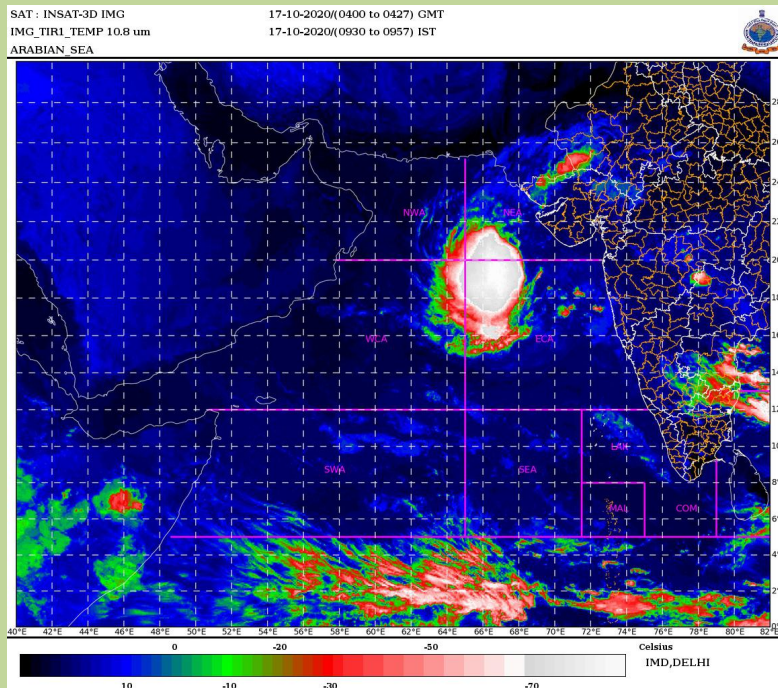




**GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
INDIA METEOROLOGICAL DEPARTMENT**

**Deep Depression over the Arabian Sea
(17-19 October, 2020): A Report**



INSAT-3D enhanced Colored IR imagery based on 0400 UTC of 17th October

**Cyclone Warning Division
India Meteorological Department
New Delhi
October, 2020**

Depression over the Arabian Sea during 17-19 October, 2020

1. Introduction

- ❖ The Depression originated from the remnant well marked low pressure area of the last Deep Depression which moved across south Peninsular India during 11th – 14th October.
- ❖ Last Deep Depression had weakened into a Well Marked Low pressure area and lay centred over South Madhya Maharashtra and neighbourhood in the evening (1200 UTC) of 14th October 2020.
- ❖ It moved across Maharashtra and emerged as a well marked low pressure area over east-central Arabian Sea (AS) off Maharashtra coast on 16th early morning (0000 UTC).
- ❖ Subsequently it re-intensified into a **Depression** over the same region (east-central AS off Maharashtra coast) on 17th morning (0300 UTC).
- ❖ It maintained its intensity of depression till 19th early morning (0000 UTC) while moving westwards, away from Indian coast and weakened into a well marked low pressure area in the early morning of 19th October.
- ❖ As it moved away from the Indian coast, it had no impact along Indian coast from 18th October 2020.

The salient features of the system were as follows:

- (i) It had a straight westward track.
- (ii) It had a life period of nearly 45 hours.
- (iii) It had a track length of nearly 500 km.
- (iv) Under the influence of this system there had been rough to very rough Seas and squally weather over east-central & adjoining northeast AS off north Maharashtra – south Gujarat coasts on 17th October and over east-central and adjoining northeast AS on 18th October.

IMD mobilised all its resources to track the system and regular warnings w.r.t. track, intensity, associated severe weather and adverse impacts & suggested actions were issued to concerned central and state disaster management agencies, print & electronic media and general public. Regular advisories were also issued to WMO/ESCAP Panel member countries. Its genesis, movement and associated adverse weather could be predicted with actionable accuracy by IMD.

The brief life history, associated weather and forecast performance of IMD/RSMC, New Delhi are presented in following sections.

The observed track of the Depression over east-central AS is presented in Fig.1. The best track parameters of the system are presented in Table 1.

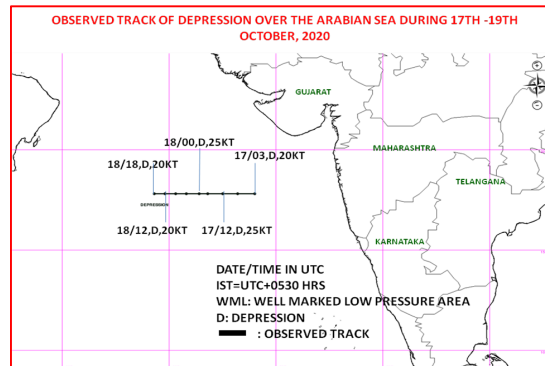


Fig.1. Observed track of Depression over the Arabian Sea (17-19 October, 2020)

Table 1: Best track positions and other parameters of the observed track of Deep Depression over west-central Bay of Bengal (11-14 October, 2020)

Date	Time (UTC)	Centre lat. ^o N/ long. ^o E	C.I. NO	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
17/10/2020	0300	17.8 69.0	1.5	1004	20	3	D
	0600	17.8 68.2	1.5	1004	20	3	D
	1200	17.8 67.5	1.5	1003	25	4	D
	1800	17.8 66.8	1.5	1003	25	4	D
18/10/2020	0000	17.8 66.4	1.5	1003	25	4	D
	0300	17.8 65.8	1.5	1004	20	3	D
	0600	17.8 65.3	1.5	1004	20	3	D
	1200	17.8 64.8	1.5	1004	20	3	D
1800	17.8 64.3	1.5	1004	20	3	D	
19/10/2020	0000	Weakened into well marked low pressure area over westcentral Arabian Sea and neighbourhood					

2. Monitoring of the system:

India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean and the development of the system was monitored since 08th October, about 9 days prior to the formation of the Depression over eastcentral AS on 17th October. The **Depression** was monitored with the help of available satellite observations from INSAT 3D and 3DR, SCAT SAT, polar orbiting satellites and available ships & buoy observations in the region. The system in its initial stage was also monitored by Doppler Weather RADAR (DWR) Mumbai. Various numerical

weather prediction models run by Ministry of Earth Sciences (MoES) institutions, models run by other Global centres and dynamical-statistical models were utilized to predict the genesis, track, landfall and intensity of the Depression. A digitized forecasting system of IMD was utilized for analysis and comparison of various models' guidance, decision making process and warning products generation. As the system was expected to move away from the Indian coast, no heavy rainfall warning was issued in association with the system. However, necessary Sea area warnings & fishermen warnings with suggested actions were issued by IMD well in advance to all concerned states, media and stakeholders.

3. Genesis, intensification and movement

Typical satellite imageries are presented in **Fig.2**.

Some of the favourable environmental features which aided in the formation of the Depression and its westward track and dissipation over the Sea are as follows:

The convectively active phase of Madden Julian Oscillation (MJO) remained in Phase 5 with amplitude more than 1. This supported convection over the north Indian Ocean during the period.

The Sea Surface Temperature (SST) remained to be around 28-29°C over most parts of Arabian Sea (AS). It was slightly higher (30-32°C) over Gulf of Oman and cooler (26- 24°C) all along Oman – Yemen and Arabian coasts and 26 -27°C over west-central & southwest AS during 17th -19th October. The Tropical Cyclone Heat Potential (TCHP) was less than 50KJ/cm² to the west of 55°E over the AS and 100 – 120 kJ/cm² over south AS. Over north AS, it was between 50-70 kJ/cm², to the east of 55°E, except over south Gujarat coast where it was less than 50KJ/cm² during 17th – 19th October.

The relative vorticity at 850 hPa was around $100 \times 10^{-6} \text{s}^{-1}$ over east-central AS & adjoining northeast AS and extended upto 200 hPa on 17th October, around $50 - 70 \times 10^{-6} \text{s}^{-1}$ over west-central AS & adjoining northeast AS extending upto 500 hPa on 18th and around $50 - 60 \times 10^{-6} \text{s}^{-1}$ over west-central AS extending upto 500 hPa on 19th October.

Low level convergence of ($5 \times 10^{-5} \text{s}^{-1}$) prevailed over east-central AS on 17th October, ($5 \times 10^{-5} \text{s}^{-1}$) over west-central AS on 18th and isolated small areas of positive convergence zone ($5 \times 10^{-5} \text{s}^{-1}$) over north & west-central AS on 19th October. Upper level divergence of ($20 \times 10^{-5} \text{s}^{-1}$) prevailed over east-central AS on 17th October, ($05-10 \times 10^{-5} \text{s}^{-1}$) over west-central AS on 18th and isolated pockets of divergence zones ($05 \times 10^{-5} \text{s}^{-1}$) over west-central AS on 19th October.

Moderate (10-20 kts) vertical wind shear (VWS) prevailed over east-central & adjoining northeast AS with a decreasing wind shear tendency on 17th October, low to moderate (05-15 kts) over north AS and high (40-50 kts) over remaining parts of Arabian Sea with a decreasing wind shear tendency over northern parts of the AS and increasing tendency over south & central parts on 18th and low to moderate (05-20 kts) over north & adjoining central AS and high (40-50 kts) over remaining parts of Arabian Sea with decreasing wind shear tendency over northern parts of the AS and increasing or neutral tendency over south & central parts of the AS on 19th October. The upper tropospheric ridge at 200 hPa extended roughly along Lat. 22°N across north Arabian Sea during 17th – 19th October, directing the system in a westward

track. As it moved westwards, it gradually experienced colder Sea area. As a result, the system did not intensify further and weakened into a well marked low on 19th due to unfavourable vertical wind shear and colder Sea.

According to satellite imagery on 17th October, the intensity of the system was T 1.5. The convection was organised in shear pattern. Associated broken low and medium clouds with embedded intense to very intense convection lay over east-central and adjoining northeast AS between latitude 16.5°N & 22.0°N & longitude 62.5°E & 68.0°E. Minimum cloud top temperature was -90°C. According to satellite imagery on 18th October, the intensity of the system was T 1.5. The convection was organised in shear pattern. Associated scattered to broken low and medium clouds with embedded intense to very intense convection lay over central and adjoining north AS between latitude 16.5°N - 22.5°N & longitude 60.0°E - 65.0°E. Minimum cloud top temperature was -78°C. According to satellite imagery of 19th October, the intensity of the system has been T 1.5. The convection was organised in shear pattern. Associated scattered to broken low and medium clouds with embedded isolated moderate to intense convection lay over west-central and adjoining northwest AS between latitude 16.0°N - 21.0°N & to the west of longitude 64.0°E and adjoining coastal Oman. Minimum cloud top temperature was -82°C.

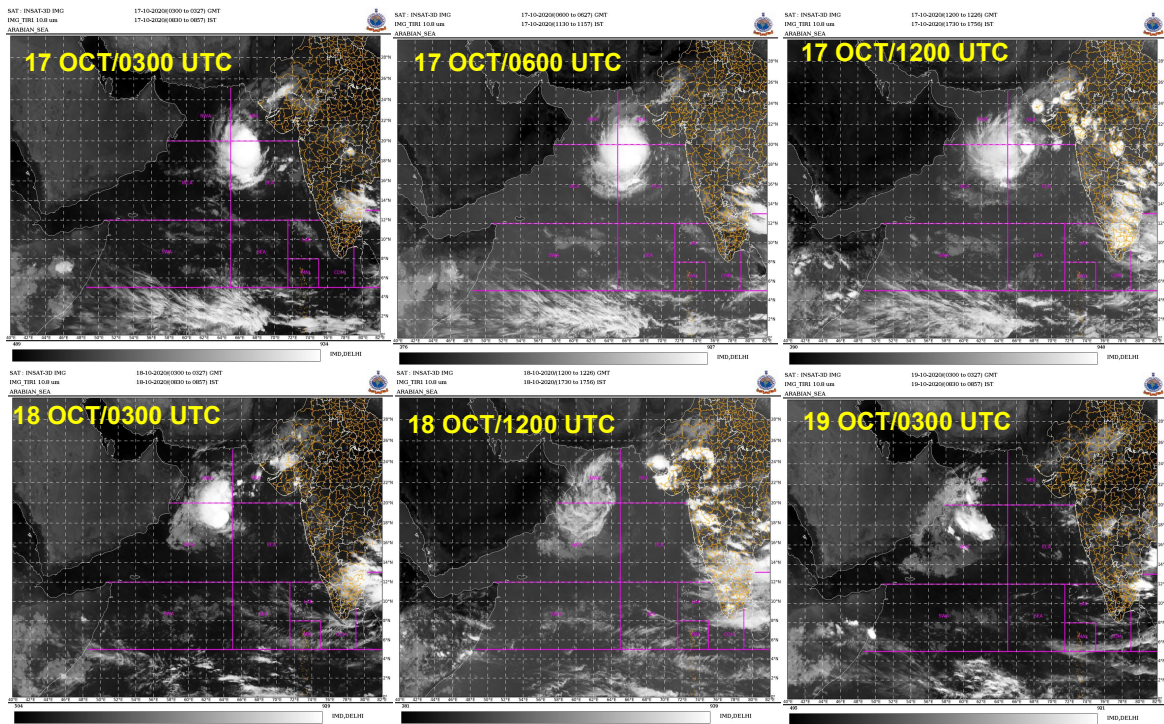


Fig. 2a: INSAT-3D IR imageries during life cycle of the Depression (17-19 October, 2020)

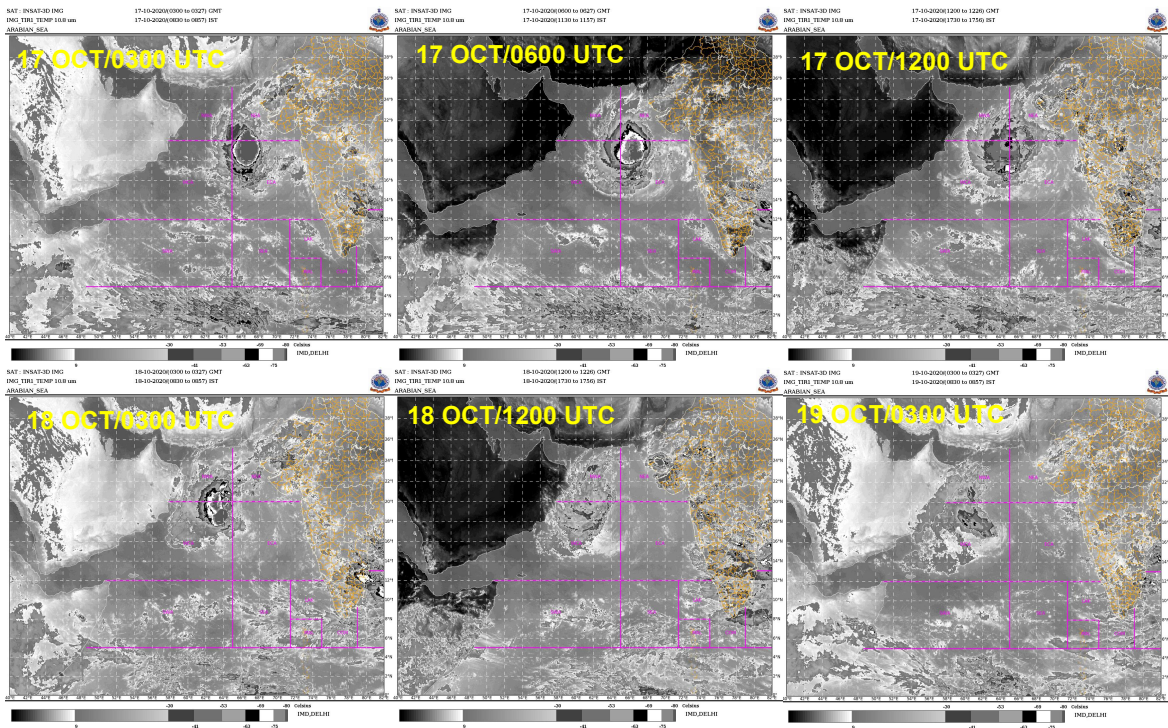


Fig. 2b: INSAT-3D cloud top brightness imageries during life cycle of the Depression (17-19 October, 2020)

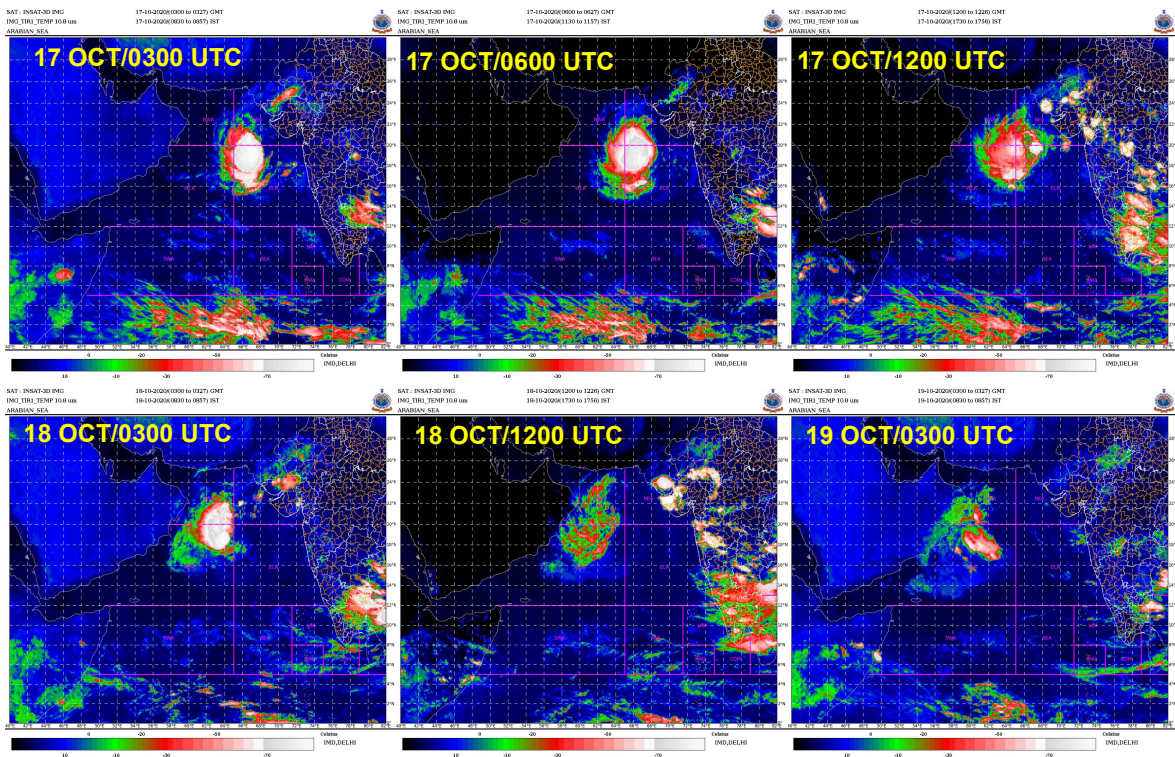


Fig. 2c: INSAT-3D enhanced colored imageries during life cycle of the Depression (17-19 October, 2020)

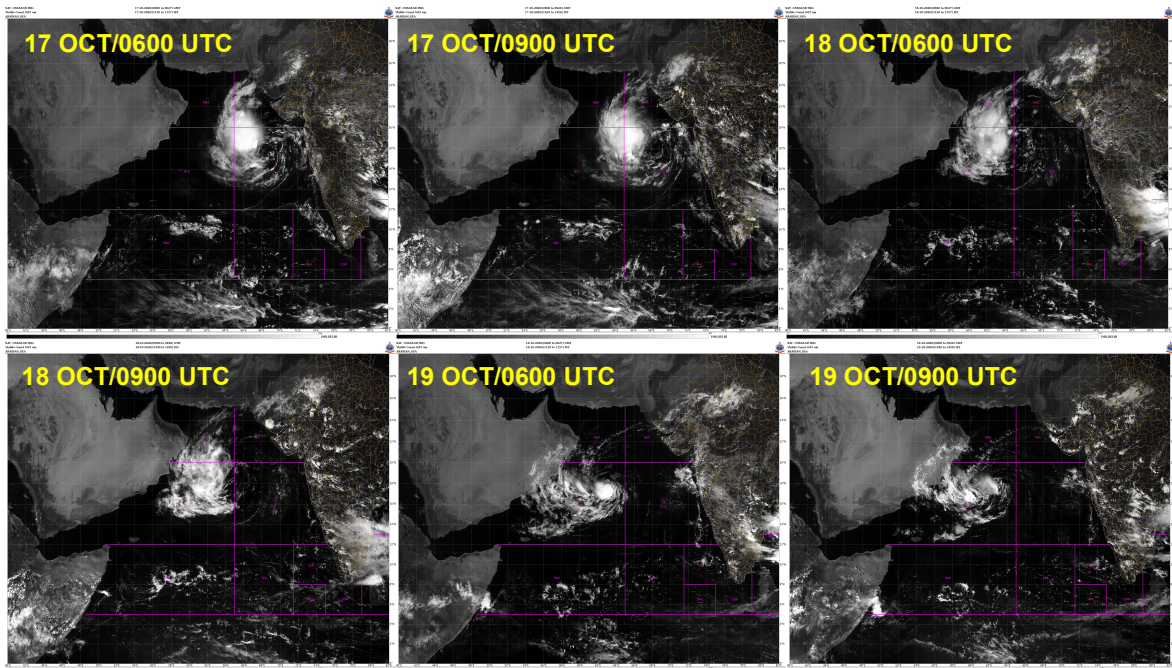


Fig. 2d: INSAT-3D visible imageries during life cycle of the Depression (17-19 October, 2020)

4. Dynamical features

IMD GFS (T1534) analysis fields of mean sea level pressure (MSLP), winds at 10 m, 850, 500 and 200 hPa levels are presented in Fig.3 (a) – 3(c). The model analysis field simulated the system as a Depression all through the period of its existence, with vertical extension upto 500 hPa. The analysis of IMD-GFS T-1534 model forecasts based on 0000 UTC of 17th October, 2020 showed that the Depression over east central AS would move further westwards by 18th morning, weaken into a low pressure area over west-central AS on 19th & persist there on 20th & 21st and dissipate subsequently. The analysis of IMD-GFS T-1534 model forecasts based on 0000 UTC of 18th October, 2020 showed that the Depression over east central AS & neighbourhood would move further westwards, weaken into a well marked low pressure area over west-central AS on 19th morning, persist there on 20th, as a low pressure area on 21st and dissipate subsequently. The analysis of IMD-GFS T-1534 model forecasts based on 0000 UTC of 19th October, 2020 showed the system as a Well marked low pressure area (WML) over west central AS & neighbourhood which would move further west-southwestwards and weaken into a low pressure area over west-central & adjoining south west AS on 21st morning, and dissipate on 22nd. Hence IMD GFS provided reliable guidance in forecasting the intensity & movement of the system all through its life period.

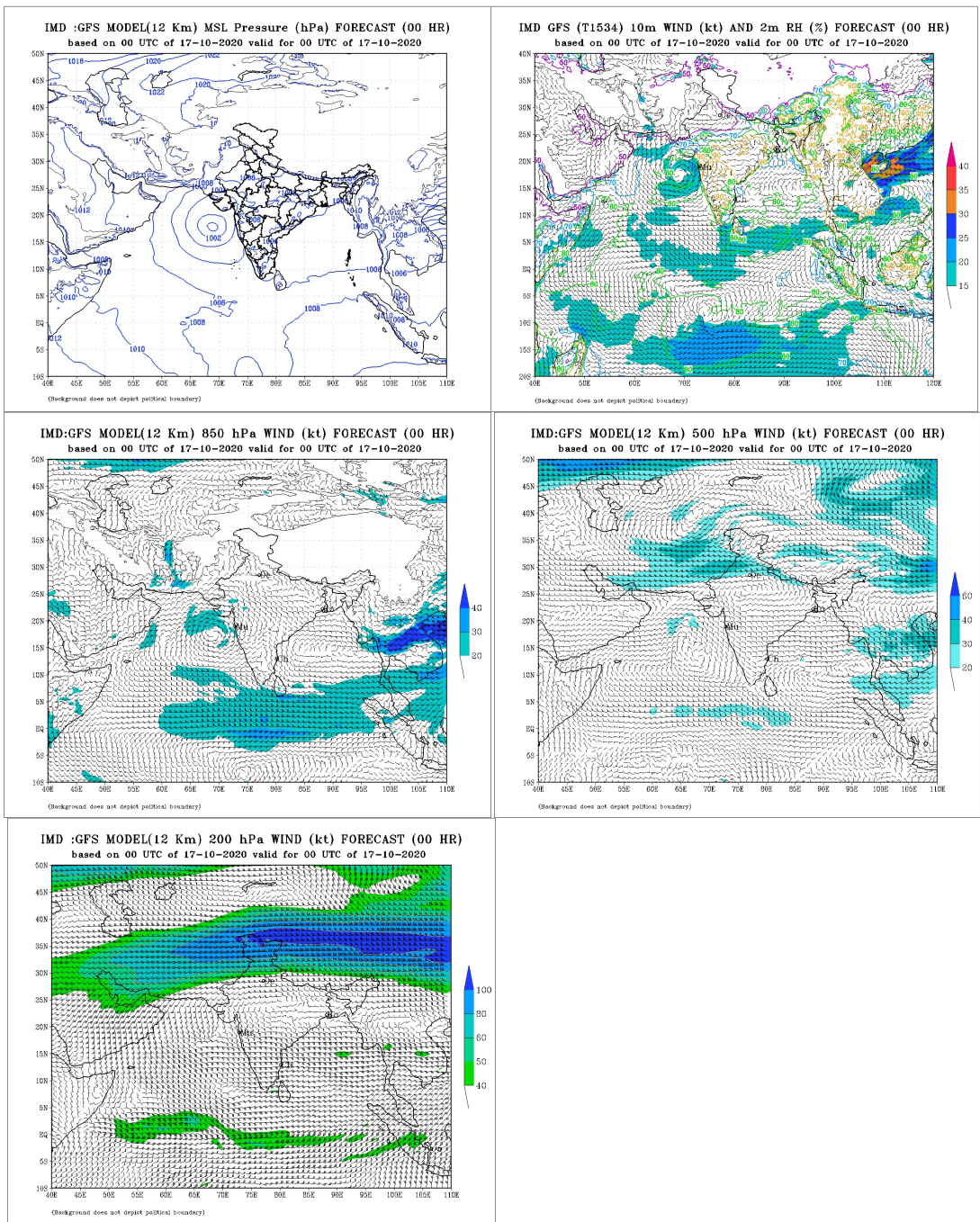


Fig.3 (a): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 17th October 2020

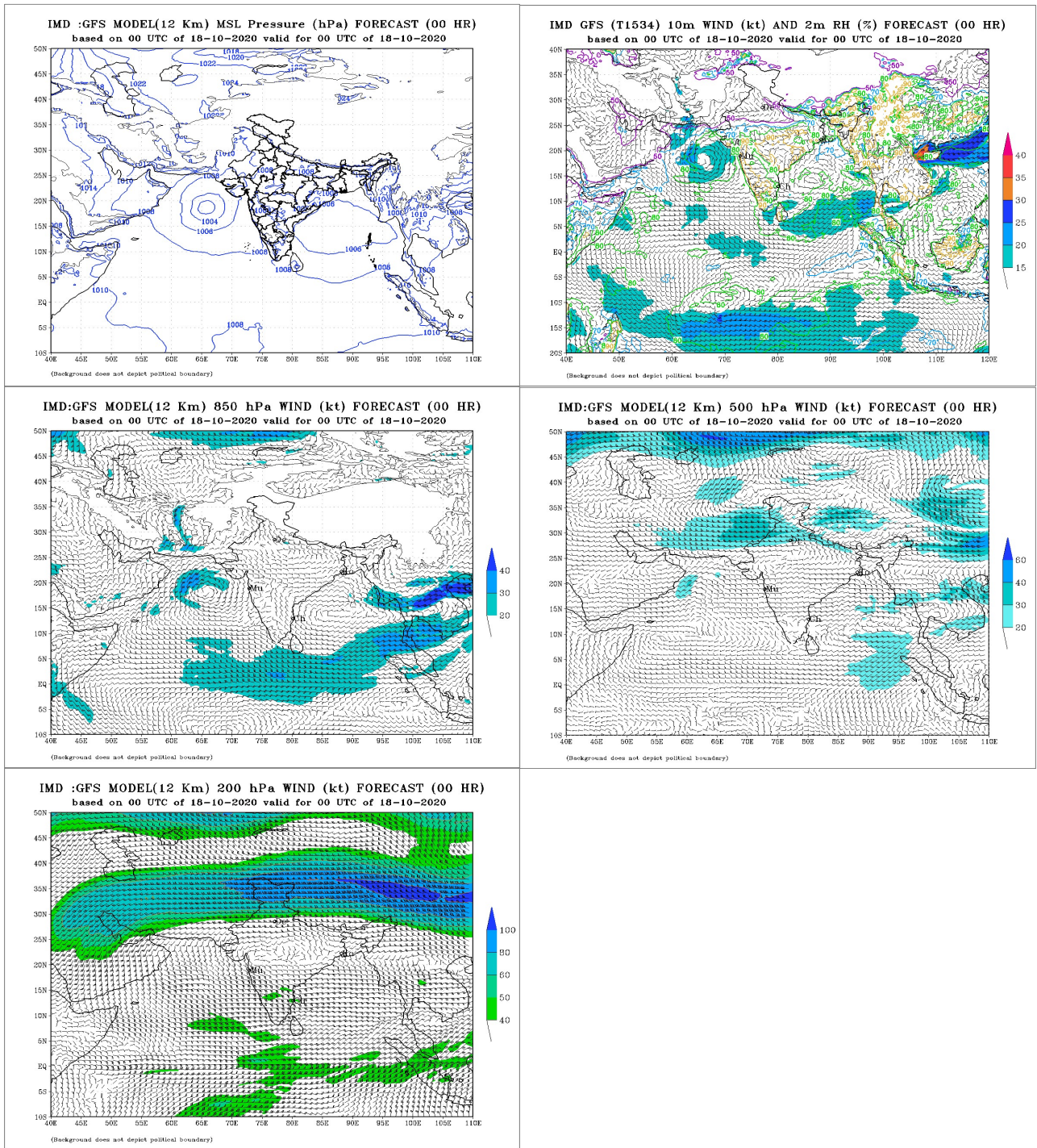


Fig.3 (b): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 18th October 2020

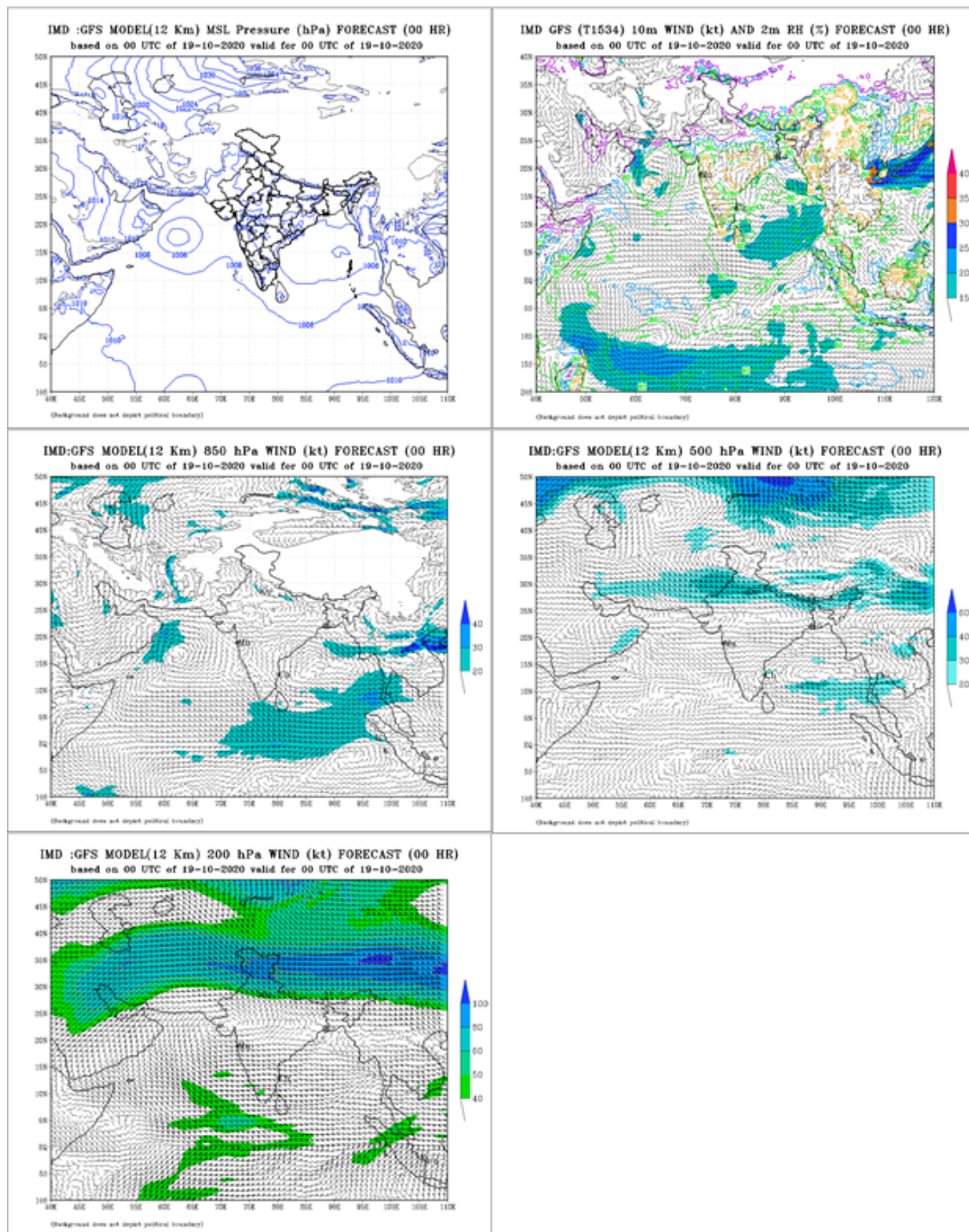


Fig.3 (c): IMD GFS (T1534) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels based on 0000 UTC of 19th October 2020

5. Realized Weather:

Since the system moved away from the Indian coast it did not cause any rainfall over the land area. The daily rainfall distribution ending at 0300 UTC of each date during 15-21 October, 2020 based on merged gridded rainfall data of IMD/NCMRWF is shown in Fig.4. It may be noted that the rainfall over Maharashtra on 15th and over coastal belt of Maharashtra on 16th October happened due to the presence of the remnant as a well marked Low pressure area over the region.

The system caused heavy rainfall Heavy rainfall (64.5 – 115.5 mm) over parts of east-central & adjoining northeast AS on 17th & 18th and over northern parts of central AS on 19th October.

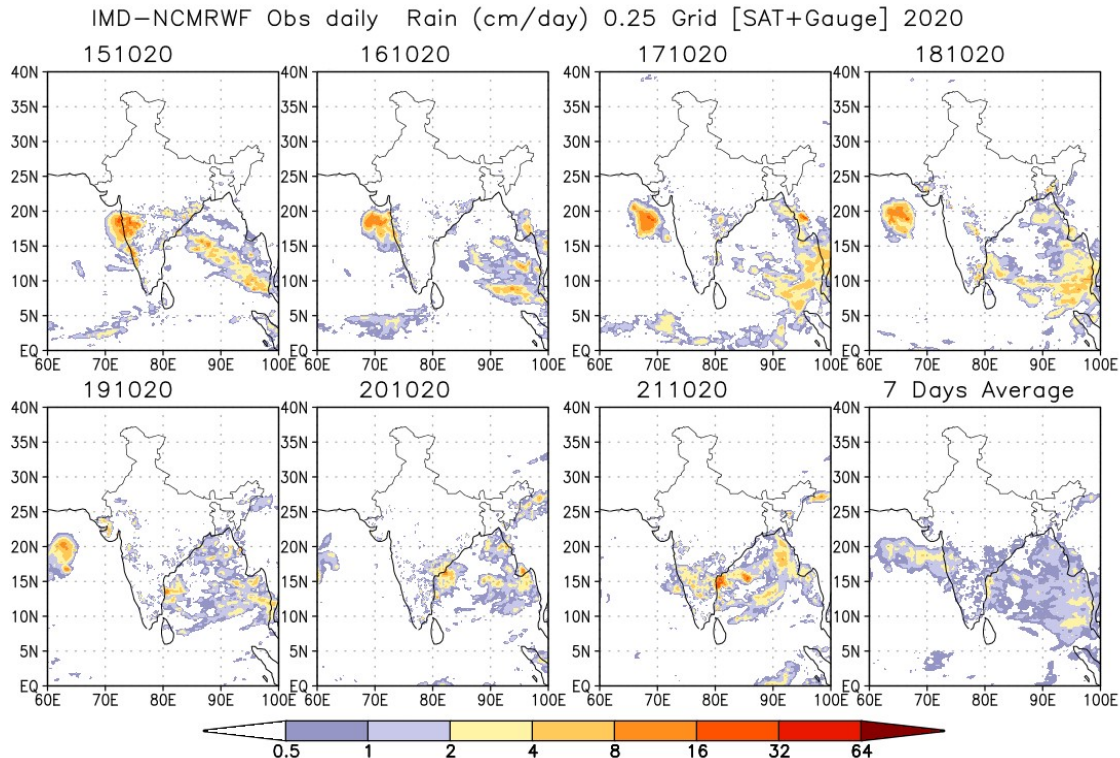


Fig.4: Daily rainfall distribution based on merged gridded rainfall data of IMD/ NCMRWF during 15-21 October, 2020

6. Bulletins issued by IMD

IMD issued regular bulletins to National & State Disaster Management Agencies of Maharashtra, Gujarat, Karnataka, Kerala, Lakshadweep Islands, general public and media and WMO/ESCAP Panel member countries including Pakistan, Oman & Yemen. Regular Bulletins every six hourly were issued since formation of depression over northwest BoB. In addition, CWD New Delhi also issued Press Release and SMS to registered users.

Three Nos. of Press Release and Bulletin from DGM during 15th-17th October along with 11 National Bulletins, 11 RSMC bulletins for WMO/ESCAP Panel Member countries and frequent updates on Facebook, Twitter and Whatsapp groups were issued in association with this system.

IMD indicated the likelihood of rough to very rough Seas over east-central & adjoining north AS during 17th – 19th and advised Fishermen not to venture into this area and prior to the formation of the Depression, advised them to return back to safety.

Apart from the number of bulletins as mentioned above, Bulletins were also issued by the respective Area Cyclone Warning Centre (ACWC) located at Mumbai, Cyclone Warning centres (CWCs) located at Ahmedabad & Thiruvananthapuram and State meteorological Centres located at Bangaluru & Goa for their area of concern.

6.1: Bulletins issued by Cyclone Warning Division, New Delhi

Bulletins issued by Cyclone Warning Division of IMD in association with the system are given in Table 2(a).

Table 2(a): Bulletins issued by Cyclone Warning Division, IMD, New Delhi

S.N.	Bulletins	No. of Bulletins	Issued to
1	National Bulletin	11	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: Odisha, Maharashtra, Telangana, Karnataka and Kerala
2	RSMC Bulletin	11	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	3	1. Disaster Managers, Media persons by email and uploaded on website
4	Facebook /Twitter	4 times a day	Highlights uploaded on facebook /twitter since formation of depression.
5	SMS	4 times a day	To disaster managers of central and state level and general public registered with RSMC website.

Table 2(b): Bulletins issued by Area Cyclone Warning Centre (ACWC) Mumbai, Cyclone Warning Centre (CWC) Ahmedabad, CWC Thiruvananthapuram, Meteorological Centre (MC) Goa and MC Bangaluru

S.N o.	Type of Bulletin Number	No. of Bulletins issued				
		CWC Ahmedabad	ACWC Mumbai	MC Goa	MC Bangaluru	CWC Thiruvananthapuram
1.	Sea Area Bulletins	-	8	-	-	NIL
2.	Coastal Weather Bulletins	08(Twice a day)	6	-	-	6
3.	Fishermen Warnings issued	16	11	10	4	12

4.	Port Warnings	05	9	10	-	2
5.	Heavy Rainfall Warning	03	1	9	8	NIL
6.	Gale Wind Warning	--	NIL	-	-	NIL
7.	Storm surge Warning	--	NIL	-	-	NIL
8.	Information & Warning issued to State Government and other Agencies	--	165	63	50	18
9.	SMS	--	Approx. 80000	398	29	18
10.	No. of Press releases	--	NIL	--		NIL
11.	No. of impact based warnings for a. District b. City	--	NIL	--	-	NIL
12.	No. of whatsapp messages	--	All warnings and messages communicated to all concerned groups	--	-	NIL
13.	No. of updates on facebook	--	5	--	-	NIL
14.	No. of updates on tweeter	--	5	--	-	NIL
15.	No. of warning video released	--	1	--	-	NIL

7. Operational Forecast Performance

7.1 Genesis:

The extended range outlook issued on 8th October indicated low probability (1-33%) of cyclogenesis over northeast Arabian Sea during 16th-20th October (about 9 days prior to formation of depression over eastcentral BoB, whose remnant seeded this system). Actually, the remnant of deep depression over BoB moved west-northwestwards and emerged into eastcentral Arabian Sea in the morning of 16th. It further intensified into a depression on 17th morning.

7.2 Intensification, landfall and movement:

- ❖ In the tropical weather outlook issued on 14th October at 0600 UTC (1130 hrs IST), it was indicated that the remnant of remnant of deep depression over BoB would emerge into eastcentral Arabian Sea around 16th morning with low to moderate (25-50%) probability of it's intensification into depression around 17th.
- ❖ In the press release issued on 14th, it was indicated that the remnant of deep depression over BoB would move west-northwestwards and emerge into eastcentral Arabian Sea in the morning of 16th, further intensify into a depression around 17th morning and move west-northwestwards away from Indian coast.
- ❖ Actually, the remnant of deep depression over BoB moved west-northwestwards and emerged into eastcentral Arabian Sea in the morning of 16th. It further intensified into a depression on 17th morning.

IMD issued regular warning bulletins to the concerned central and state disaster management authorities and press & media. It may be noted that the occurrence of strong winds over the Arabian Sea in association with the system could be predicted well in advance.

7. Summary and Conclusions:

The remnant of Deep Depression over west-central Bay of Bengal emerged into east-central Arabian Sea as a well marked low pressure area on 16th October morning (0000 UTC). It concentrated into a **depression** over the same region on 17th morning (0300 UTC). It maintained its intensity of depression till 19th early morning while moving westwards, away from Indian coast. It weakened into a well marked low pressure area in the early morning of 19th October. As it moved away, it had no impact along Indian coast from 18th October 2020. IMD monitored and predicted the genesis, movement and weather associated with the system accurately and timely bulletins were disseminated to the user agencies.

8. Acknowledgements:

India Meteorological Department (IMD) duly acknowledges the contribution from all the stake holders who contributed to the successful monitoring, prediction and early warning service of the system. We specifically acknowledge the contribution from Indian Space Research Organisation (ISRO) and all Sister organizations of Ministry of Earth Sciences including Indian Institute of Tropical Meteorology (IITM), Pune, National Centre for Medium Range Weather Forecasting Centre (NCMRWF) NOIDA, National Institute of Technology (NIOT) Chennai & Indian National Centre for Ocean Information Services (INCOIS). The support from various Divisions/Sections of IMD including Area Cyclone Warning Centre Mumbai, Cyclone Warning Centres Ahmedabad & Thiruvananthapuram, Meteorological centres Goa & Bengaluru, Numerical Weather Prediction (NWP) Division, Information System & Services Division (ISSD) and Satellite and Radar Division at IMD HQ New Delhi is also duly acknowledged for monitoring and predicting the system.
