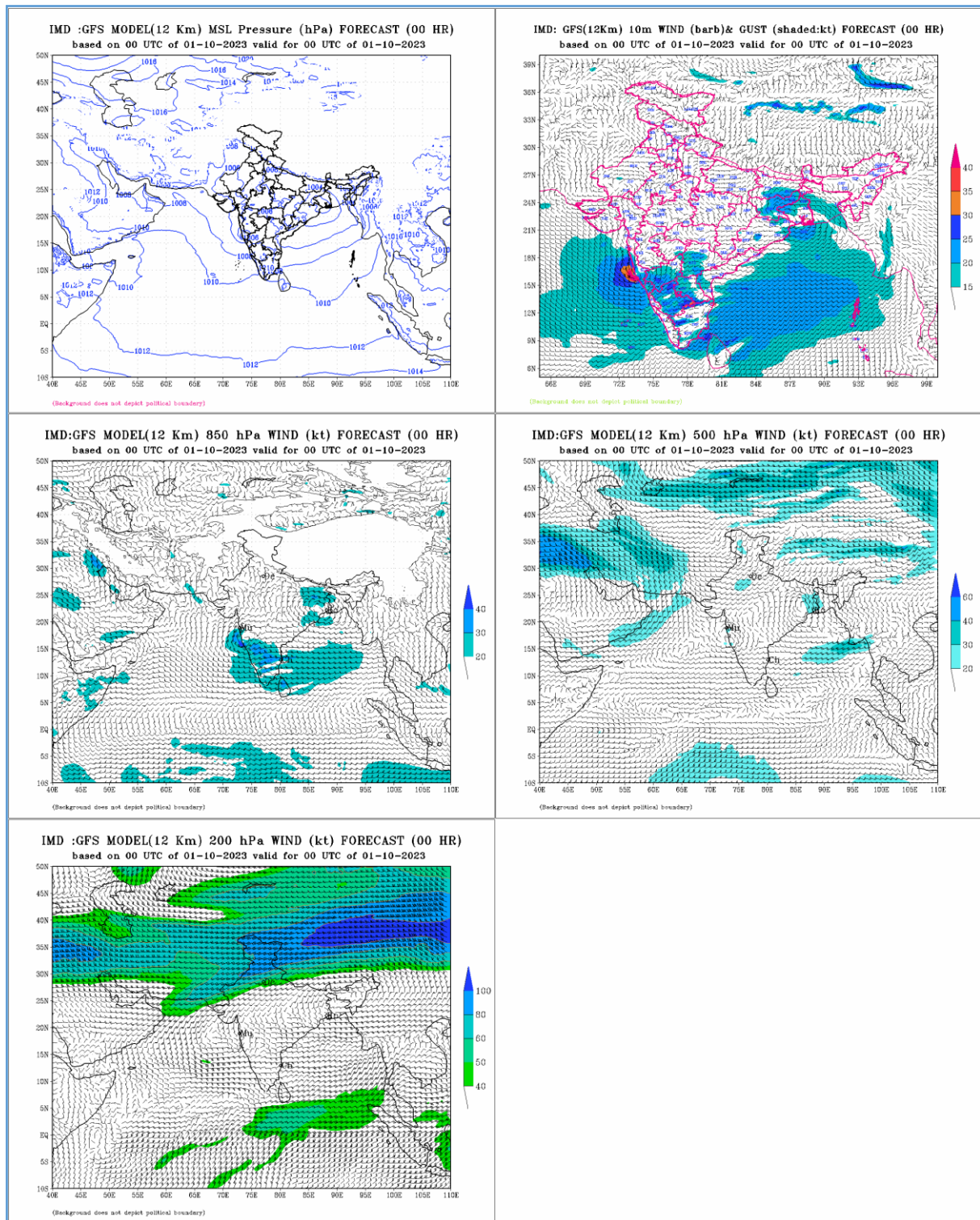

Fig. 3(a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 29th September, 2023

The MSLP analysis at 0000 UTC of 30th September with two closed isobars clearly depicted the low pressure system as a depression over eastcentral Arabian sea off south Konkan-Goa coasts. The wind fields over eastcentral Arabian Sea indicated the associated cyclonic circulation extending upto 500 hPa level. The system was steered by the lower and middle tropospheric winds which suggested northeastward to east-northeastward movement of the system.
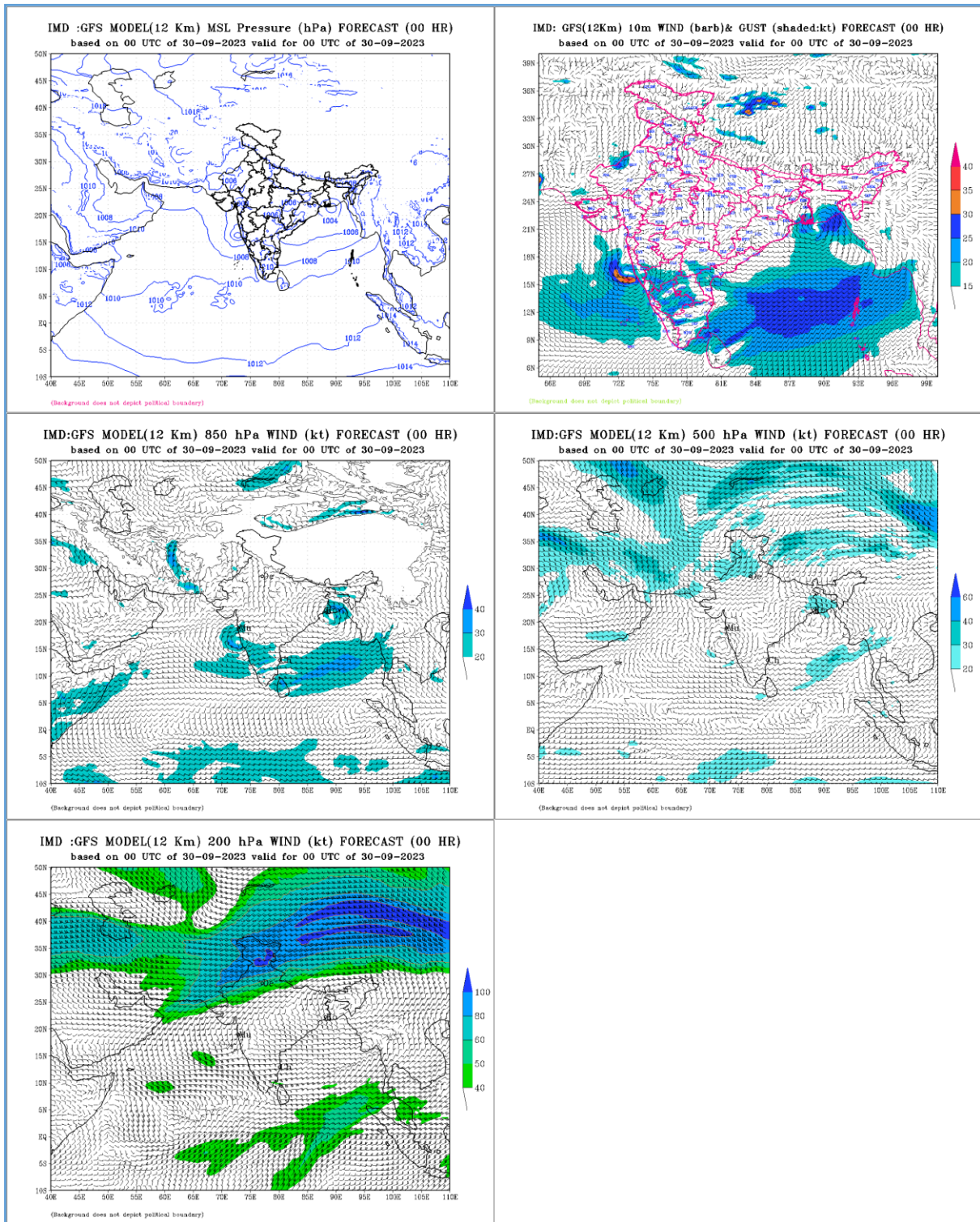

Fig. 3(b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 30th September, 2023

The MSLP analysis at 0000 UTC of 1st October indicates the weakening of the system at 0000 UTC of 1st October over south Madhya Maharashtra & neighbourhood.

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 October, 2023

ASCAT winds during 29th and 30th September are shown in figure 4. It indicated the cyclonic circulation at surface level associated with low pressure area on 29th September with intensification on 30th September.
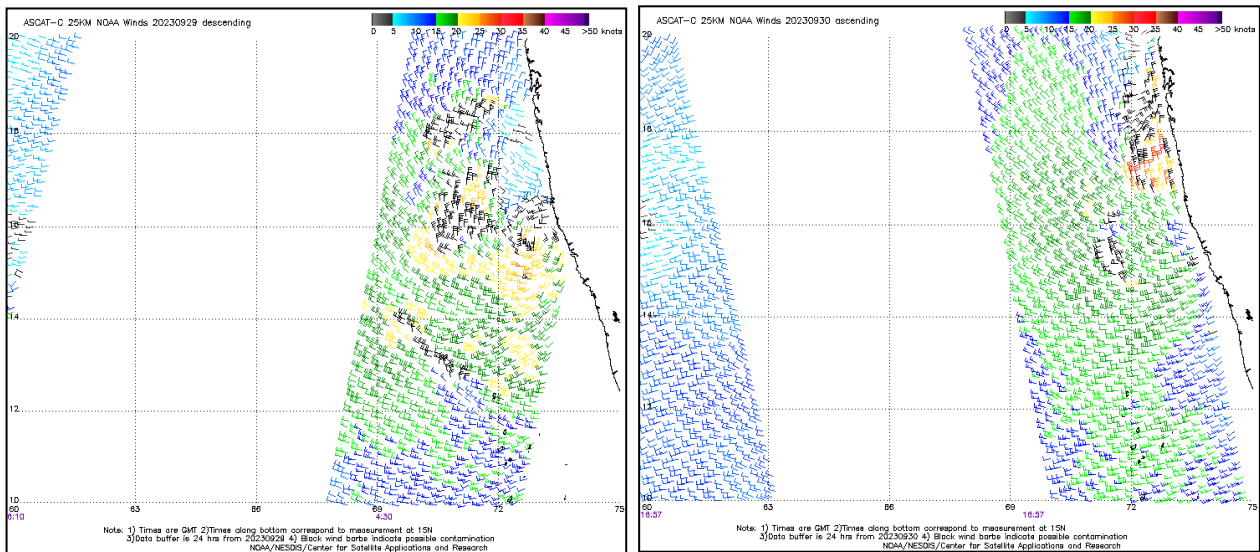
Fig. 4: ASCAT wind on 29th Sep 2023 (left) and 30th Sep 2023

6. Realized Weather

Rainfall associated with the depression based on IMD-NCMRWF GPM-gauge merged analyses and station-wise rainfalls are depicted in Fig 5 respectively.
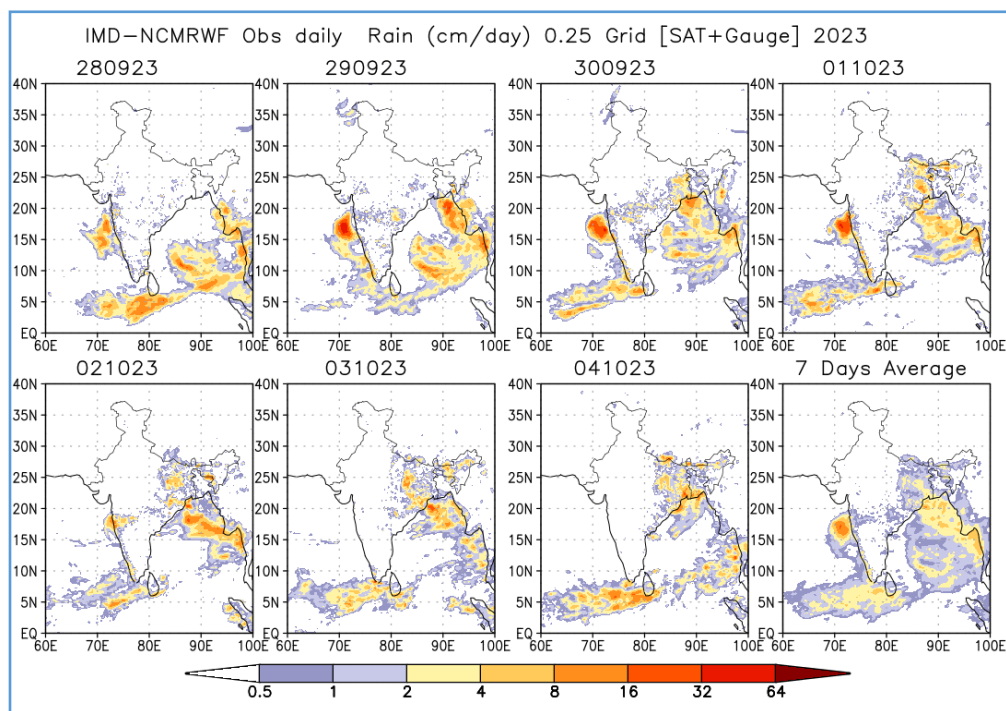
Fig. 5: IMD-NCMRWF Rain gauge and satellite merged rainfall plots during 28th Sep to 04th Oct, 2023 weekly average rainfall (cm/day)

The spatial distribution of rainfall during 28th Sep to 04th Oct clearly showed the rainfall belts over Goa, Kerala, Maharashtra & Kerala region due to the depression. It also indicates higher rainfall activity in the southwest sector of the system.

7. Damage due to the system

No damage was reported in association with this system.

8. Operational Forecast Performance

- The daily tropical weather outlook issued at 1130 hours IST of 29th September, 2023 indicated formation of low pressure area over eastcentral Arabian Sea off South Konkan-Goa coasts.
- Actually, the low Pressure Area formed over east central Arabian Sea off Konkan-Goa coasts on 30th September morning.
- In the first bulletin issued on 30th September at 0830 hours IST, it was indicated that the depression would continue to move East-Northwestwards and cross Konkan-Goa coasts between Panjim and Ratnagiri by night of 30th September.
- Thus, the genesis, track, movement and intensification/weakening of the system were well predicted by IMD/RSMC New Delhi.

9. Bulletins issued by IMD

- 7 National and 7 RSMC bulletins were issued during the system period.
- Fishermen Warning: Regular fishermen were issued in both textual and graphical formats.
- Diagnostic and prognostic features of Depression: The prognostics and diagnostics of the systems 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	7	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: Goa, Maharashtra, Karnataka, Gujarat, Daman & Diu, Dadra & Nagar Haveli, Odisha, West Bengal, Chhatisgarh, Jharkhand & Bihar.

2	RSMC Bulletin	7	1. IMD's website 2. All WMO/ESCAP member countries through GTS and E-mail. 3. Indian Navy, IAF by E-mail
3	GMDSS Bulletins	3	Highlights uploaded on facebook/twitter since formation of low pressure area.
4	Warnings through SMS	4	Nil
5	Warnings through Social Media	4	Warnings were uploaded on Social networking sites (Face book and Tweeter) since inception to weakening of system (every six hourly).

10. Summary

Under the influence of the cyclonic circulation over North coastal Karnataka & neighbourhood, a low pressure area formed over Eastcentral Arabian Sea off South Konkan-Goa coasts in the early morning (0530 hours IST) of the 29th September, 2023. It lay as a Well Marked Low Pressure Area (WML) over the same region in the early morning (0530 hours IST) of 30th September, 2023. It concentrated into a depression over the same region in the morning (0830 hours IST) of 30th September. It moved northeastwards and crossed south Konkan coast between Panjim (Goa) and Ratnagiri (Maharashtra) during 2030-2230 hours IST of 30th September. Thereafter, it moved east-northeastwards and weakened into a well marked low pressure area over south Maharashtra in the morning (0830 hours IST) of 1st October. The system caused intense rainfall activity over Kerala, Karnataka, Konkan & Goa, Maharashtra during 30th September to 2nd October.

11. Acknowledgment