

Deep depression over the Bay of Bengal (19-20 October, 2011)

6.1 Introduction

A deep depression formed over northeast Bay of Bengal on 19 October, 2011 morning. Moving northeaster wards, it crossed Bangladesh coast near lat. 21.2°N and long. 92.1°E (south of Cox's Bazar) around 1830 HRS IST of 19th October. The characteristic of the system are described below.

6.2 Genesis

Synoptic analysis suggested that a lower level cyclonic circulation lay over the southeast and adjoining eastcentral Bay of Bengal from 12th October onwards. There was an active east-west shear zone passing through this circulation. Under the influence of these synoptic conditions, the cross equatorial flow over the Bay of Bengal leading to southerly surge increased gradually. As a result, the lower level relative vorticity and convergence also increased. It was manifested in the satellite imageries with gradual organisation of convective clouds over the southeast and east central Bay of Bengal.

Considering the large scale environmental conditions, the sea surface temperature over the Bay of Bengal continued to be about $28\text{-}32^{\circ}\text{C}$. The upper tropospheric ridge at 200 hPa level lay to far north of the area of circulation (around 19°N on 15th October) and provided the required divergence over the region. The vertical wind shear was low to moderate over the central and north Bay of Bengal. There was no significant system over the south China Sea. The cyclone, Banyan over the south China Sea lay as a depression near 17.5°N and 116°E on 14th and became less marked on 15th. However, the Ocean heat content was about 80 KJ/cm^2 over the south and central Bay of Bengal and less than 50 KJ/cm^2 over the north Bay of Bengal. The Madden Julian Oscillation (MJO) index lay in phase 8 on 14th and moved gradually to phase 1 during 14-19th. As such, it was not favourable for cyclogenesis. Due to this unfavourable MJO condition, the convection could not be amplified rapidly. Rather, the convection exhibited a marked diurnal variation. However, the cyclonic circulation over southeast & adjoining east central Bay of Bengal moved to east central Bay of Bengal & neighbourhood and extended upto mid tropospheric level on 16th October 2011. The east-west trough also extended upto mid tropospheric level through the above system. Under the influence the cyclonic circulation, a low pressure area formed over the same region with associated cyclonic circulation extending upto mid-tropospheric level on 17th October. It became well marked over east central & adjoining north and west central Bay of Bengal on 18th. The well marked low pressure area concentrated into a depression over north Bay of Bengal and lay centred at 0530 hrs IST of 19th October 2011 over north Bay of Bengal near latitude 20.0°N and longitude 90.5°E .

6.3 Intensification and movement

All the above mentioned favourable and unfavourable conditions continued during 19th and 20th. At 0830 hrs IST of 19th October, the 24 hrs pressure change was negative over Bangladesh coast (around -3.0 hPa) and negative over north Andhra Pradesh and Orissa-West Bengal coast (around -2.0 hPa). Maximum pressure fall was reported as -4.2 hPa over Cox's Bazar. Pressure departure from normal was negative (-5.0 to -6.0 hPa) over Cox's Bazar and Chittagong. The depression moved to the north of upper tropospheric ridge, which roughly ran along 19^oN on 19th October 2011 in association with an anticyclonic circulation to the southeast of the system centre. As a result of these, the system moved east-northeastwards and intensified into a deep depression and lay centred at 0830 hrs IST over northeast Bay of Bengal near lat 20.2^oN and long. 91.0^oE. It then moved northeastwards and crossed Bangladesh coast near lat. 21.2^oN and long. 92.1^oE (south of Cox's Bazar) around 1830 HRS IST of 19th October. After the landfall it also continued to move northeastwards for sometime and then eastwards and weakened gradually. It weakened into a low pressure area at 0830 hrs IST of 20th October 2011 over Myanmar and adjoining Bangladesh, Mizoram and northeast Bay of Bengal.

At 1430 hrs IST of 19th, Cox's Bazar reported lowest pressure of 999.5 hPa and northeasterly wind of 15 knots. Sittwe (Myanmar) reported southwesterly wind of 20 knots. The best track parameters are shown in Table 6.1. The track of deep depression is shown in Fig. 6.1. The typical satellite imageries of the system are shown in Fig. 6.2. The ECMWF model analyses of lower level vorticity, upper level divergence, upper level wind and vertical wind shear are shown in Fig. 6.3.

Table 6.1: Best track position and other parameters of deep depression over the northeast Bay of Bengal during 19-20 October, 2011

Date	Time (UTC)	Centre (lat ^o N/long ^o E)	C. I. No.	Estimated centre pressure (hPa)	Estimated pressure drop at the centre (hPa)	Estimated Maximum sustained wind (kts)	Grade
19-10-2011	0000	20.0/90.5	1.5	1002	3	25	D
	0300	20.2/91.0	1.5	1000	3	25	D
	0600	20.5/91.5	2.0	1000	5	30	DD
	1200	21.0/92.0	2.0	1000	5	30	DD
	The system crossed Bangladesh coast near lat. 21.2 ^o N and long. 92.1 ^o E (south of Cox's Bazar) around 1300 UTC.						
	1800	21.5/92.5	2.0	1002	5	30	DD
20-10-2011	0000	21.5/93.5	1.5	1004	3	25	D
	0300	The system weakened into a low pressure area over Myanmar and adjoining Bangladesh, Mizoram and northeast Bay of Bengal.					

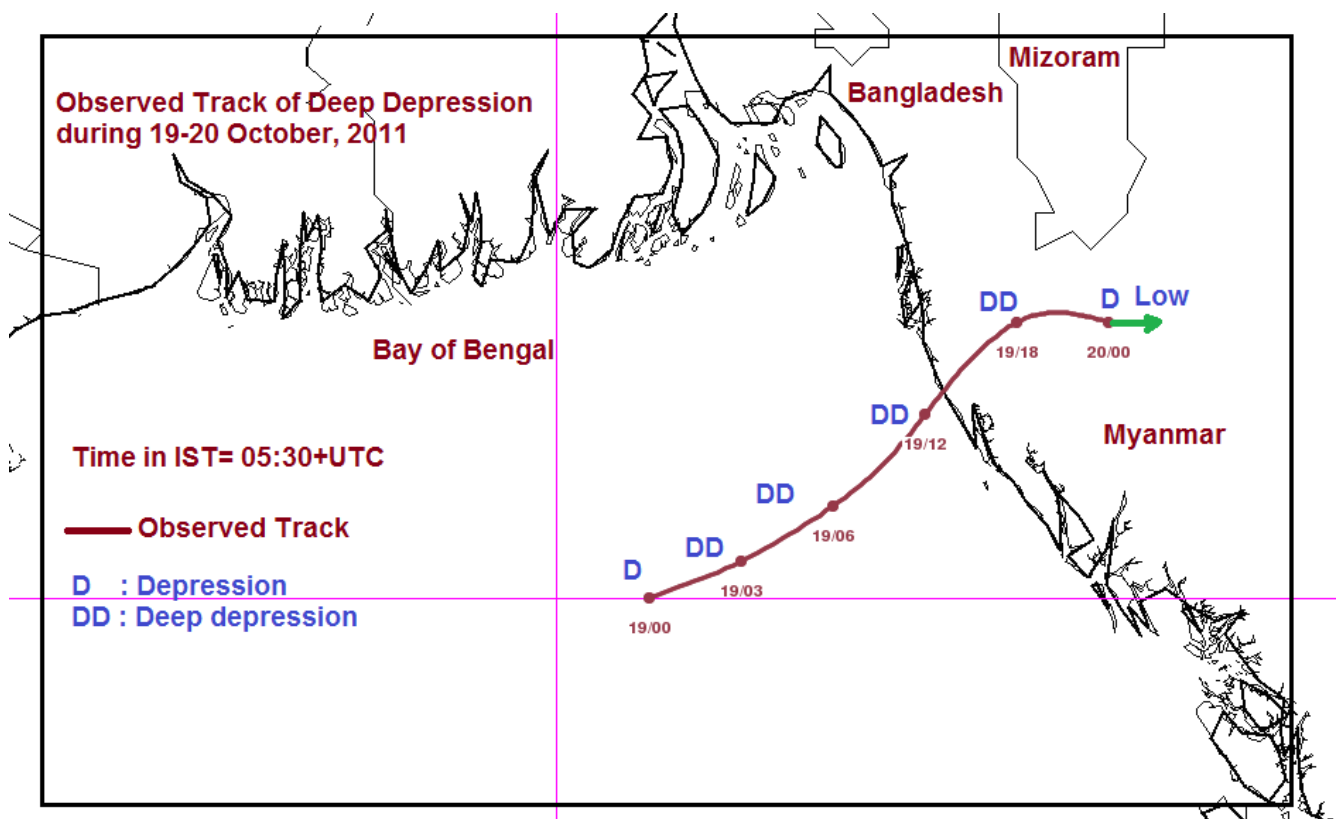


Fig. 6.1 Track of deep depression over the Bay of Bengal (19-20 October, 2011)

6.4. Realised Weather:

Not available from Bangladesh and Myanmar. However according to media reports, along the border between Myanmar and Bangladesh, torrential rain produced devastating flash floods. Squally winds also prevailed over the region.

6.5. Damage:

In the Magway region, roughly 2000 homes were washed away and more than 6000 remained flooded for days. Initial estimates placed the damage of 1.64 million US dollars. At least 215 people were confirmed to have been killed with many more missing.

6.6 Bulletins issued by IMD

The system was continuously monitored and predicted since 14th Oct. 2011. Once daily bulletin was issued to Bangladesh and Myanmar through e-mail during 14-18th Oct. 2011. The Special Tropical Weather Outlook was issued to Bangladesh and Myanmar based on 00, 03, 06, 12 and 15 UTC of 19th Oct. 2011 giving details of the depression and its forecasts. The bulletin was also issued to control room,

National Disaster Management (NDM), MHA, Govt. of India, other high officials and chief secretaries of Mizoram, Manipur and Tripura. The statistics of the number of bulletins issued by IMD are given below.

Number of bulletins issued for National disaster management agencies : 08

Number bulletins issued to WMO/ESCAP Panel countries : 05

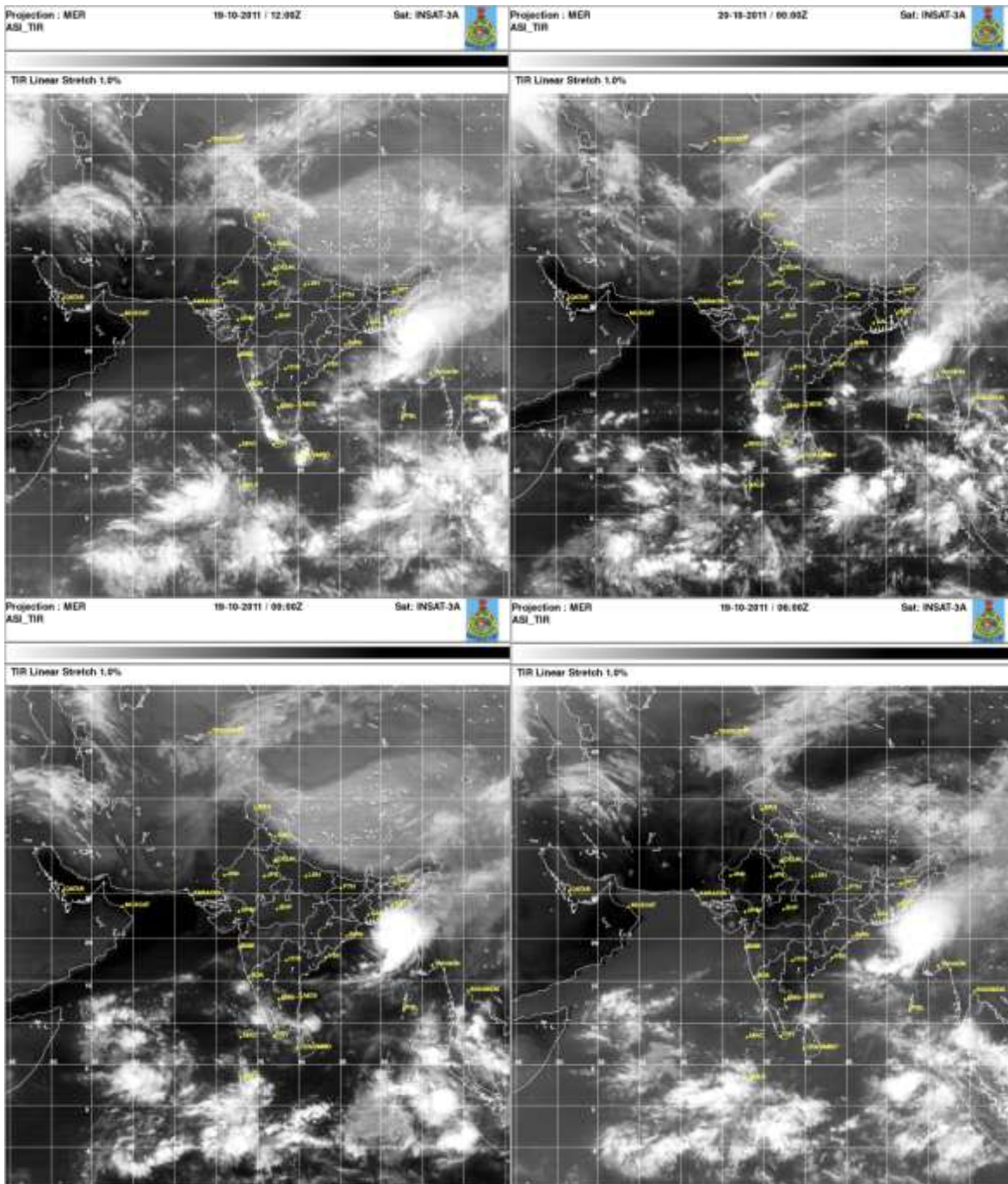


Fig. 6.2 Typical Satellite imageries at 0000, 0600 and 1200 UTC of 19-10-2011 and 0000 UTC of 20-10-2011 in association with the depression over the Bay of Bengal.

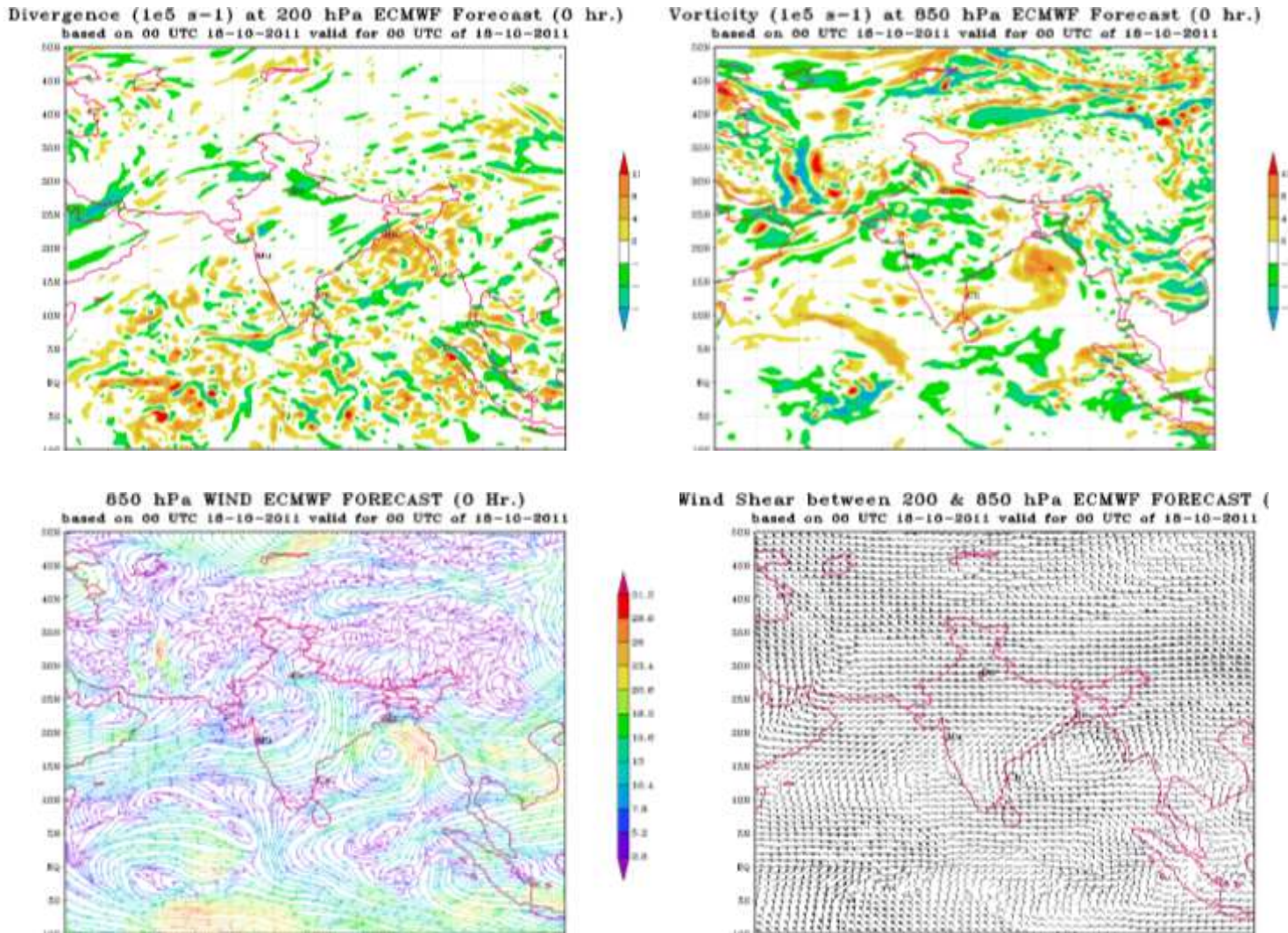


Fig. 6.3 (a) (i) Upper level divergence at 200 hPa level (ii) low level relative vorticity at 850 hPa level (iii) wind at 850 hPa level (iv) vertical wind shear of horizontal wind between 200 and 850 hPa level based on the ECMWF model analysis of 0000 UTC of 18th October, 2011.

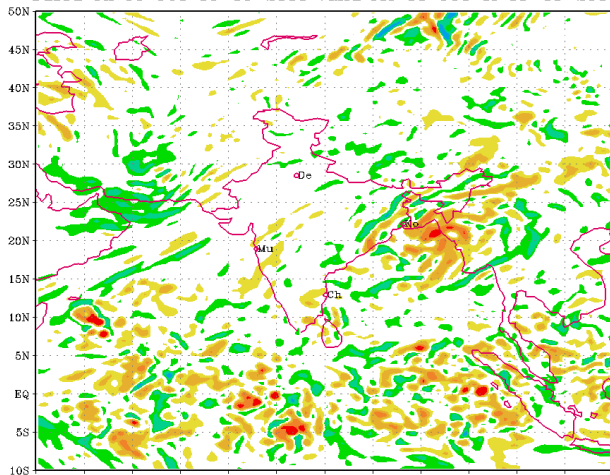
6.7 Forecast performance

The verification of genesis, intensity and track forecast issued by IMD is discussed below

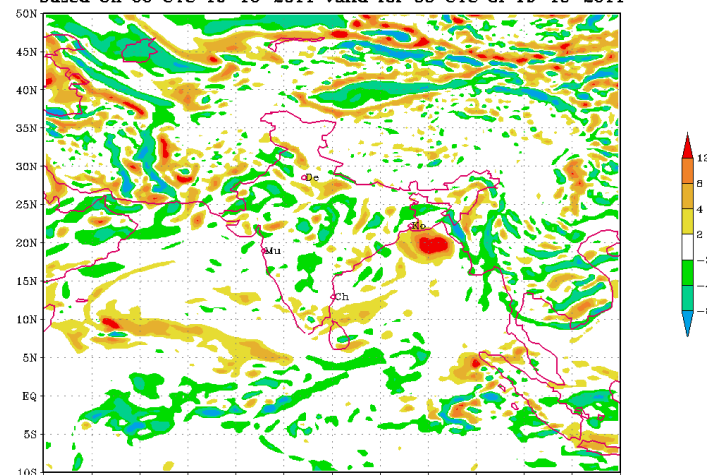
6.7.1 Genesis forecast

The genesis of the system was first predicted on 14th October, 2011 and message was sent to Bangladesh stating that a depression may form over east central Bay of Bengal on 17th which may intensify gradually into a cyclonic storm and cross Bangladesh coast near Lat.22.5^o N and Long. 91.5^oE around 20th morning. Later on 15th it is stated that the depression which will form on 18th and cross Bangladesh coast near 22^oN and 92^oE as a deep depression around 20th morning. Same forecast was mentioned during 16-18th with genesis of depression on 19th.

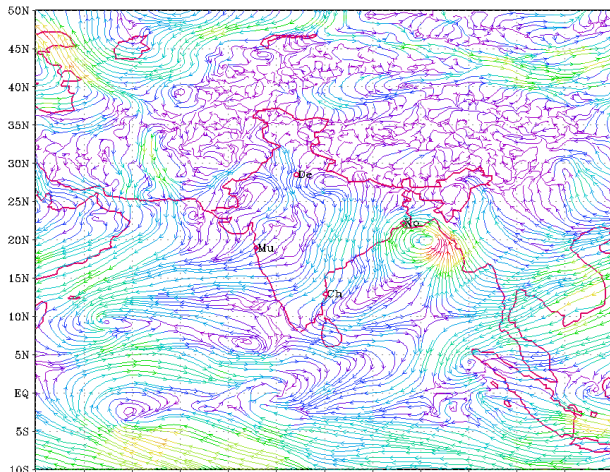
Divergence ($1e5 \text{ s}^{-1}$) at 200 hPa ECMWF Forecast (0 hr.)
 based on 00 UTC 19-10-2011 valid for 00 UTC of 19-10-2011



Vorticity ($1e5 \text{ s}^{-1}$) at 850 hPa ECMWF Forecast (0 hr.)
 based on 00 UTC 19-10-2011 valid for 00 UTC of 19-10-2011



850 hPa WIND ECMWF FORECAST (0 Hr.)
 based on 00 UTC 19-10-2011 valid for 00 UTC of 19-10-2011



Wind Shear between 200 & 850 hPa ECMWF FORECAST (0 Hr.)
 based on 00 UTC 19-10-2011 valid for 00 UTC of 19-10-2011

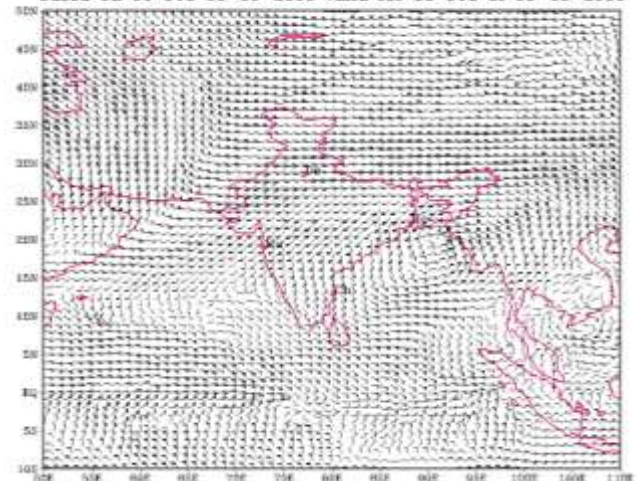


Fig. 6.3(b) (i) Upper level divergence at 200 hPa level (ii) low level relative vorticity at 850 hPa level (iii) wind at 850 hPa level (iv) vertical wind shear of horizontal wind between 200 and 850 hPa level based on the ECMWF model analysis of 0000 UTC of 19th October, 2011.

6.7.2 Track and Intensity forecast:

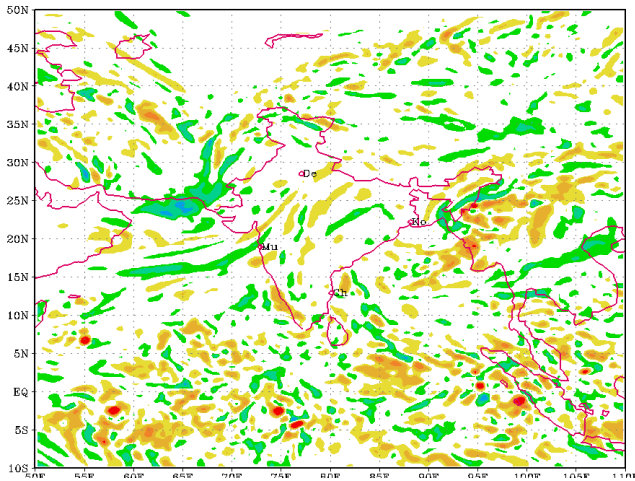
The possibility of intensification of the system upto a cyclone before the landfall on 20th October predicted on 14th October 2011. Later on 15th October, it was predicted that maximum intensity will be deep depression before landfall on 20th. The performance of intensity and track forecast issued in a structured bulletin issued since 0000 UTC of 19th October 2011 are given table below (Table 6.2). The average 12 and 24 hrs track and intensity forecast errors were 43 and 55 km respectively. These are significantly less than the 5 year average of 75 and 130 km The average intensity forecast error was 7 and 10 knots respectively for 12 and 24 hrs forecasts.

As the life period of the deep depression was very less (only 24 hrs), the track forecasts are verified for 12 hrs and 24 hrs forecast period only.

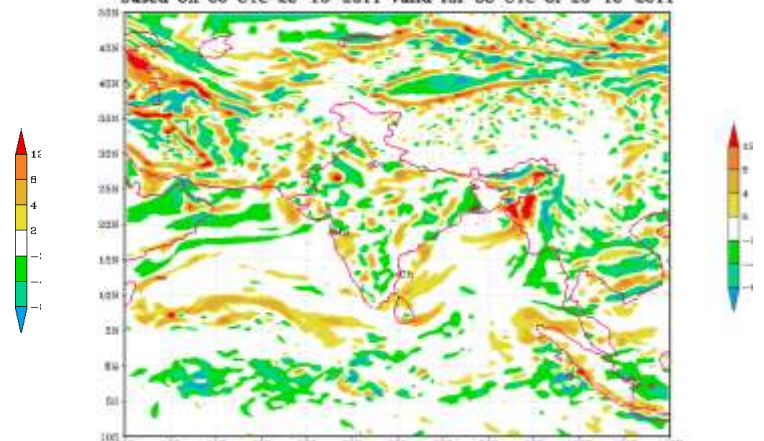
Table 6.2. Average Track & Intensity Forecast Error

Lead period (hrs)	Average track forecast error (kms)	Average intensity Forecast error (kts)
12	43 (3)	7 (3)
24	55 (1)	10 (1)

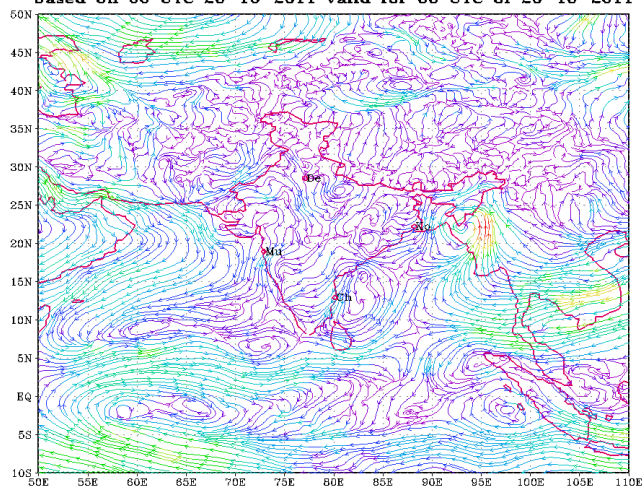
Divergence ($1e5 \text{ s}^{-1}$) at 200 hPa ECMWF Forecast (0 hr.)
based on 00 UTC 20-10-2011 valid for 00 UTC of 20-10-2011



Vorticity ($1e5 \text{ s}^{-1}$) at 850 hPa ECMWF Forecast (0 hr.)
based on 00 UTC 20-10-2011 valid for 00 UTC of 20-10-2011



850 hPa WIND ECMWF FORECAST (0 Hr.)
based on 00 UTC 20-10-2011 valid for 00 UTC of 20-10-2011



Wind Shear between 200 & 850 hPa ECMWF FORECAST (
based on 00 UTC 20-10-2011 valid for 00 UTC of 20-10-2011



Fig. 6.3 (c) (i) Upper level divergence at 200 hPa level (ii) low level relative vorticity at 850 hPa level (iii) wind at 850 hPa level (iv) vertical wind shear of horizontal wind between 200 & 850 hPa level based on the ECMWF model analysis of 0000 UTC of 20th October, 2011.

6.7.3 Landfall forecast : The landfall forecast error for the system is given in Table 6.3

Table 6.3.Verification of landfall forecast

Lead Time(hrs)	Landfall point error(Km)	Landfall time error (hrs)
12	10	0

6.7.4. Adverse Weather Warning:

Isolated heavy rainfall warning during next 48 hrs was issued for Mizoram, Manipur and Tripura based on 0300 UTC of 19th Oct. 2011. However only moderate rainfall occurred over these states as the intense convection lay confined to eastern sector of the track of the system only.

Storm surge guidance was also issued to Bangladesh as the system was predicted to be a marginal cyclone before landfall. The predicted storm surge was 1- 1.5 m above the astronomical tide near the landfall point based on observation of 0600 UTC of 19th Oct. 2011. However there was no significant surge as the system crossed as a deep depression.

Table 6.4. Verification of heavy rainfall warning

F/C Date & Time(IST)	Sub-Division	F/C Valid for 24 hrs.	F/C Valid for 48 hrs.	Realized weather during 24 hrs.	Realized weather during 48 hrs.
22.9.2011 0830 hrs	N.Orissa	SCT H-VH	---	SCT H-VH	---
	S.Orissa	ISOL H-VH	---	ISOL H-VH	---
	Jharkhand	ISO H-VH	---	ISOL H-VH	ISOL H-VH
	N. Chattisgarh	ISOL H-VH	---	-	ISOL H-VH
	Gangetic WB	ISOL H-VH	---	-	-
23.9.2011 0830hrs	N. Chattisgarh	ISOL H-VH	---	ISOL H-VH	ISOL H-VH
	Jharkhand	ISOL H-VH	ISOL H-VH	ISOL H-VH	-
	Bihar	ISOL H-VH	ISOL H-VH	-	ISOL H-VH
	East Uttar Pradesh	ISOL H-VH	ISOL H-VH	ISOL H-VH	ISOL H-VH

Legend: H: Heavy (7-12 cm) VH: Very heavy (13-24 cm)

Table 6.5. Verification of squally Wind Warning:

Date& Time(IST)	Region	Warning Valid for 24 hrs	Realised Wind
22.09.2011 0830 hrs	Along and off Orissa coast West Bengal coast	45-55 Gusting to 65 kmph 45-55 Gusting to 65 kmph	45-55 kmph along and off Orissa and West Bengal coast

Table 6.6. Verification of storm surge guidance:

Date& Time(IST)	Region	Warning Valid for 24 hrs	Realised Wind
22.09.2011 0830 hrs	Along and off Orissa coast West Bengal coast	45-55 Gusting to 65 kmph 45-55 Gusting to 65 kmph	45-55 kmph along and off Orissa and West Bengal coast