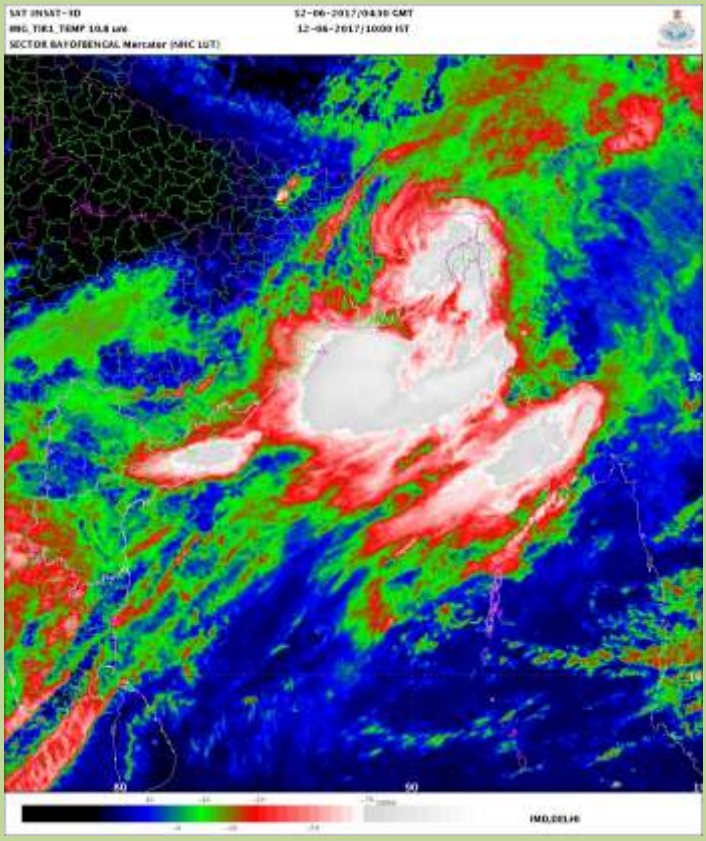
GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
INDIA METEOROLOGICAL DEPARTMENT

Deep Depression over West Bengal (11-13 June 2017): A Report



INSAT-3D enhanced colored IR imagery based on 0430 UTC of 12th June

Cyclone Warning Division

India Meteorological Department

New Delhi

July 2017

Deep Depression over Bay of Bengal (11-13 June 2017)

1. Introduction

A depression formed over north Bay of Bengal (BoB) in the evening of 11th June 2017 in association with advance of southwest monsoon over the region. It moved north-northeastwards, intensified into a **deep depression** and crossed Bangladesh coast near Khepupara between 0430 & 0530 hrs IST of 12th June 2017. It lay as a deep depression over coastal Bangladesh, close to Northeast of Khepupara at 0530 hrs IST of 12th June 2017. It then moved northeastwards across Bangladesh and weakened gradually. It weakened into a depression around mid night of 12th June 2017 and further into a well marked low pressure area over east Bangladesh and neighbourhood in the early morning of 13th June 2017. It caused heavy rainfall activity over northeastern states and Bangladesh.

Brief life history, characteristic features and associated weather along with performance of NWP and operational forecast of IMD are presented and discussed in following sections.

2. Monitoring and Prediction of system

The deep depression was monitored & predicted continuously by India Meteorological Department (IMD) since its inception over north BOB in the evening of 11th June. At the genesis stage, the system was monitored mainly with satellite observations from INSAT 3D, 3DR and Kalpana along with available ships & buoy observations. On 11th, Bangladesh Meteorological Department provided imageries from Doppler Weather Radar (DWR), Cox's Bazar. Various national and international NWP models and dynamical-statistical models were utilized to predict the genesis, track and intensity of the system. Tropical Cyclone Module, the digitized forecasting system of IMD was utilized for analysis and comparison of various models guidance, decision making process and warning product generation. IMD issued regular bulletins to WMO/ESCAP Panel member countries including Bangladesh, National & State Disaster Management Agencies, general public and media since inception of the system over BOB.

2. Genesis

A low pressure area formed over westcentral & adjoining north BoB off north Andhra Pradesh - south Odisha coast in the morning of 10th June. It concentrated into a well marked low pressure area over northern parts of central BoB & adjoining north BoB on 11th morning and into a depression over north BoB in the evening of 11th. At 1200 UTC of 11th, the sea surface temperature around the region of depression was 29-30^{0}C. The ocean thermal energy was less than 50 KJ/cm^2. The vertical wind shear was moderate to high (15-25 knots) around the system centre. The low level relative vorticity and convergence were about 150x10^{-6} s^{-1} and 20x10^{-5} s^{-1}. An anti-cyclonic circulation lay to the southeast of the system centre leading to poleward outflow favouring genesis of the system. The upper level divergence was about 30x10^{-5} s^{-1}. The upper tropospheric ridge at 200 hpa level ran along 23.5^{0}N.

3. Intensification and movement

Moving nearly north-northeastwards, it intensified into a deep depression over

north BoB in the night of 11th (1800 UTC). Moving north-northeastwards, it crossed Bangladesh coast near Khepupara between 2300 UTC of 11th and 0000 UTC of 12th June. It lay centered near latitude 22.5ºN and longitude 90.5ºE over south Bangladesh & neighbourhood at 0000 UTC of today, the 12th. At 0000 UTC of 12th, the vertical wind shear around the system centre was moderate to high (15-20 knots). The low level relative vorticity and convergence were about $200x10^{-6}$ s^{-1} and 30 x 10^{-5} s^{-1}. There was favourable poleward outflow in association with the anti-cyclonic circulation lying to the souheast of the system centre. The upper level divergence was about 30 x 10^{-5} s^{-1}. The upper tropospheric ridge at 200 hpa level ran along 22.0^0N. As the system moved over land, it weakened gradually into a depression over east Bangladesh & neighbourhood due to land surface interaction and lay centered near latitude 24.5°N & longitude 91.5°E at 1800 UTC . The system moved north-northeastwards under the influence of anticyclonic circulation lying to southeast of system centre.

The best track of the system is presented in Fig.1 and the best track parameters are shown in Table 1. The typical satellite imageries of the system are presented in Fig.2. The model analyses based on IMD GFS model at 0000 UTC of 11-13 June, 2017 are presented in Fig.3.

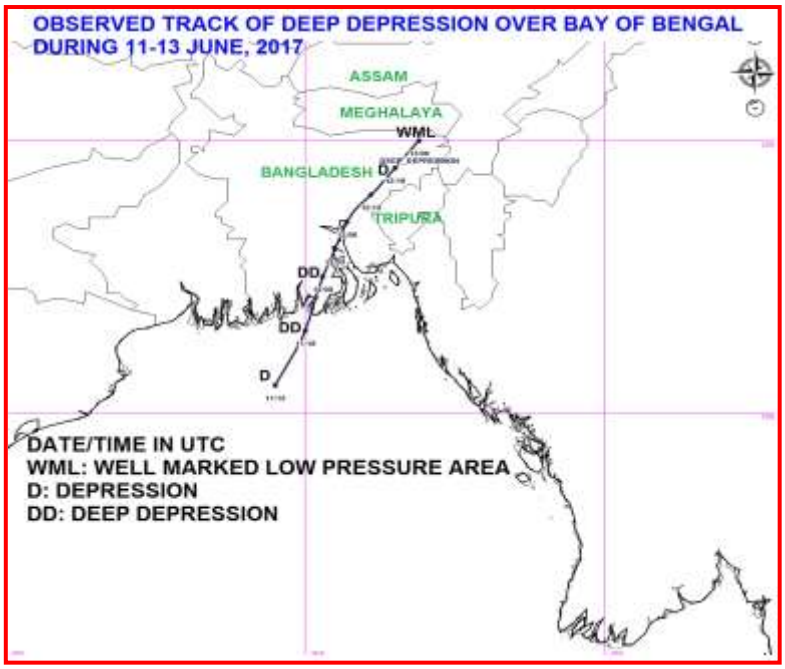


Fig.1: Track of deep depression (11-13 June, 2017)

Table 1: Best track positions and other parameters of the deep depression (11-13 June, 2017)

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
11/06/2017	1200	20.5/89.5	1.5	990	25	4	**D**
	1800	21.5/90.0	2.0	988	25	6	**DD**
	Crossed Bangladesh coast near Khepupara between 2300 UTC of 11th and						

	0000 UTC of 12th						
12/06/2017	0000	22.5/90.5	-	988	30	6	DD
	0300	23.0/90.5	-	990	30	5	DD
	0600	23.5/90.7	-	990	30	5	DD
	1200	24.0/91.0	-	990	30	5	DD
	1800	24.5/91.5	-	995	25	3	**D**
13/06/2017	0000	**Weakened into a well marked low pressure area over Nagaland & neighbourhood**					

4. Features observed through satellite and Radar

Satellite monitoring of the system was mainly done by using half hourly Kalpana-1 and INSAT-3D imageries. Satellite imageries of international geostationary satellites Meteosat-7 & MTSAT and microwave & high resolution images of polar orbiting satellites DMSP, NOAA series, TRMM, Metops were also considered for monitoring the system.

4.1 INSAT-3D features

Typical INSAT-3D visible and IR imageries are presented in Fig.2. According to satellite imageries at 1200 UTC of 11th, intensity was C.I. 1.5. The convection showed shear pattern. Maximum convection lay over southwest sector of the depression. Associated broken low and medium clouds with embedded intense to very intense convection lay over north and adjoining westcentral BoB, coastal Odisha and coastal areas of West Bengal and Bangladesh.

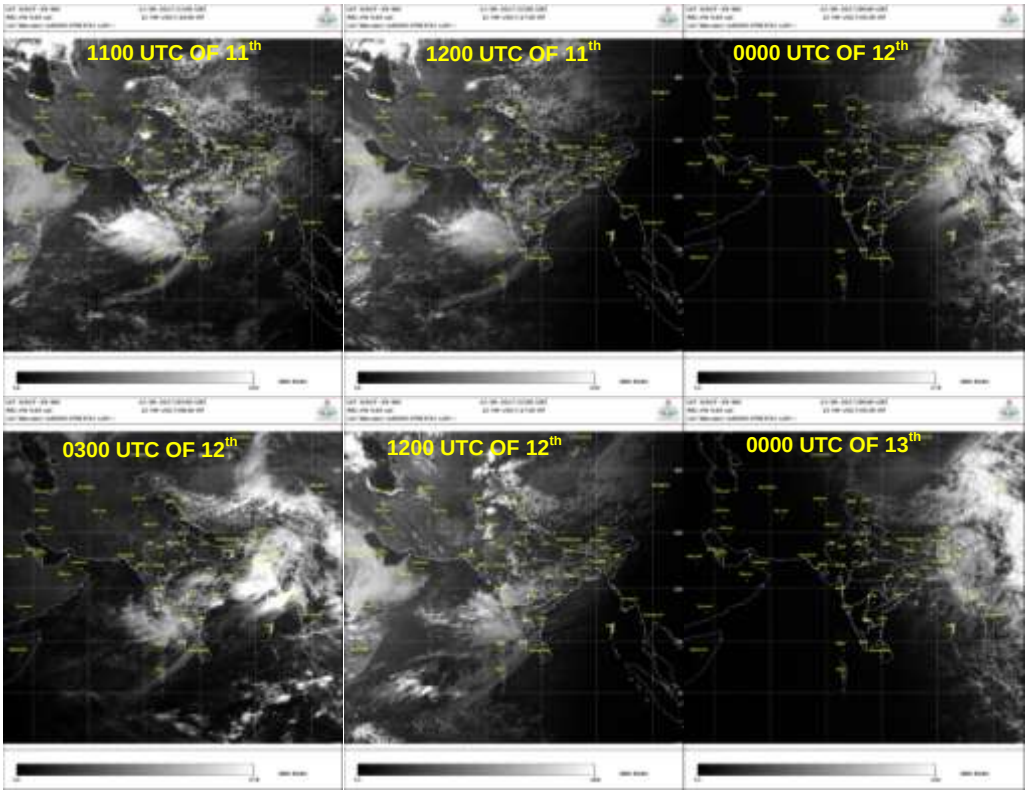


Fig.2 (i) INSAT 3D based visible imagery of deep depression during 11-13 June, 2017

At 0000 UTC of 12th, intensity was C.I. 2.0. The convection further got organised. Associated broken low and medium clouds with embedded intense to very intense convection lay over northwest and adjoining northeast BoB. At 1800 UTC of 12th, broken low and medium clouds with embedded intense to very intense convection lay over south Bangladesh, northeast & adjoining northwest BoB and south gangetic West Bengal. At 0000 UTC of 13th, broken low and medium clouds with embedded intense to very intense convection lay over south Bangladesh, northeast & adjoining northwest BoB and south Gangetic West Bengal.

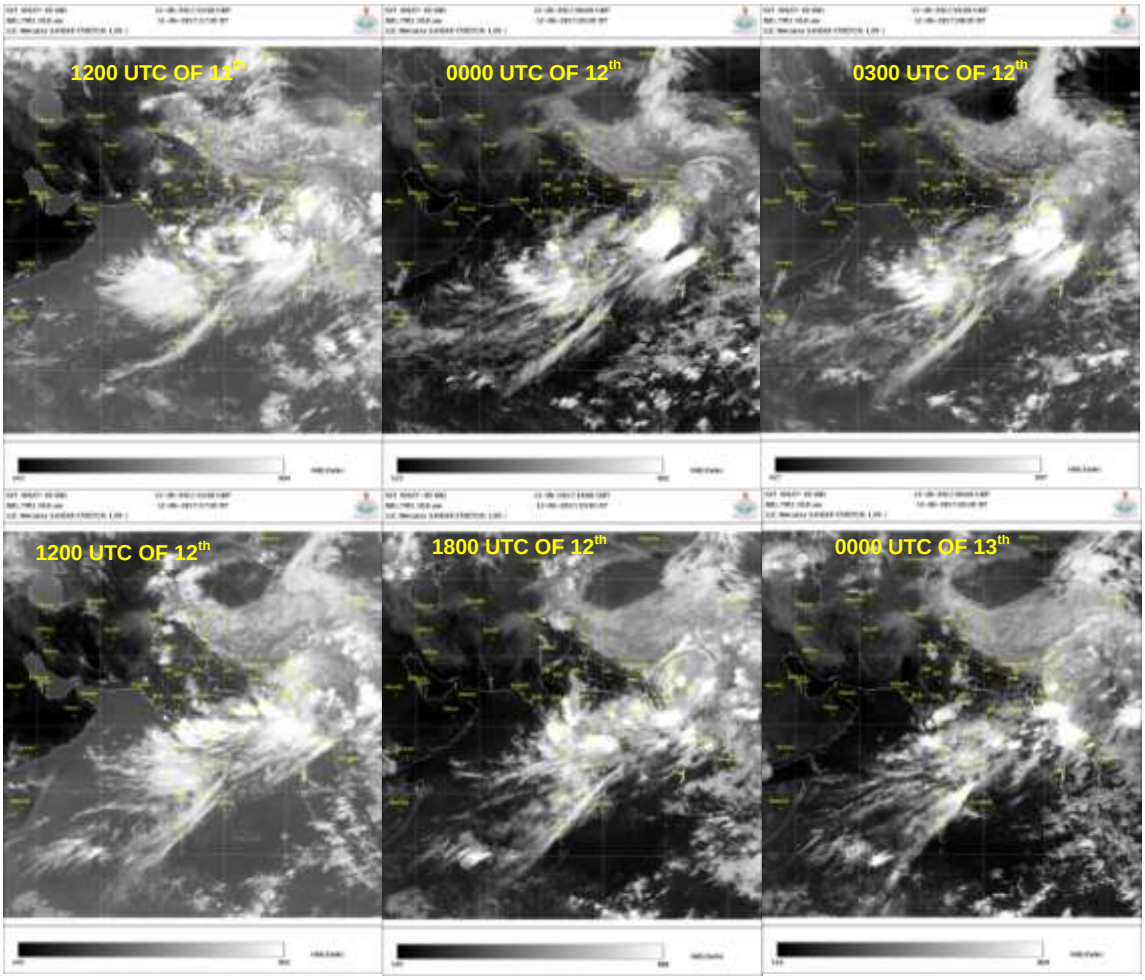


Fig.2(ii). INSAT 3D based IR imagery of deep depression during 11-13 June, 2017

4.2 Radar features

As the system was moving north-northeastwards, it was tracked by DWR Cox's Bazar on 11th June. Typical Radar imageries are presented in Fig. 12. DWR Cox's Bazar could capture the location and associated rainfall correctly.It could also show curved bands entering towards the centre from the southeast.

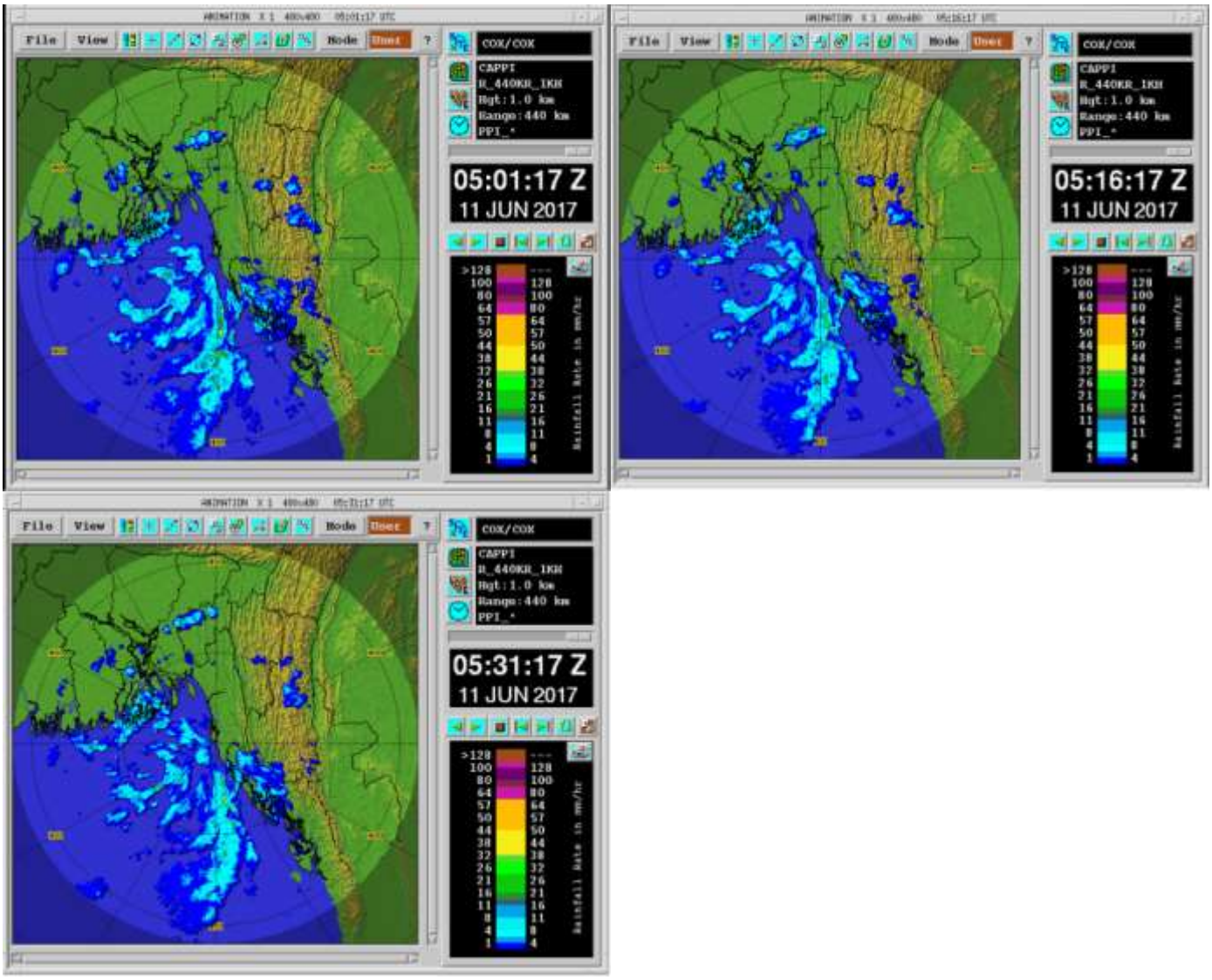


Fig.3 (ii). Typical Radar imageries of deep depression on 11th June, 2017

6. Dynamical features

IMD GFS (T574) mean sea level pressure (MSLP), winds at 10m, 850, 500 and 200 hPa levels are presented in Fig.4. GFS (T574) could simulate the genesis of the system and the associated circulation features during it's life period. Anticyclonic circulation lying to the northeast of system centre was well captured by the system.

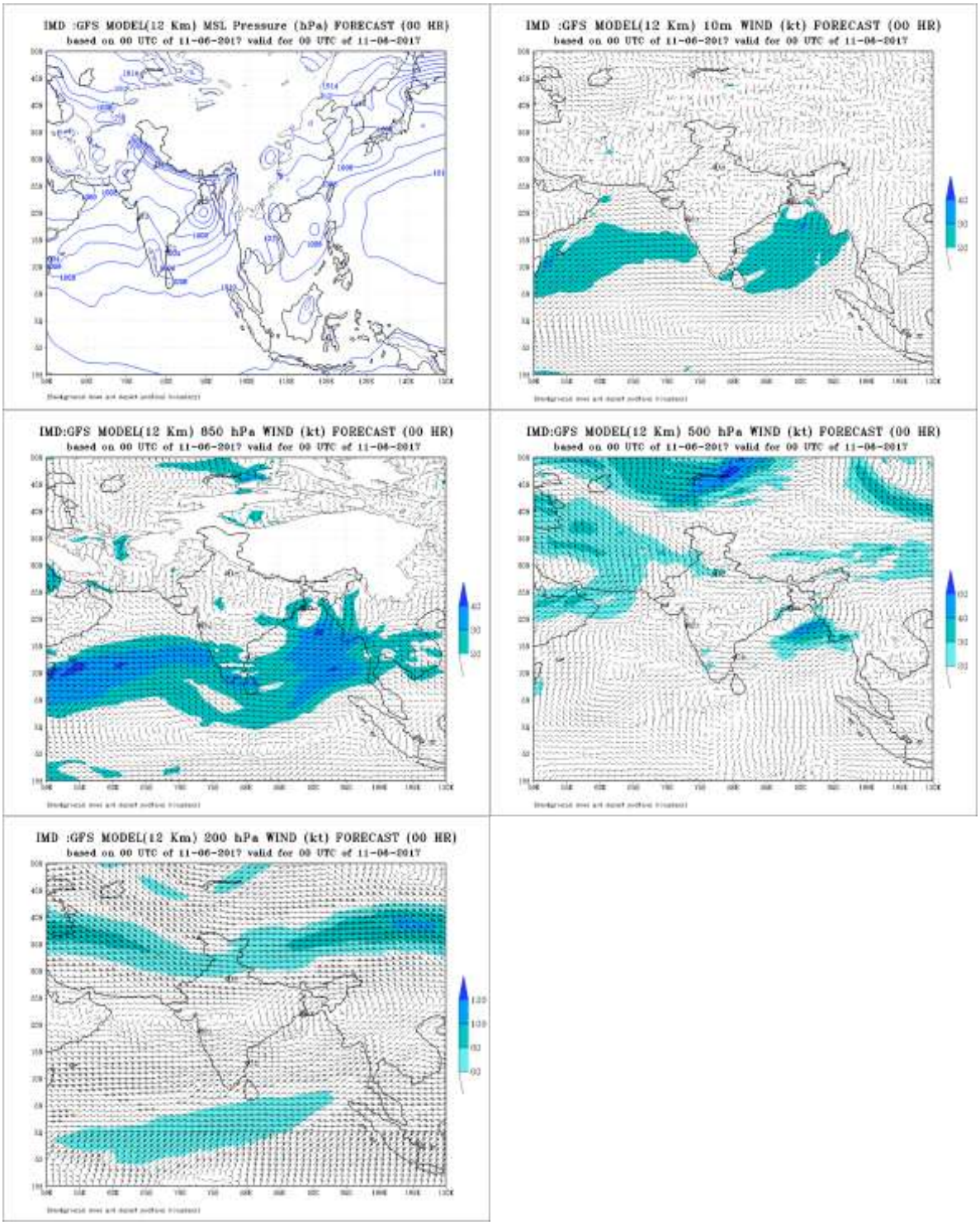


Fig.3 (i) IMD GFS Model analyses of mean sea level pressure (MSLP), 10m wind and winds at 850, 500 & 200 hPa levels of 0000 UTC of 11th June

At 0000 UTC of 12th, it could capture that the system has crossed Bangladesh coast as a DD.

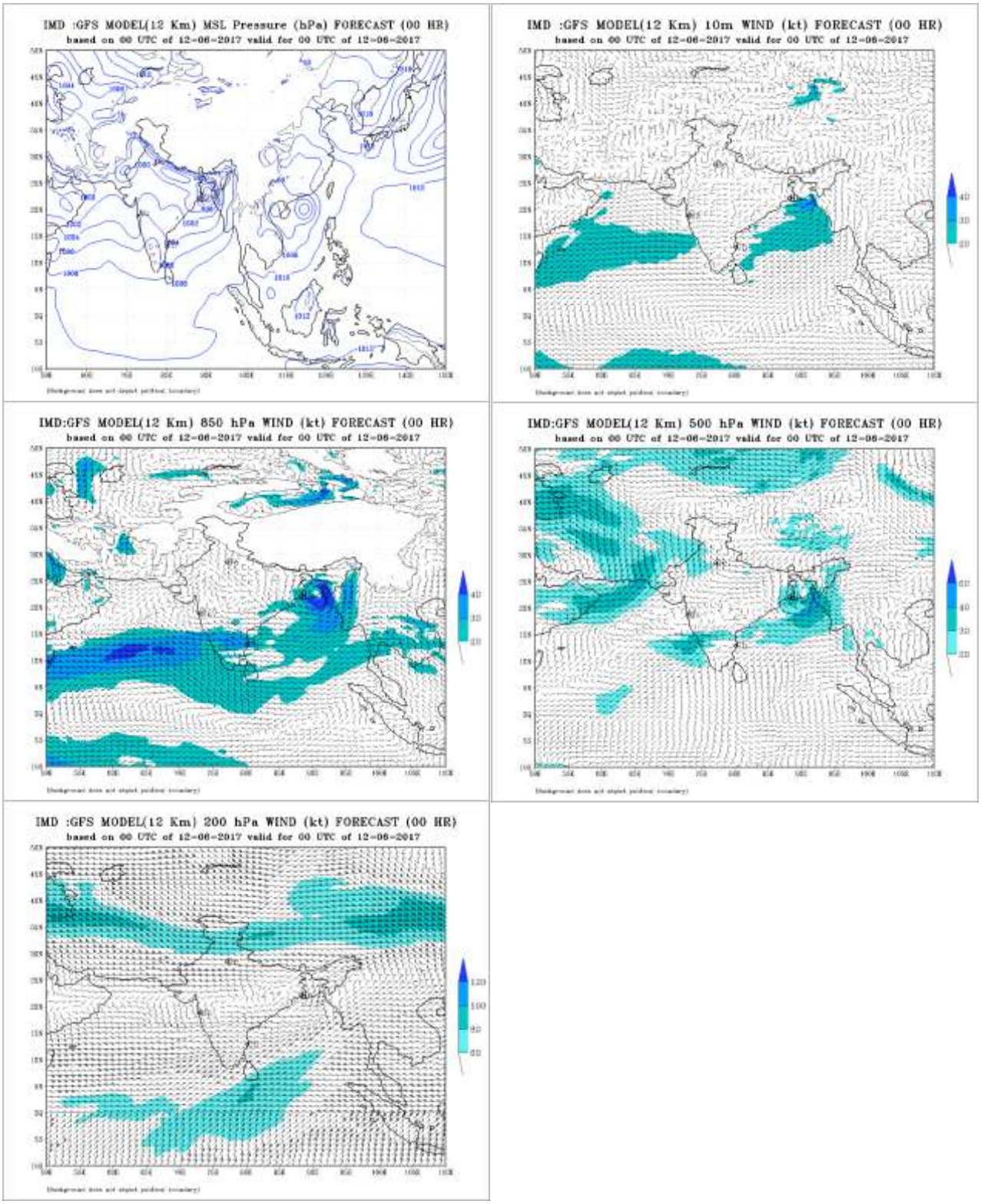


Fig.3 (ii) IMD GFS Model analyses of mean sea level pressure (MSLP), 10m wind and winds at 850, 500 & 200 hPa levels of 0000 UTC of 12th June

At 0000 UTC of 13th, it could capture weakening of the system over southeast Bangladesh.

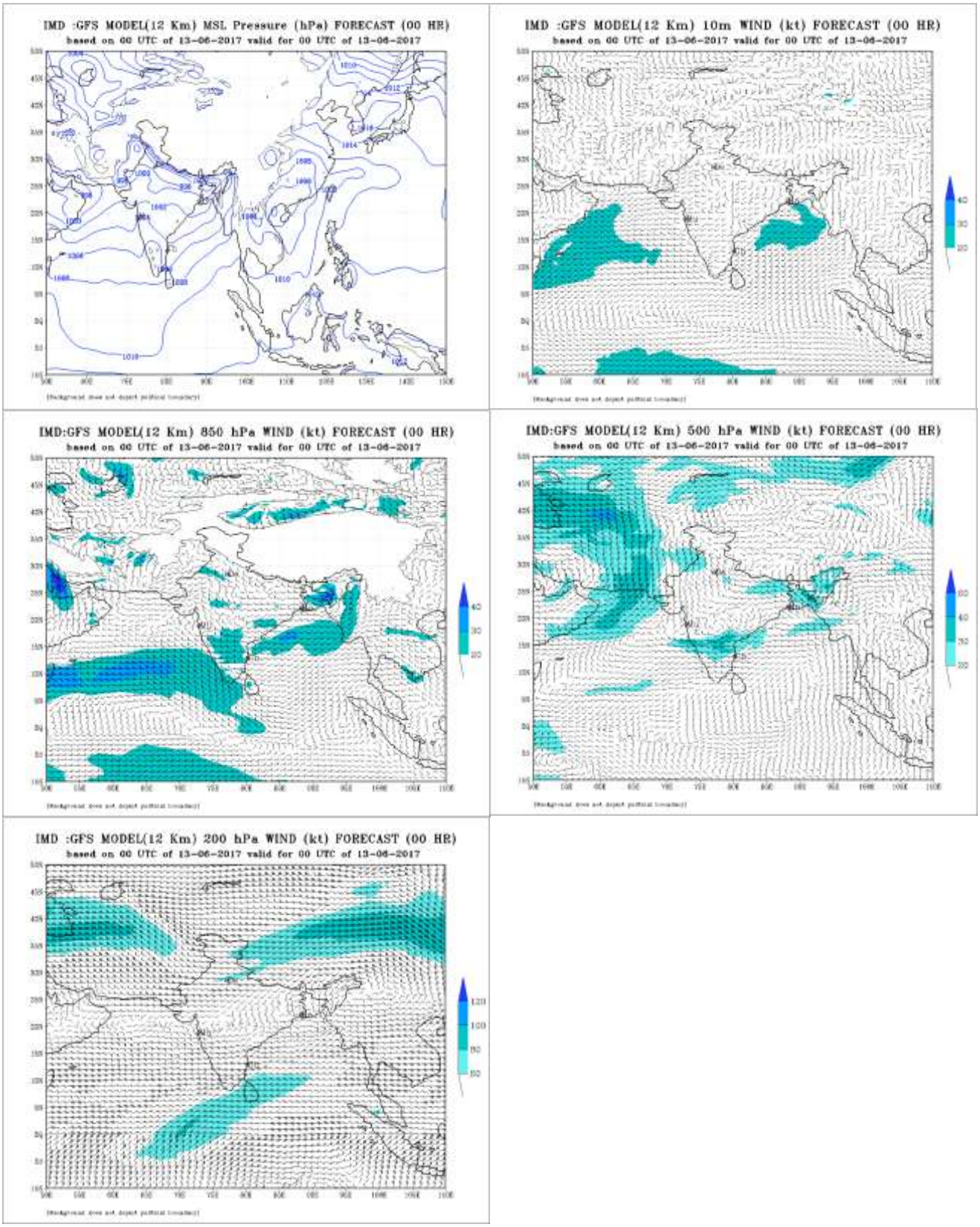


Fig.3 (ii) IMD GFS Model analyses of mean sea level pressure (MSLP), 10m wind and winds at 850, 500 & 200 hPa levels of 0000 UTC of 13th June

4. Realised weather:

The deep depression caused heavy rainfall over northeastern states and Bangladesh. The chief amounts of 24 hr cumulative rainfall ending at 0830 hrs IST of data are given below/

12 June 2016:
Assam & Meghalaya: N.Lakhimpur/Lilabari, Kampur : 7 Each **Nagaland, Manipur, Mizoram & Tripura:** Bishalgarh: 9, Arundhutinagar: 7.
13 June 2017:
Assam & Meghalaya: Cherrapunji : 32, Mawsynram: 19, Shillong: 11, Williamnagar: 10, Karimganj, Panbari : 10 each, Goalpara, Barpeta: 8 each, Beky Railway.Bridge: 7, **Nagaland, Manipur, Mizoram &Amp; Tripura:** Serchip: 24, Aizwal: 18, Bishalgarh: 10, Agartala : 9, Khowai: 8, Arundhutinagar, Kailashahar : 7 each.
14 June 2017:

Arunachal Pradesh: Itanagar, Naharlagun : 7 each **Assam & Meghalaya:** Jia Bharali N T Xing, Puthimari, Guwahati Airport: 11 each; Tezpur, Majbat, Karimganj : 9 each; Goibargaon, Dhekiajuli, Badatighat: 8 each, Nalbari/Pagladia: 7.

5. Forecast performance

The genesis of depression on 11th June was predicted by IMD on 10th. After the genesis of the depression, its subsequent intensification into a deep depression and its north-northeastward movement was predicted from the first bulletin itself. Similarly the landfall over Bangladesh coast was also predicted in the first bulletin issued based on 1200 UTC of 11th and its gradual weakening after the landfall was predicted based on the 0000 UTC observation of 12th June.

IMD issued warning bulletins to the concerned central and state disaster management authorities & press and media. The verification of heavy rainfall warnings issued by IMD for this deep depression is presented in Table 2.

Table 2: Verification of heavy rainfall warning issued by IMD for Deep Depression over Bay of Bengal (11-13 June 2017)

Date/Time of issue	Heavy rainfall warning	Realised **heavy rainfall** (7cm or more) ending at 0830 hrs IST of date
1730 IST of 11 June 2017	Heavy to very heavy rainfall (7-19 cm) at a few places over coastal districts of north Odisha and West Bengal during next 48 hours and isolated heavy to very heavy rainfall over remaining parts of Odisha & West Bengal, Jharkhand, Assam, Meghalaya, Nagaland, Manipur, Mizoram and Tripura during the same period.	**12 June 2016:** **Assam & Meghalaya:** N.Lakhimpur/Lilabari, Kampur : 7 Each **Nagaland, Manipur, Mizoram & Tripura:** Bishalgarh: 9, Arundhutinagar: 7. **13 June 2017:** **Assam & Meghalaya:** Cherrapunji : 32, Mawsynram: 19, Shillong: 11, Williamnagar: 10, Karimganj, Panbari : 10 each, Goalpara, Barpeta: 8 each, Beky Railway.Bridge: 7, **Nagaland, Manipur, Mizoram &Amp; Tripura:** Serchip: 24, Aizwal: 18, Bishalgarh: 10, Agartala : 9, Khowai: 8, Arundhutinagar, Kailashahar : 7 each. **14 June 2017:** **Arunachal Pradesh**: Itanagar, Naharlagun : 7 each **Assam & Meghalaya:** Jia Bharali N T Xing, Puthimari, Guwahati Airport: 11 each; Tezpur, Majbat, Karimganj : 9 each; Goibargaon, Dhekiajuli, Badatighat: 8 each, Nalbari/Pagladia: 7.

6. Acknowledgements:

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