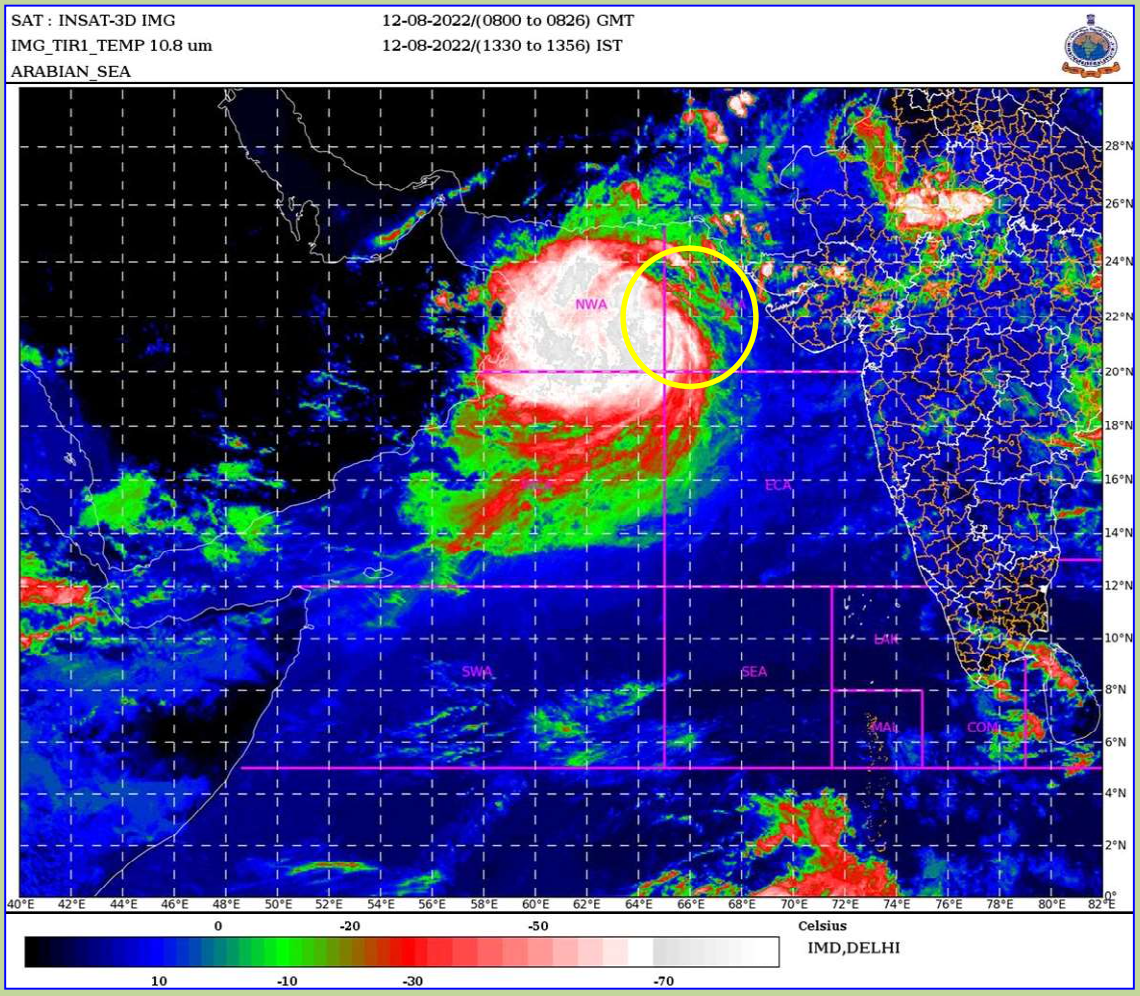
GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
INDIA METEOROLOGICAL DEPARTMENT

Depression over Arabian Sea
(12th- 13rd August, 2022): A Report



INSAT-3D enhanced Colored IR imagery based on 0600 UTC of 12th August

Cyclone Warning Division

India Meteorological Department

New Delhi

August 2022

Depression over the Arabian Sea during 12th-13th August, 2022

1. Introduction

A low pressure area formed over Saurashtra and adjoining northeast Arabian Sea (AS) in the forenoon (0830 hours IST) of 10th August, 2022. It lay as a well marked low pressure area over Saurashtra & adjoining northeast AS in the evening (1730 hours IST) of 10th August, 2022. Under favourable environmental conditions, it concentrated into a depression over northeast AS in the forenoon (0830 hours IST) of 12th August about 260 km west-southwest of Naliya (Gujarat). It moved nearly west-southwestwards till forenoon (0830 hours IST) of 13th August and thereafter moving slightly northwestwards and weakened into a WML in the evening (1730 hours IST) of 13th August, 2022, over the northwest & adjoining northeast AS.

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

Table 1: Best track positions and other parameters of Depression over Arabian Sea during 12th-13th August 2022

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)	Category
12.08.22	**0300**	22.5	66.5	**1.5**	**990**	**25**	**4**	D
	0600	22.4	66.0	**1.5**	**990**	**25**	**4**	D
	1200	22.3	65.2	**1.5**	**990**	**25**	**4**	D
	1800	22.2	64.5	**1.5**	**990**	**25**	**4**	D
13.08.22	0000	22.1	63.8	**1.5**	**990**	**25**	**4**	D
	0300	22.0	63.6	**1.5**	**990**	**25**	**4**	D
	0600	22.0	63.4	**1.5**	**990**	**20**	**3**	D
	1200	Weakened into a well marked low pressure area over the northwest & adjoining northeast Arabian Sea.						

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

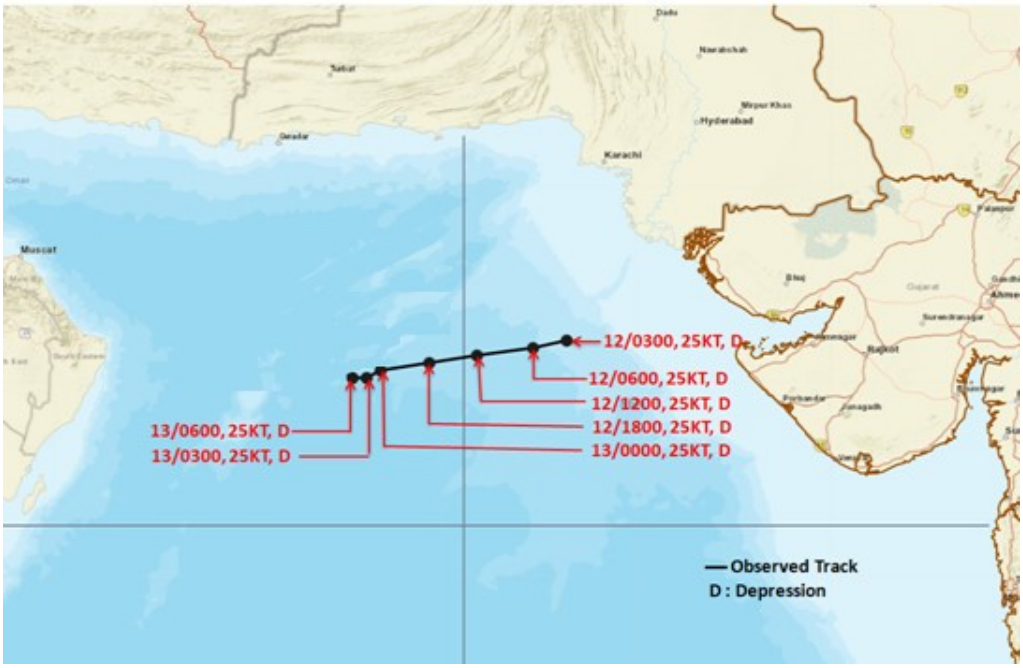


Fig.1 : Depression over northeast Arabian Sea

2. Climatological guidance

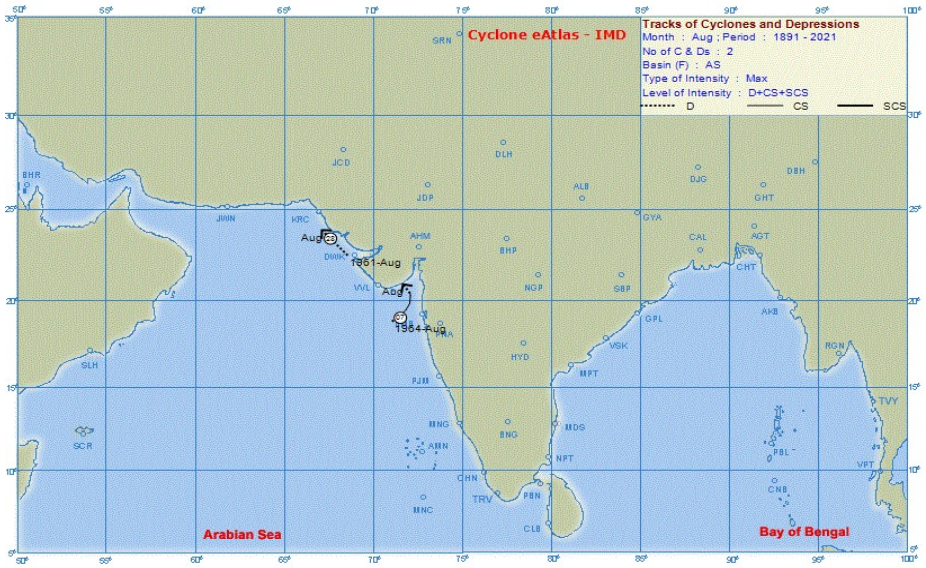


Fig: 2 Track of cyclonic disturbance during March for the period of 1891-2020

Considering past records from the year 1891 to 2021 in the E-Atlas for the cyclonic disturbances over the region, it was found that only two short-lived depressions had formed over northeast AS off Gujarat coast during August 1961 and 1964. Both the systems did not cross Indian coast. Therefore, the climatological guidance over the region suggested very low probability for the formation of cyclonic

disturbance over northeast AS along with less possibility of intensification into a tropical storm. It was also evident from the climatology that the long-life of the cyclonic disturbances was very unlikely over the region during the specified period.

3. Brief life history- Genesis Intensification and movement

Under the influence of cyclonic circulation over Gujarat region, a low pressure area formed over Saurashtra and adjoining northeast AS at 0300 UTC of 10 August. The system persisted over the same region as a well-marked low pressure area in the morning (0300 UTC) of 11 August.

The Madden Julian Oscillation (MJO) index on 12th August lay in phase 3 with amplitude less than 1. The sea surface temperature was around 28-29°C over north Arabian Sea. Total perceptible water imagery indicated warm moist air incursion into the core of system over northeast Arabian Sea. Low level vorticity increased and was around 150 x10^{-6}s^{-1} to the south of system centre. At the same time, low level convergence also increased significantly and was around 50 x10^{-5} s^{-1} to the southwest of system centre. Upper level divergence was around 30x10^{-5} s^{-1} over the same region. Wind shear was moderate (15-20 knots) over the system area. Under these favourable environmental conditions over northeast AS, the system concentrated into a depression on 0300 UTC of 12th August.

The environmental conditions from 12th morning till afternoon of 13th August supported the sustenance of the system over region and it moved nearly west-southwestward steered by the upper-level easterly outflow from an anticyclone situated over Rajasthan area.

At 1200UTC of 13th August, the low-level vorticity decreased and was around 100 x10^{-6} s^{-1} to the south of system centre. Simultaneously, low level convergence (~ 20 x10^{-5} s^{-1}) and upper level divergence (~ 10x10^{-5} s^{-1}) around the system decreased along with an increase in wind shear (high ~ 25-30 knots) over the system area. Consequently, the depression weakened gradually into a well-marked low pressure area in the night of 13th August.

4. Monitoring through satellite:

As the extended range forecast issued on 4th August indicated that the remnant of a depression originated from coastal Odisha would move nearly westward and likely to emerge into Arabian Sea towards the end of that week, India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean and the system was monitored since 4th August, about 6 days prior to the formation of LPA over Saurashtra and adjoining northeast AS on 10th and 10 days prior to formation of depression on 12th. The cyclonic disturbance 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 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. Typical satellite and radar imageries of the depression over southeast AS are presented in Fig.3.

4.1 Features observed through satellite

At 0300UTC of 12th August, as per INSAT 3D imagery the intensity of the system was characterized as T 1.5. The cloud mass was sheared to the west of system centre. Broken low and medium clouds with embedded intense to very intense convection lay over north and adjoining central Arabian Sea. Minimum CTT was -93^{0}C. At 1200UTC of 13th August , as per INSAT 3D imagery at 1200 UTC, intensity of the system was characterised as T 1.0. The sheared cloud mass of broken low and medium clouds with embedded intense to very intense convection lay over northwest and adjoining westcentral Arabian Sea and Oman with sign of disorganisation. Minimum cloud top temperature increased to -72^{0}C as the system weakened.

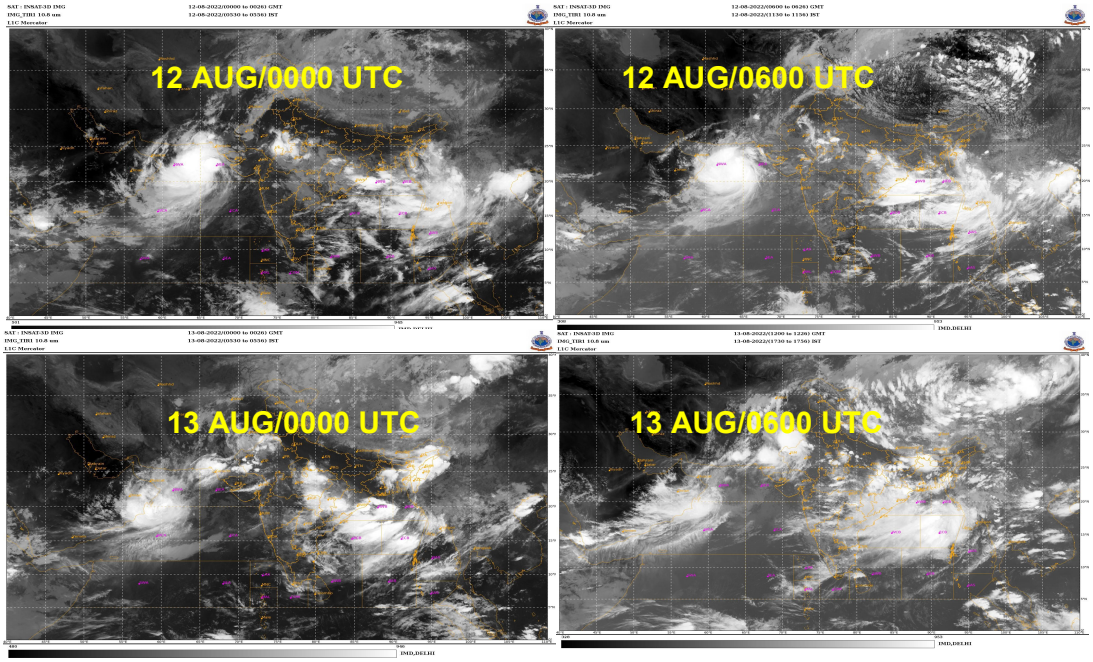


Fig. 3(i): INSAT-3D IR imageries of depression during 12th-13th August, 2022

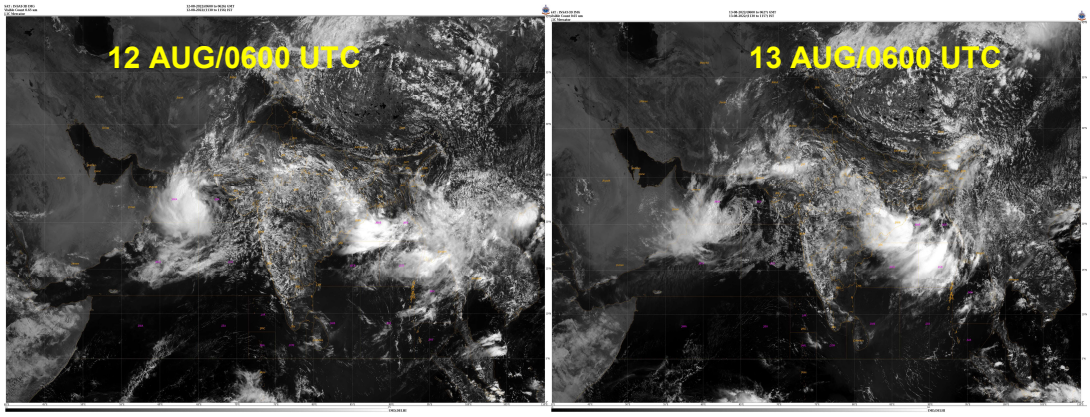


Fig. 3(ii): INSAT-3D Visible imageries of depression during 12th-13th August, 2022

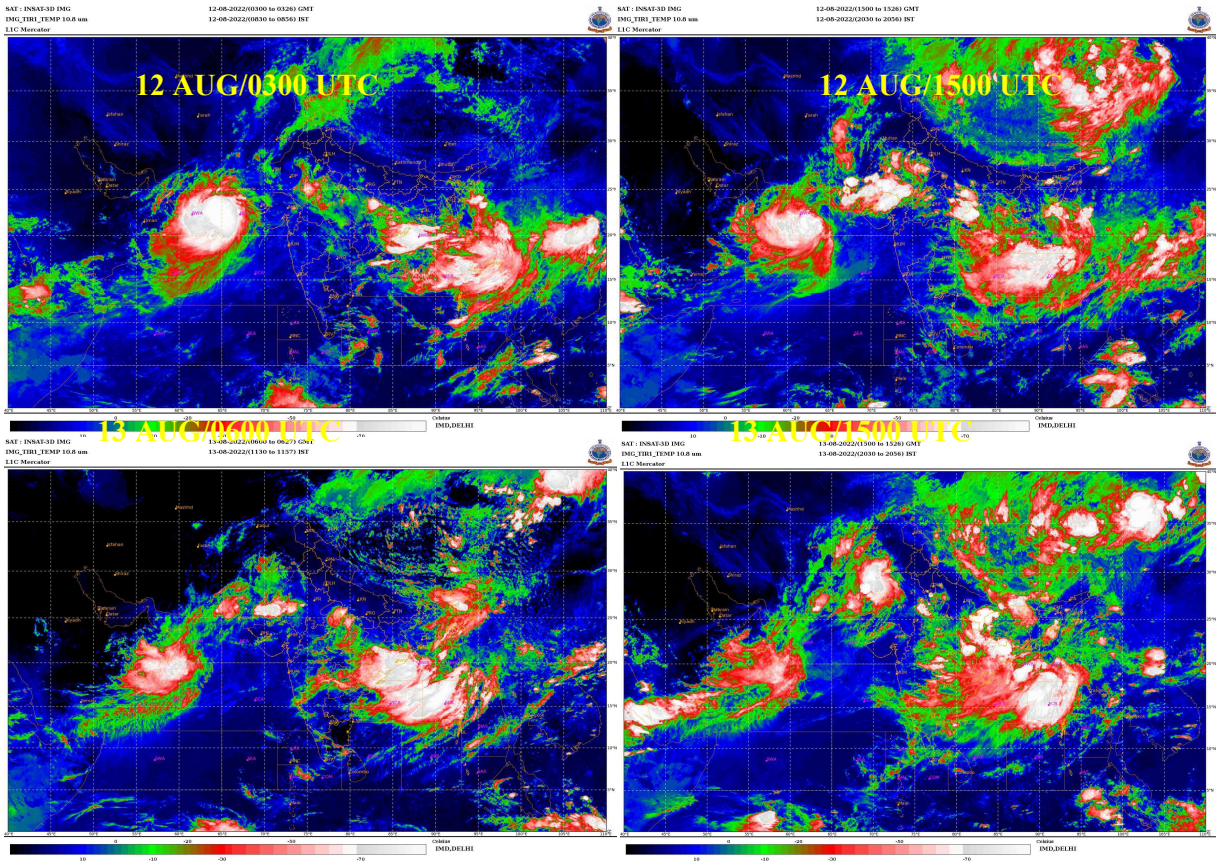


Fig. 3(iii): INSAT-3D coloured imageries of depression during 12th-13th August, 2022

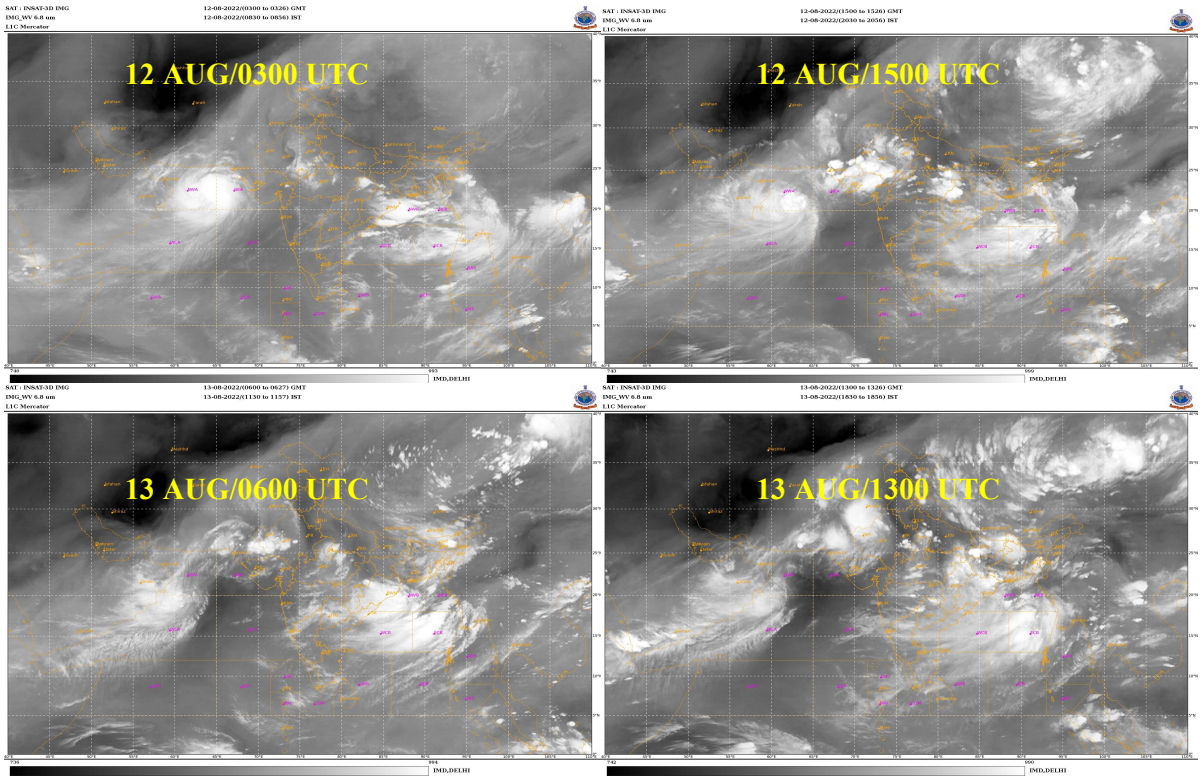


Fig. 3(iv): INSAT-3D Water Vapour imageries of depression (12th-13th August, 2022)

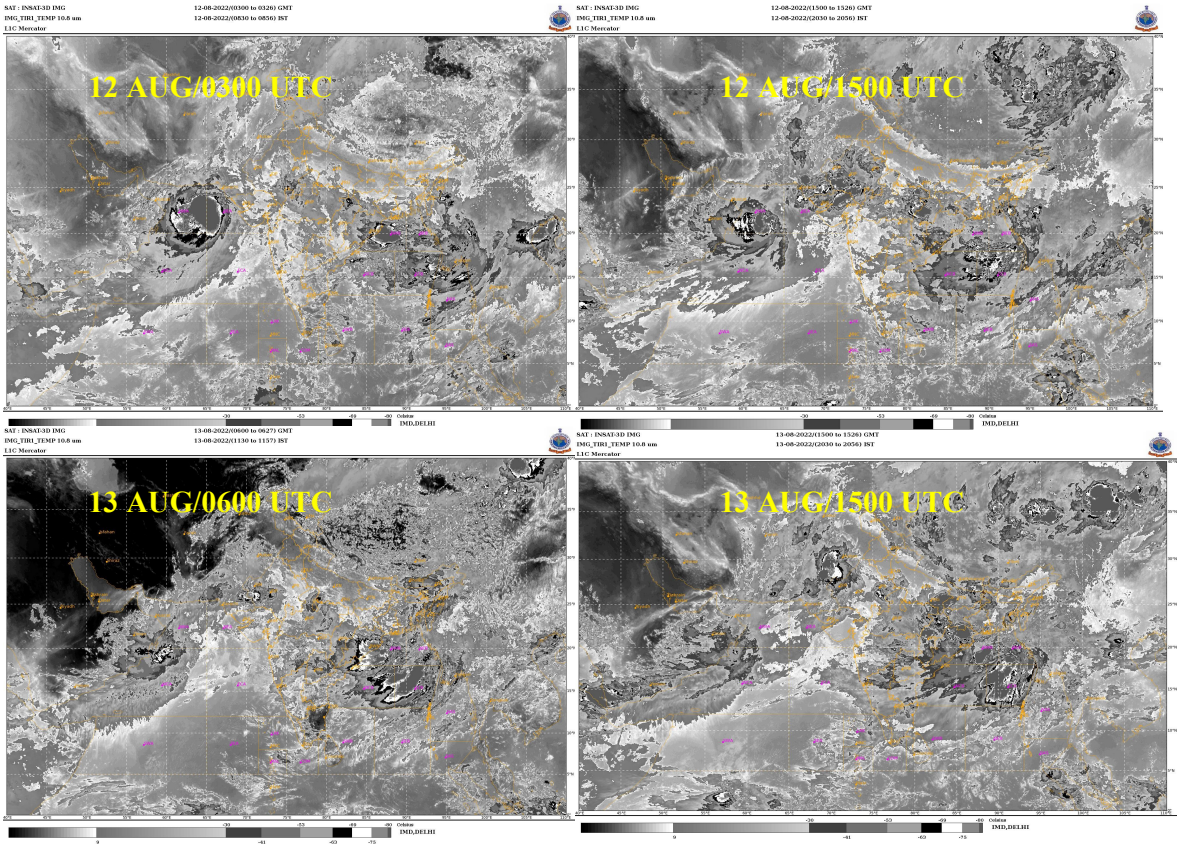


Fig. 3(iv): INSAT-3D IR BD imageries of depression during 12th-13th August, 2022

5. Dynamical features

IMD GFS (T1534) analyses of mean sea level pressure (MSLP), winds at 10 m, 850, 500 and 200 hPa levels are presented in Fig.5. The MSLP analysis field of IMD GFS at 0000 UTC of 12th August indicated the system over northwest Sourashtra & adjoining northeast AS with associated cyclonic circulations extending up to 500 hPa level in the wind field. East-northeasterly winds prevailed in the upper level indicating nearly westwards movement. GFS slightly underestimated the intensity at 0000 UTC of 12th, as system lay as a depression over the region at that time.

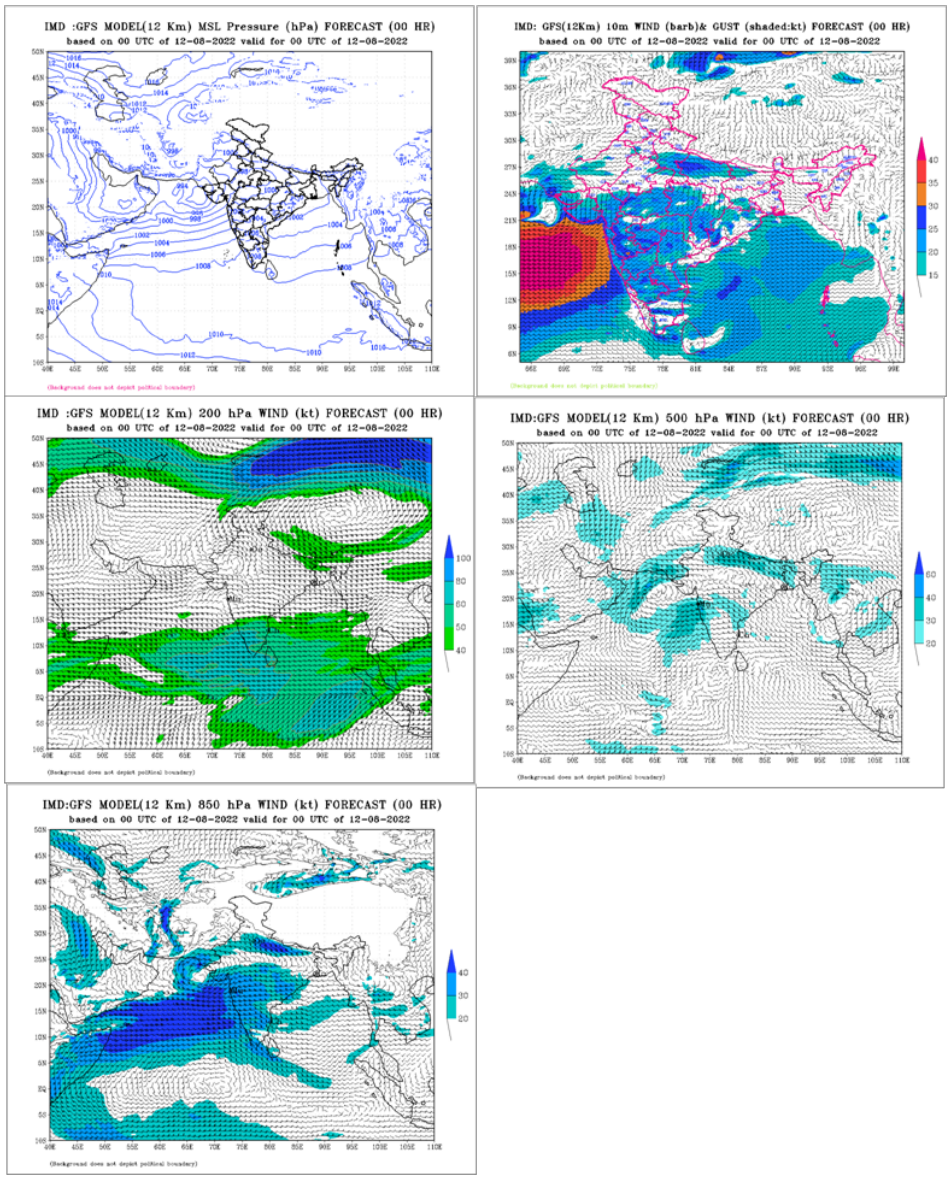


Fig4 (i): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 12th August 2022

The analysis field of IMD GFS at 0000 UTC of 13th September indicated further intensification of system over northwest & adjoining northeast AS with vertical extension up to 500 hPa level. However, GFS slightly over-estimated the intensity at 0000 UTC of 13th, as the system weakened into a well-marked low and lay over the northeast & adjoining northwest AS at that time.

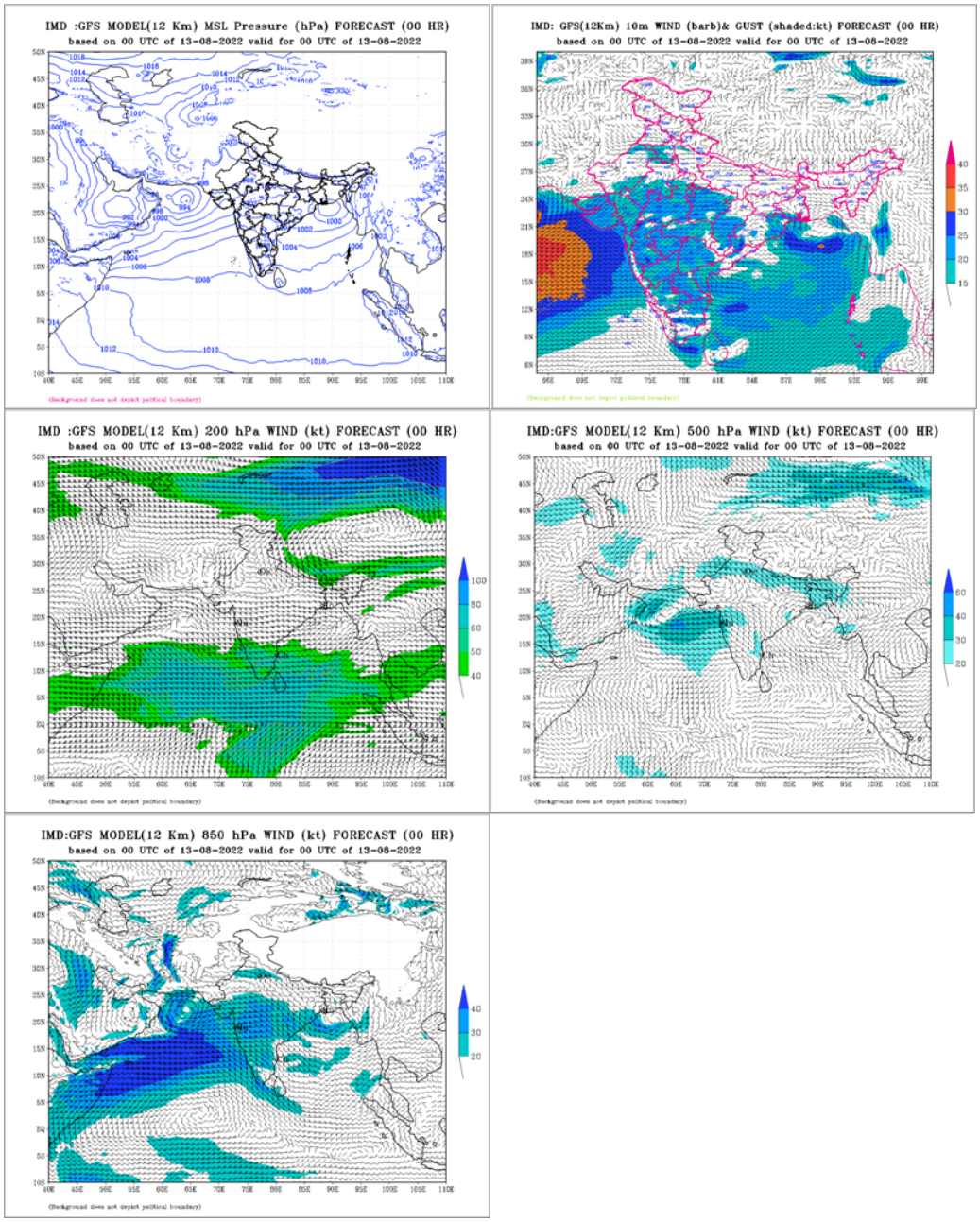


Fig4 (ii): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 13rd August 2022

Thus, IMD GFS could capture the genesis and movement correctly. However, it slightly underestimated the intensity on 12th whereas overestimated the intensity of the system on 13th August.

6. Realized Weather:

6.1 Rainfall

The daily rainfall distribution ending at 0300 UTC of each date during 11-17 August, 2022 based on GPM-gauge merged gridded rainfall analyses of IMD/NCMRWF are shown in Fig.5.

In conjunction with another low pressure area over Sourashtra and adjoining area, heavy rainfall at a few places occurred over Saurashtra and north Konkan on 11th August. However, due to low pressure system and depression over the region, the heavy rainfall was realized over northeast AS. The system did not caused rainfall activity over Indian land mass.

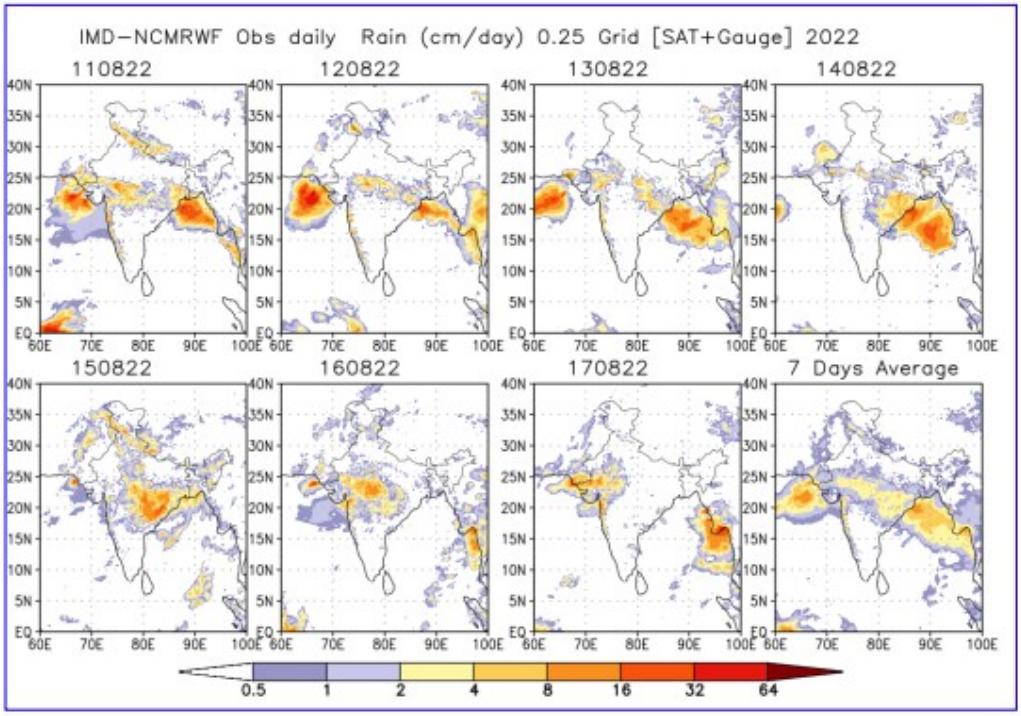


Fig.5: Daily rainfall distribution based on merged grided rainfall data of IMD/NCMRWF during 11 August- 17 August, 2022

(Heavy rainfall distribution: Isolated places: upto 25%, A few places: 26-50%, Many places : 51-75%, Most places: 76-100% of total stations in the region;
Heavy rainfall: 64.5 – 115.5 mm, Very heavy rainfall: 115.6 – 204.4 mm, Extremely heavy rainfall: 204.5 mm or more).

The station-wise rainfall distribution for the daily cumulative rainfall during 11th to 13th August are shown in Fig 6. It is clear that the influence of the system was visible during 11th to 12th over Sourashtra & Gujarat region which diminished on 13th August as the system moved further away from the Indian region.

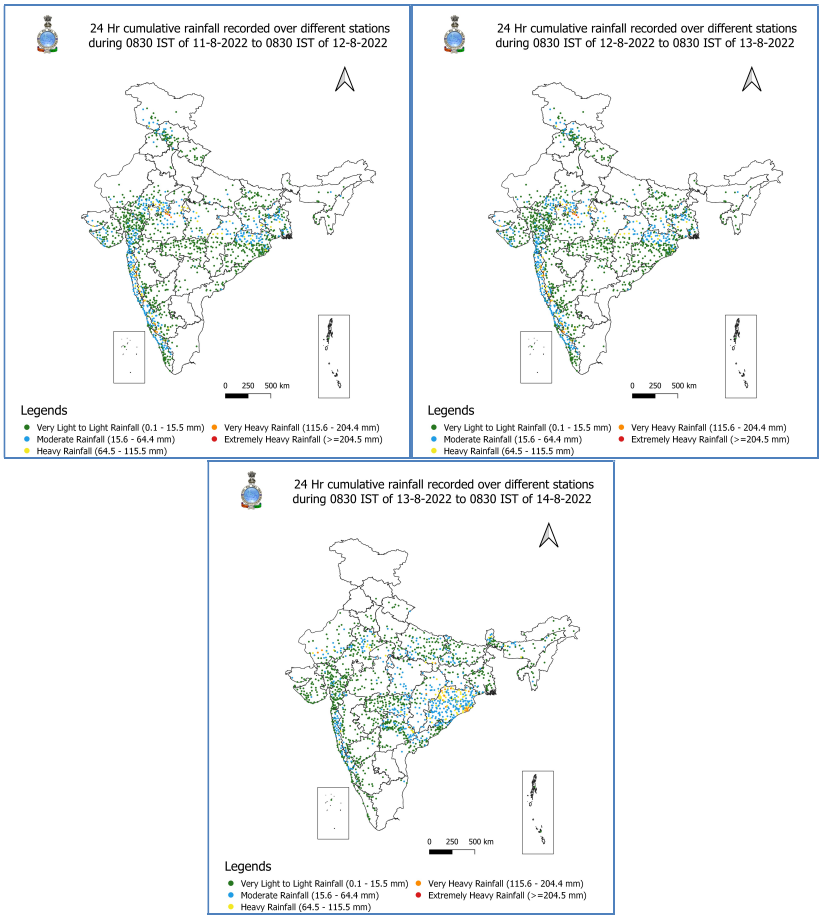


Fig. 6. Daily 24 hr cumulative rainfall distribution recorded over different stations of IMD during 11-13th August 2022.

Daily 24 hours cumulative rainfall ending at 0830 hours IST of date in association with the system exceeding 7 cm (≥ 7cm) are described below.

12th August:

EAST RAJASTHAN:-

Aklera-13, Mandana Sr-12, Bhainsroadgarh Sr-11, Bijoliya Sr-10, Manohar Thana-8, Sangod-8, Ramganjmandi Sr-7, Pirawa-7

WEST MADHYA PRADESH:-

Biaora-22,Ashoknagar-Aws-18, Rajgarh-13,Khilchipur-12,Narsingarh-12, Neemuch-Aws-11,Zirapur-10, Bamori-8, Ganjbasoda-8, Jawad-8, Mungaoli-7, Malhargarh-7, Shyampur-7, Manasa-7, Guna-Aws-7, Nateran-7, Chanderi-7

EAST MADHYA PRADESH:-

Badamalhera-18, Birsa-12, Simariya-11, Pawai-10, Jaitpur-10, Hatta-10, Bijawar-9, Lalburra-8, Shahpura (District: Dindori)-8, Malanjkhand-7, Patan-7, Bakal-7, Batiyagarh-7, Bina-7

SAURASHTRA & KUTCH:-Porbandar-8, Mandvi(K)-7

6. Operational Forecast Performance

- The extended range forecast issued on 4th August mentioned about the emergence of the low pressure system nearly 6 days prior to the formation of LPA over Sourashtra and adjoining northeast AS.
- The daily tropical weather outlook issued at 1130 hours IST of 10th August indicated of formation of depression over northeast & adjoining northwest Arabian Sea during 12th-13th August with low probability (1-33%).
- Actually, low pressure area/well marked low pressure area formed over northeast & adjoining northwest Arabian Sea on 10th & 11th August respectively and depression formed over northeast & adjoining northwest Arabian Sea on 12th August.
- In the first bulletin issued on 12th August at 0830 hours IST, it was indicated that the depression would continue to move nearly westwards, weaken gradually over northwest AS. It was also mentioned that the remnant of the depression as a WML would recurve north-northeastwards over northeast AS.

Table 2. Rainfall forecast verification

S.No.	Rainfall Forecast upto 0300 UTC	Verification (Realized Rainfall at 0300 UTC of)
12/08 0300UTC	Light to moderate rainfall at a few places is likely over Saurashtra & Kutch and Gujarat region during next 24 hours.	**SAURASHTRA & KUTCH:-** Porbandar-8, Mandvi(K)-7

7. Damage by Depression

No damage was reported due to Depression as it moved away from India coast.

8. Bulletins issued by IMD

IMD issued regular bulletins to WMO/ESCAP Panel member countries including Pakistan, Oman and Iran, National & State Disaster Management Agencies of Gujarat, Rajasthan, Daman and Diu, Dadra & Nagar Haveli & Maharashtra along with public and media. Regular Bulletins every six hourly were issued since formation of depression over northeast AS. In addition, RSMC New Delhi also issued Press Release and SMS to registered users. The frequent updates on WhatsApp, Facebook, Tweeter were issued by IMD to trigger early action.

Bulletins issued by Cyclone Warning Division of IMD in association with the system are given in Table 3(a) and the details of bulletins issued by Cyclone Warning Centre (CWC) Ahmadabad are shown in Table 3(b).

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

S. N.	Bulletins	No. of Bulletins	Issued to
1	National Bulletin	8	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	8	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	2	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	59108 131	Sent to general public and fishermen Disaster Managers, State officers

Table-3(b): Bulletins issued by Cyclone Warning Centre (CWC) Ahmadabad

S. N.	Type of Bulletin	Number of Bulletins
		MC Ahmadabad
1.	Sea Area Bulletins	NIL
2.	Coastal Weather Bulletins	10(twice a day * 5 days)
3.	Fishermen Warnings issued	20(four times a day * 5 days)
4.	Port Warnings	08
5.	Heavy Rainfall Warning	02
6.	Gale Wind Warning	NIL
7.	Storm surge warning	NIL
8.	Information & Warning issued to State Government and other Agencies	Briefing to C.S , DoR ,CoR , By email ,social media
9.	SMS/ Whatsapp (message in group)	Message through CAP

9. Summary and Conclusions:

A low pressure area (LPA) formed over Sourashtra & adjoining northeast AS at 0830 IST of 10th August under the influence of the remnant of the low pressure system which earlier emerged from the coastal Odisha region and dissipated over southeast Madhya Pradesh and adjoining Gujarat region. Moving nearly westward away from the Indian region the system gradually intensified into a depression on 12th August over northeast AS. Continuing to move further nearly west-southwestward, it weakened into a WML over northwest & northeast AS on 13th August.

The system caused widespread rainfall with isolated heavy rainfall over Sourashtra & Kutch region on 12th August but the prominent rainfall area was noticed over the northeast AS. Subsequently, during 13th August, the associated heavy rainfall zone shifted westward over the sea along with the system and rainfall activity over Gujarat state decreased significantly.

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 IIT Bhubaneswar, and Indian Space Research Organisation (SAC-ISRO) for their valuable support. The support from various Divisions/Sections of IMD including Area Cyclone Warning Centre (ACWC) Mumbai, Cyclone Warning Centre (CWC) Ahmedabad, 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.