Tropical Cyclone Analysis and Forecasting in PTC region

MUSACUT, OMAN

December 17-19, 2012

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www.bmd.gov.bd

Fig.1. Photographs showing damage in coastal areas of Bangladesh, 10-11 October' 2012

Bangladesh

Maximum surface wind of 22 knots over Hatia, 25 knots over Sandip and 32 knots in gust/squalls were reported from Chittagong at the time of landfall. Widespread rainfall occurred over Bangladesh on 10th and 11th October, 2012. Chief amounts of 24 hrs cumulative rainfall (≥ 5 cm) ending at 0300 UTC of 11th October, 2012 are given below: Hatia- 9 cm, Sandip- 6.5 cm, Kutubdia- 10 cm, Cox's Bazar- 10.6 cm, Rangamati- 6 cm and Chittagong- 6 cm. Hourly rainfall rates as observed through DWR, Agartala during 0100 to 0600 UTC of 11th October 2012 are shown in Fig.15. It indicated that the maximum rainfall rate was observed around 0200 UTC and it decreased gradually thereafter.

Damage

The storm brought high winds and heavy rains to much of Bangladesh, causing extensive damage. 34 people were killed and dozens injured when powerful storms lashed several upzillas of Noakhali, Bhola, Chittagong and Feni districts early yesterday. Over 200 thatched cottages in Hatia were damaged. Scores of trees along the subarnachar and Hatia were uprooted, several fishermen with their fishing trawlers remained missing. Squalls destroyed mosques and educational institutions. Afew damage photographs are shown in Fig.1.

Deep Depression over the Bay of Bengal (10-11 October, 2012)

Introduction

Deep depression formed over northeast Bay of Bengal in the evening of 10th October, 2012. It moved northward and crossed Bangladesh coast near Hatia during 11th morning and then moved northeastwards across Bangladesh. It weakened into a well marked low pressure area at 0600 UTC of 11th October, 2012 over Tripura and adjoining Bangladesh and Mizoram. It caused the death of about 34 persons and left several injured in southeastern part of Bangladesh. The salient features of this deep depression were as follows.

Deep Depression over the Bay of Bengal (10-11 October, 2012)

Introduction

(i) It formed from a remnant from the south China Sea which moved across VietNam and Myanmar and emerged into the northeast and adjoining eastcentral Arabian Sea.

(ii) It was short lived with the life period of about 15 hrs

(iii) It intensified into a deep depression before landfall, though it was lying very close to coast.

Deep Depression over the Bay of Bengal (10-11 October, 2012)

Monitoring of depression

As the deep depression formed over northeast Bay of Bengal close to Bangladesh and Myanmar coasts, it could be monitored with INSAT imageries, microwave imageries from Polar Orbiting Satellites, Doppler Weather Radars (DWR) at Khepupara, Cox's Bazar (Bangladesh) and Agartala.

Summery Report of the Depression (9-11 Oct2012) by BMD

- The System was detected as a low pressure area over Northwest Bay and adjoining West-central Bay on 08th October 2012.
- It intensified into a well marked low over North Bay at 09 UTC of 10th October 2012.
- The system moved northeastwards and intensified into a monsoon depression over Northeast Bay and adjoining area at 18 UTC of 10th October. It was reported by RSMC that as per STATISTICAL AND NWP MODEL PREDICTIONS, IT IS EXPECTED TO LIE IN PHASE 7 DURING NEXT 2-3 DAYSWITH DECREASE IN AMPLITUDE. HENCE IT IS NOT FAVOURABLE FOR FURTHER INTENSIFICATION.THE SEA SURFACE TEMPERATURE IS ABOUT 29-30 DEG. C. OVER NORTH BAY OF BENGAL. CONSIDERING THE NWP MODEL GUIDANCE, MOST OF THE MODELS did NOT SUGGEST FURTHER INTENSIFICATION OF THE SYSTEM. ACCORDING TO SATELLITE IMAGERIES, THE INTENSITY OF THE SYSTEM IS T 1.5. THE LOWEST CLOUD TOP TEMPERATURE (CTT) IS ABOUT -70^{0}C.
- The depression moved north-northeastwards and was crossing Chittagong coast near Hatiya-Sandwip at 00UTC of 11 October.
- The system competed crossing the coast at 01 UTC of 11th October.

Deep Depression over the Bay of Bengal (10-11 October, 2012)

Genesis, intensification and movement

A remnant of a tropical storm over south China Sea moved westwards across Vietnam and Myanmar emerged into northeast and adjoining east central Bay of Bengal as an upper air cyclonic circulation on 9th October 2012. It moved northwestwards and was seen as a low pressure area at 0300 UTC of 10th October,2012. It concentrated into a depression and lay centred at 1200 UTC of 10th October, 2012 over northeast Bay of Bengal near latitude 21.00N and longitude 91.00E. Track of the system is shown in Fig.1.Sustained maximum surface wind speed was estimated to be about 25 knots gusting to 35 knots around system centre.

Deep Depression over the Bay of Bengal (10-11 October, 2012)

Genesis, intensification and movement

The state of the sea was rough to very rough around the system centre. The estimated central pressure was about 1003 hPa with outer most closed isobar as 1006 hPa. The 24 hrs pressure tendency was negative and about 1 hPa along Bangladesh coast. The best track parameters are shown in Table In association with favourable environmental conditions like low to moderate wind shear, increase in convergence and vorticity in lower levels, increase in upper level divergence and its location near the upper tropospheric steering ridge, the depression moved northward and intensified into a deep depression 1800 UTC of10th October. It then moved north-northeastwards as the system lay close to the north of the upper tropospheric ridge.

Deep Depression over the Bay of Bengal (10-11 October, 2012)

BMD

1. A remnant of a tropical storm over south China Sea moved westwards across Vietnam and Myanmar emerged into northeast and adjoining east central Bay of Bengal as an upper air cyclonic circulation on 9th October 2012. It moved northwestwards and was seen as a low pressure area at 0300 UTC of 10th October,2012.

2. The low became a well marked low over north bay at 09 utc of 10th October 2012. It was likely intensify further.

3. The system moved northeastwards and concentrated into a monsoon depression over northeast bay Bengal near latitude 21.00N and longitude 91.00E and adjoining area at 18 utc of 10th october.

RSMC, NEW DELHI

1. A remnant of a tropical storm over south China Sea moved westwards across Vietnam and Myanmar emerged into northeast and adjoining east central Bay of Bengal as an upper air cyclonic circulation on 9th October 2012. It moved northwestwards and was seen as a low pressure area at 0300 UTC of 10th October,2012.

2. Low pressure area at 0900 UTC.

3. It concentrated into a depression and lay centred at 1200 UTC of 10th October, 2012 over northeast Bay of Bengal near latitude 21.00N and longitude 91.00E. Sustained maximum surface wind speed was estimated to be about 25 knots gusting to 35 knots around system centre.

Deep Depression over the Bay of Bengal (10-11 October, 2012)

BMD

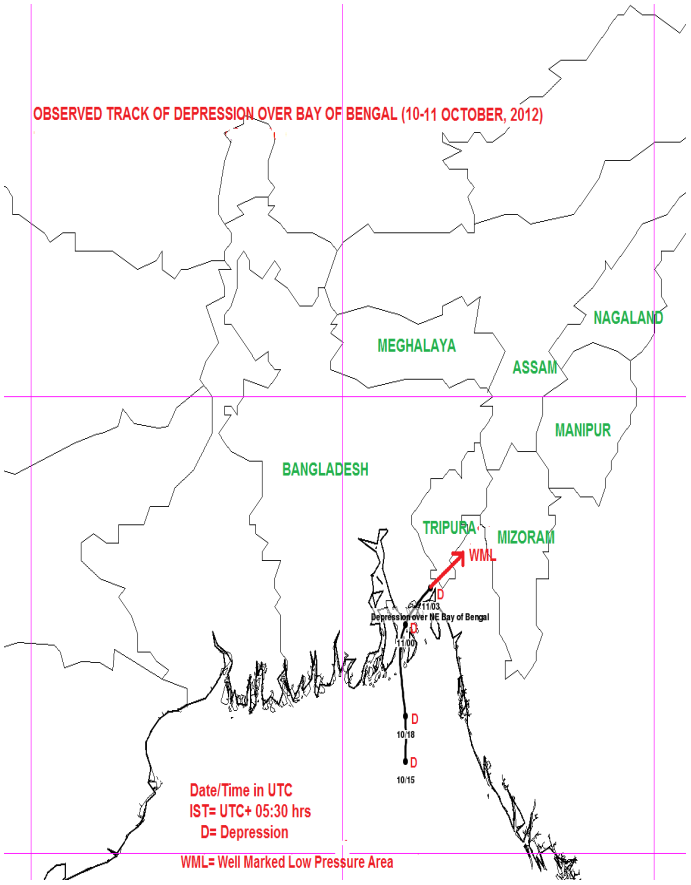
4. The deep depression crossed Bangladesh coast near Hatia between 0000-0100 UTC of 11th October, 2012. The associated sustained maximum wind speed at the time of landfall was about 30 knots.After the landfall, the deep depression continued to move north-northeastwards, weakened into a depression and lay centred at 0300 UTC over Bangladesh and adjoining Tripura near latitude 23.00N and longitude 91.50E, about100 km south of Agartala. It then continued to move northeastwards and further weakened into a well marked low pressure area over Tripura and adjoining Bangladesh and Mizoram at 0600 UTC of 11th October, 2012.

RSMC, NEW DELHI

4. The deep depression crossed Bangladesh coast near Hatia between 0000-0100 UTC of 11th October, 2012. The associated sustained maximum wind speed at the time of landfall was about 30 knots.After the landfall, the deep depression continued to move north- northeastwards, weakened into a depression and lay centred at 0300 UTC over Bangladesh and adjoining Tripura near latitude 23.00N and longitude 91.50E, about100 km south of Agartala. It then continued to move northeastwards and further weakened into a well marked low pressure area over Tripura and adjoining Bangladesh and Mizoram at 0600 UTC of 11th October, 2012.

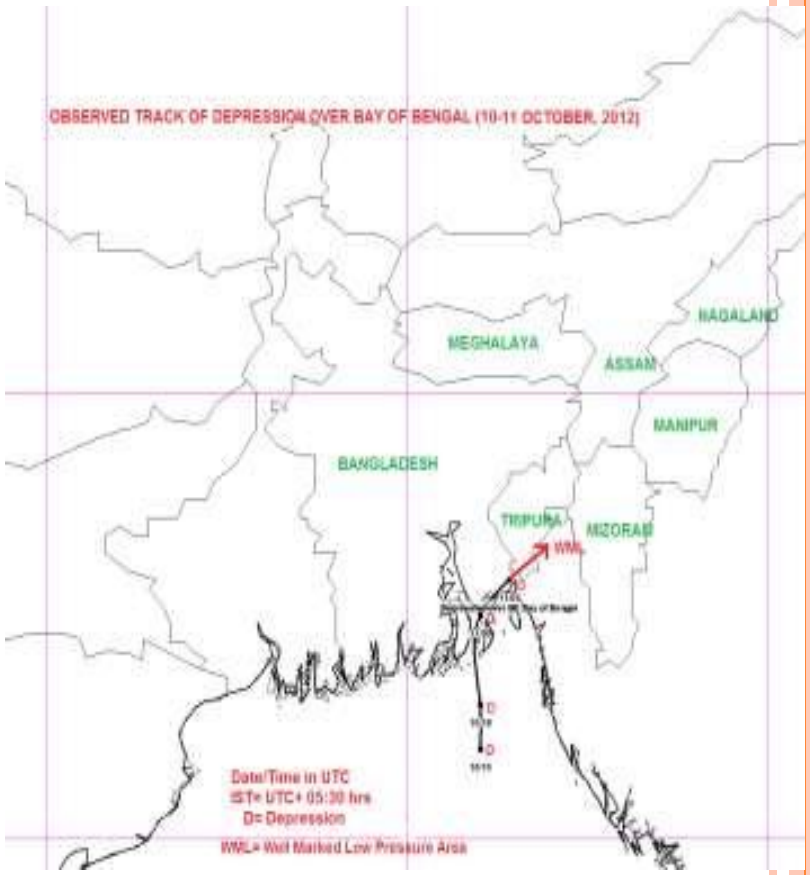
Deep Depression over the Bay of Bengal (10-11 October, 2012)

BMD



Date/Time in UTC BST=UTC+06:00 hrs D=Depression

RSMC, NEW DELHI



RSMC New Delhi

Table 1 The best rack position and other parameters of deep depression over the Bay of Bengal during 10-11 October, 2012

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
10.10.2012	1200	21.0/91.0	1.5	1003	25	3	D
	1500	21.5/91.0	1.5	1003	25	4	D
	1800	22.0/91.0	2.0	1002	30	5	DD
11.10.2012	0000	22.5/91.3	2.0	1002	30	5	DD
	Deep Depression crossed near Hatia (Bangladesh) between 0000-0100 UTC						
	0300	23.0/91.5	1.5	1006	20	3	D
	0600	Weakened into a well marked low pressure area over Mizoram & neighbourhood					

RSMC, New Delhi Forecast Evaluation

Parameter	Base Date/Time (UTC)	Forecast	Actual
Track, intensity & landfall	10.10.2012/ 0900 UTC. Received at 1030 UTC in Storm warning Centre, Dhaka	IMD is maintaining it as a low pressure area in its official bulletin based on 0900 UTC of today. There was no indications of intensifying of the low pressure into a depression during next 02 -03 hrs in the forecast.	Intensified into a depression after 2 hrs at 10.10.2012/1200 UTC.
Track, intensity & landfall	10.10.2012/ 1500 UTC. Received at mid-night in Storm warning Centre, Dhaka	Depression likely to intensify further, move northward and cross Bangladesh coast near Hatia in the morning of 11th October.	Depression moved northward, intensified into a deep depression and crossed Bangladesh coast near Hatia between 0000-0100 UTC (0530-0630 hrs IST) of 11th October.
Rainfall	10.10.2012/ 1500 UTC.	Fairly widespread and isolated heavy rainfall during next 48 hrs over Assam, Meghalaya, Nagaland, Manipur, Mizoram and Tripura	Fairly widespread rainfall with isolated heavy falls (Sec.5)
Surface Wind	10.10.2012/ 1500 UTC.	25 knots gusting to 35 knots.	Chittagong- 32 kts in gustiness at 2330 UTC, Hatia-22kts at 2045 UTC and Sandip-25 kts at 2250 UTC of 10th October.

RSMC, New Delhi Forecast Evaluation (remarks & NWP guidance)

Parameter Base	Date/Time (UTC)	Forecast	Actual
Track, intensity & landfall	10.10.2012/ 0900	Thank you for your mail and conversation over phone. The organisation of the convection during past six hours as seen in INSAT Kalpana imageries has remained same. However, the depth of convection near the centre has decreased as seen in cloud top temperature. It may be due to diurnal variation. As such, Satellite Division of IMD is continuing with T 1.0 at 0900 UTC. However, the low pressure area has moved northwestwards during past six hours and lay centred near 20.0 North and 91.0 East at 0900 UTC. IMD is maintaining it as a low pressure area in its official bulletin based on 0900 UTC of today.	**Special tropical weather outlook Dems–rsmc tropical cyclones new delhi 10.10.2012** Tropical weather outlook for north indian ocean (the bay of bengal and arabian sea) valid for next 24 hours issued at 1630 utc of 10 october, 2012 based on 1500 utc of 10 October, 2012 (.)

RSMC, New Delhi Forecast Evaluation (remarks & NWP guidance)

Parameter Base	Date/Time (UTC)	Forecast	Actual
Track, intensity & landfall	10.10.2012/ 0900	The ECMWF model and MeteoFrance global tropics model based on 0000UTC initial condition suggest that the low pressure area may concentrate into a depression by 1200 UTC, while moving in a near northerly/north-northwesterly direction. It is likely to lie near Bangladesh coast by 0000 UTC of 11th October 2012 as a depression according to these models. IMD GFS model does not suggest intensification.	Latest satellite imagery indicates that a depression has formed over northeast bay of bengal and lay centred at 1500 utc of today, the 10th october, 2012 near latitude 21.0^{0}n and longitude 91.0.^{0}e, about 350 km southeast of kolkata (42809), 150 km southeast of khepupara (41984) and 150 km south of Hatia (41963).

RSMC, New Delhi Forecast Evaluation (Remarks & NWP Guidance)

Parameter Base	Date/Time (UTC)	Forecast	Actual
Track, intensity & landfall	10.10.2012/ 0900	Considering the synoptic and environmental conditions, the pressure fall along the coast is not significant yet. The estimated central pressure is 1005 hPa. The maximum sustainedsurface wind is estimated as 15-20 knots. There is low to moderate vertical wind shear with no significant shear tendency. The SST is about 29 deg. C. But the Ocean thermal energy is less and is about 50-60 KJ/cm square. It significantly decreases towards Head Bay. The upper tropospheric ridge lies along 21.5 deg. N in association with anticyclonic circulation over southeast China. As such the synoptic and environmental conditions and NWP models suggest marginal intensification and initial north-northwestward movement across Bangladesh near Long. 90.5-91.0 deg. East and then northward/northnortheastward movement. RSMC, New Delhi is in constant watch of the system. I will provide you further updates based on 1200 UTC.	Associated broken low/medium clouds with embedded intense to very intense convection seen over bay of bengal north of lat 18.5^0n east of long $90.5.0^0$e sustained maximum surface wind speed is estimated to be about 25 knots gusting to 35 knots around system centre. The state of the sea is rough to very rough around the system centre. The estimated central pressure is about 1003 hpa. The 24 hrs pressure tendency is negative and about 1 hpa along Bangladesh coast.

RSMC, New Delhi Forecast Evaluation (Remarks & NWP Guidance)

Parameter Base	Date/Time (UTC)	Forecast	Actual
Track, intensity & landfall	10.10.2012/ 1500	The Depression is likely to intensify further, move northwards and cross Bangladesh coast near Hatia by tomorrow the 11th October, 2012 morning . according to satellite imageries, the intensity of the system is t 1.5. The lowest cloud top temperature (CTT) is about -70^{0}c. Associated broken low/medium clouds with embedded intense to very intense convection seen over bay of bengal north of lat 18.5^{0}n east of long 90.5.0^{0}e sustained maximum surface wind speed is estimated to be about 25 knots gusting to 35 knots around system centre. The state of the sea is rough to very rough around the system centre. The estimated central pressure is about 1003 hpa. The 24 hrs pressure tendency is negative and about 1 hpa along Bangladesh coast.	The deep depression crossed Bangladesh coast near Hatia between 0000-0100 UTC of 11th October, 2012. The associated sustained maximum wind speed at the time of landfall was about 30 knots. After the landfall, the deep depression continued to move north-northeastwards, weakened into a depression and lay centred at 0300 UTC over Bangladesh and adjoining Tripura near latitude 23.00N and longitude 91.50E, about100 km south of Agartala.

RSMC, New Delhi Forecast Evaluation (remarks & NWP guidance)

Parameter Base	Date/Time (UTC)	Forecast	Actual
Track, intensity & landfall	10.10.2012/ 1500	Considering the environmental features, the madden julian oscillation index currently lies over phase 6 with amplitude of 1. As per statistical and nwp model predictions, it is expected to lie in phase 7 during next 2-3 dayswith decrease in amplitude. Hence it is not favourable for further intensification.The sea surface temperature is about 29-30 deg. C. Over north bay of bengal. The ocean thermal energy is 50 - 60 kj/cm square around the system centre it decreases towards bangladesh coast. The upper tropospheric ridge lies along 20 deg. N and hence close to system centre. A trough in mid-tropospheric westerlies roughly runs along 80 deg. E to the north of 18 deg. N. It is likely to steer the system northeastwards.	It then continued to move northeastwards and further weakened into a well marked low pressure area over Tripura and adjoining Bangladesh and Mizoram at 0600 UTC of 11th October, 2012.

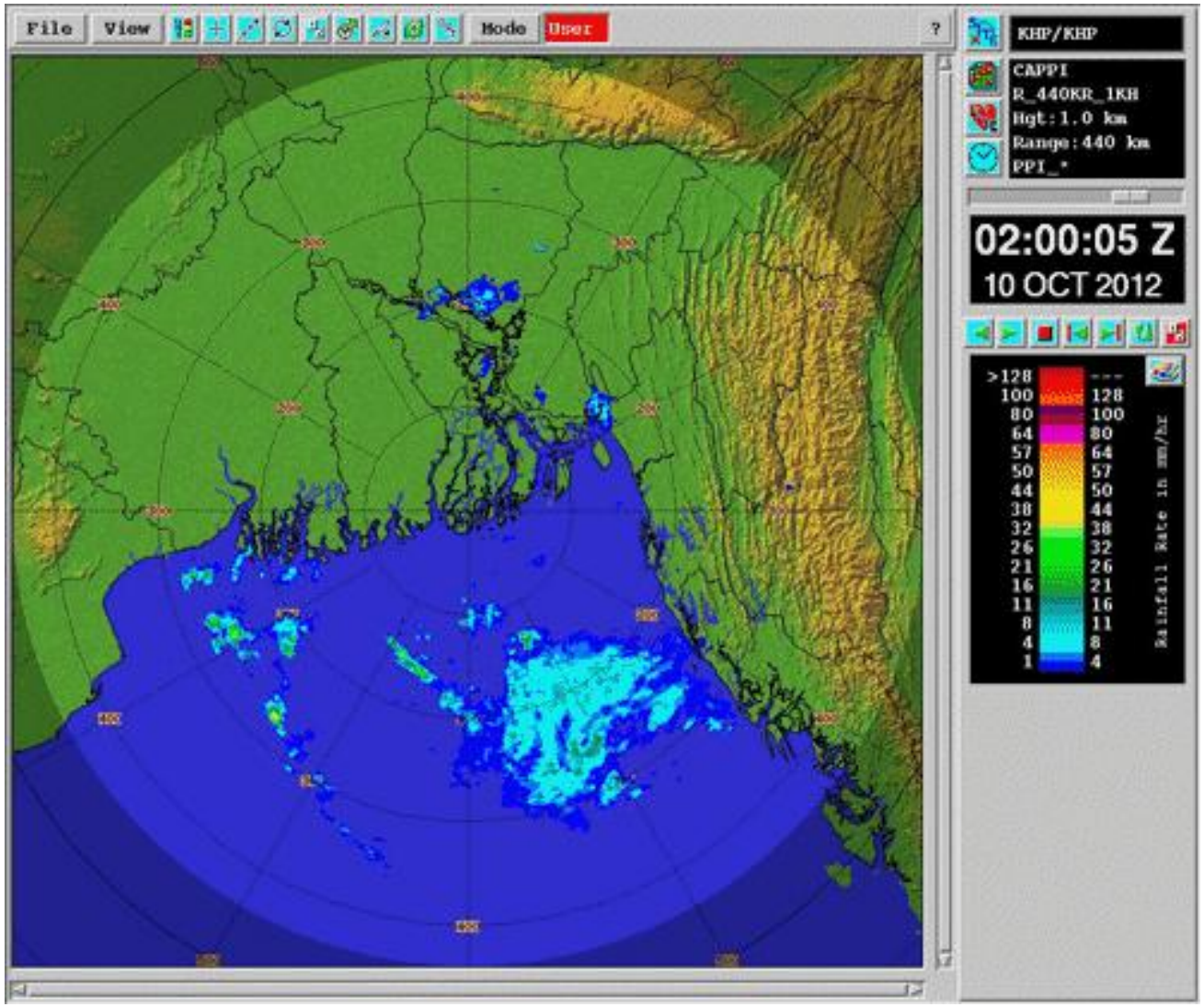
RSMC, New Delhi Forecast Evaluation (remarks & nwp guidance)

Parameter Base	Date/Time (UTC)	Forecast	Actual
Track, intensity & landfall	10.10.2012/ 1500	The low level convergence has increased during past 12 hrs as well as upper level divergence and lower level relative vorticity. The vertical wind shear between 200 and 850 hpa levels is low to moderate (10-20 knots) around system centre. However, it increases towards bangladesh coast. Considering the nwp model guidance, most of the models do not suggest further intensification of the system. Most of the models suggest northward movement and landfall over bangladesh coast near 91 deg. E by 11th october, morning. It then may move northeastwards.	

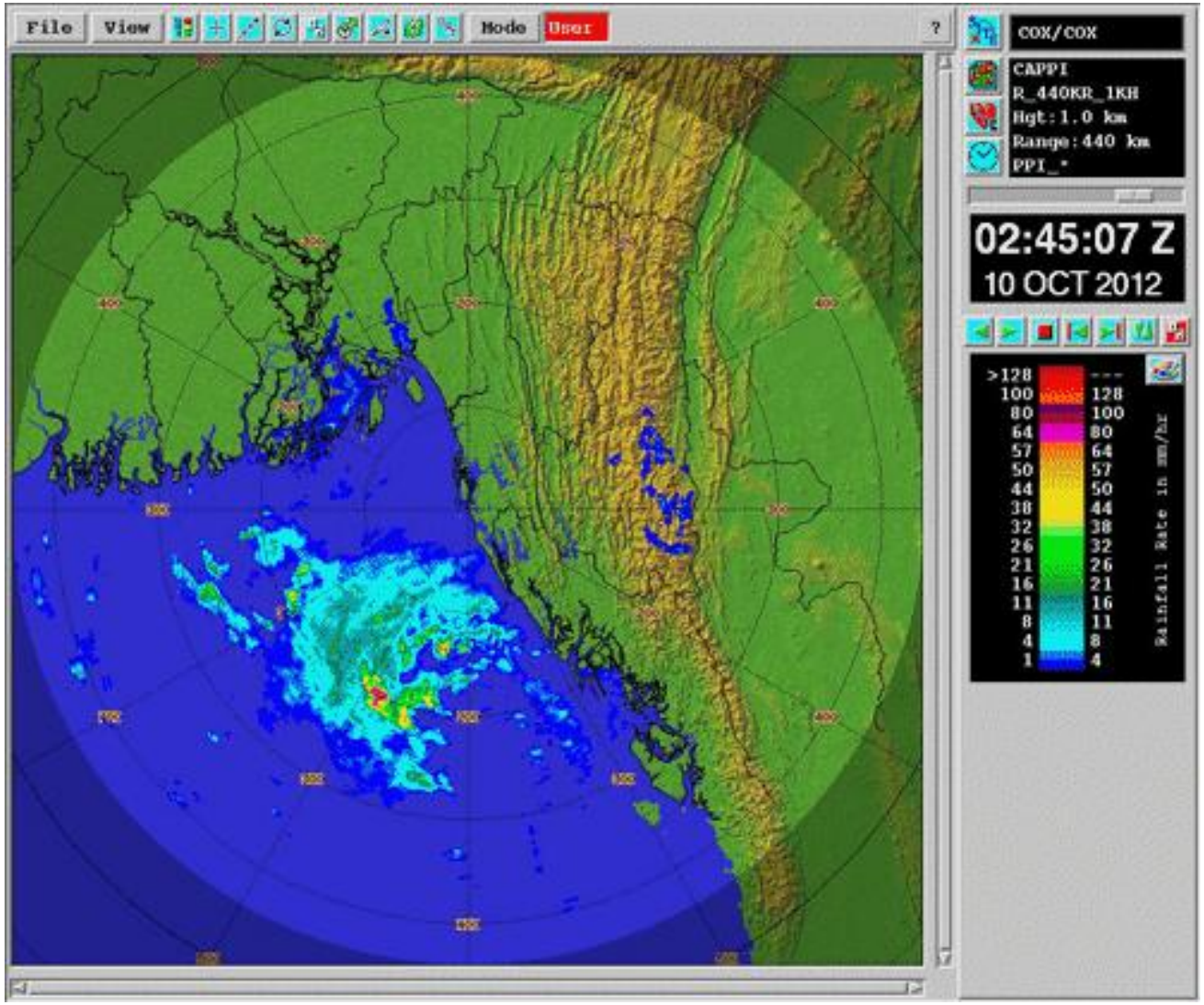
RSMC, New Delhi Forecast Evaluation (remarks & NWP guidance)

Parameter Base	Date/Time (UTC)	Forecast	Actual
Rainfall	10.10.2012/ 1500	Fairly widespread and isolated heavy rainfall during next 48 hrs over Assam, Meghalaya, Nagaland, Manipur, Mizoram and Tripura	Fairly widespread rainfall with isolated heavy falls (Sec.5)
Surface Wind	10.10.2012/ 1500	25 knots gusting to 35 knots.	Chittagong- 32 kts in gustiness at 2330 UTC, Hatia-22kts at 2045 UTC and Sandip-25 kts at 2250 UTC of 10th October. **12. Damage**

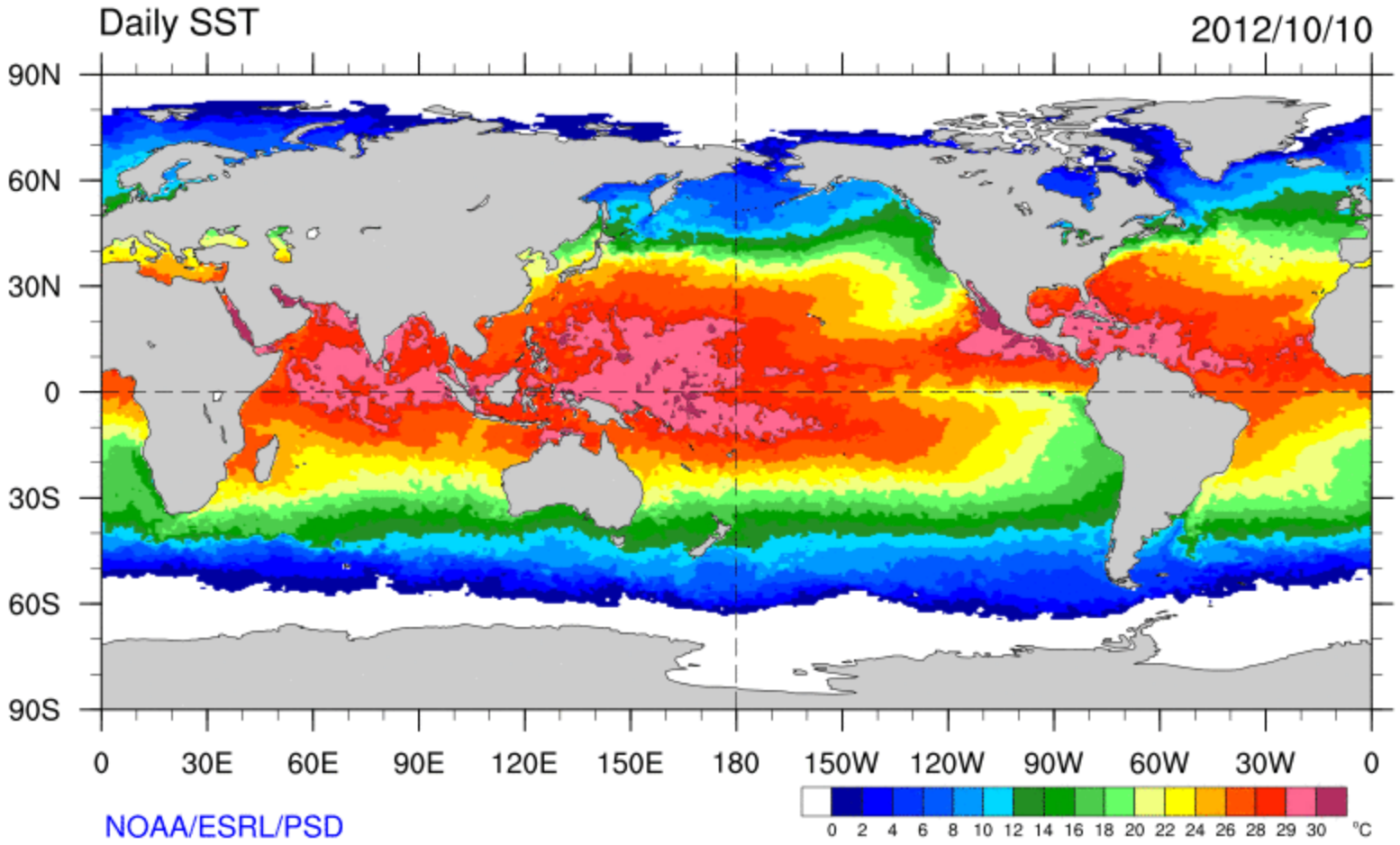
KHEPUPARA RADAR, BANGLADESH



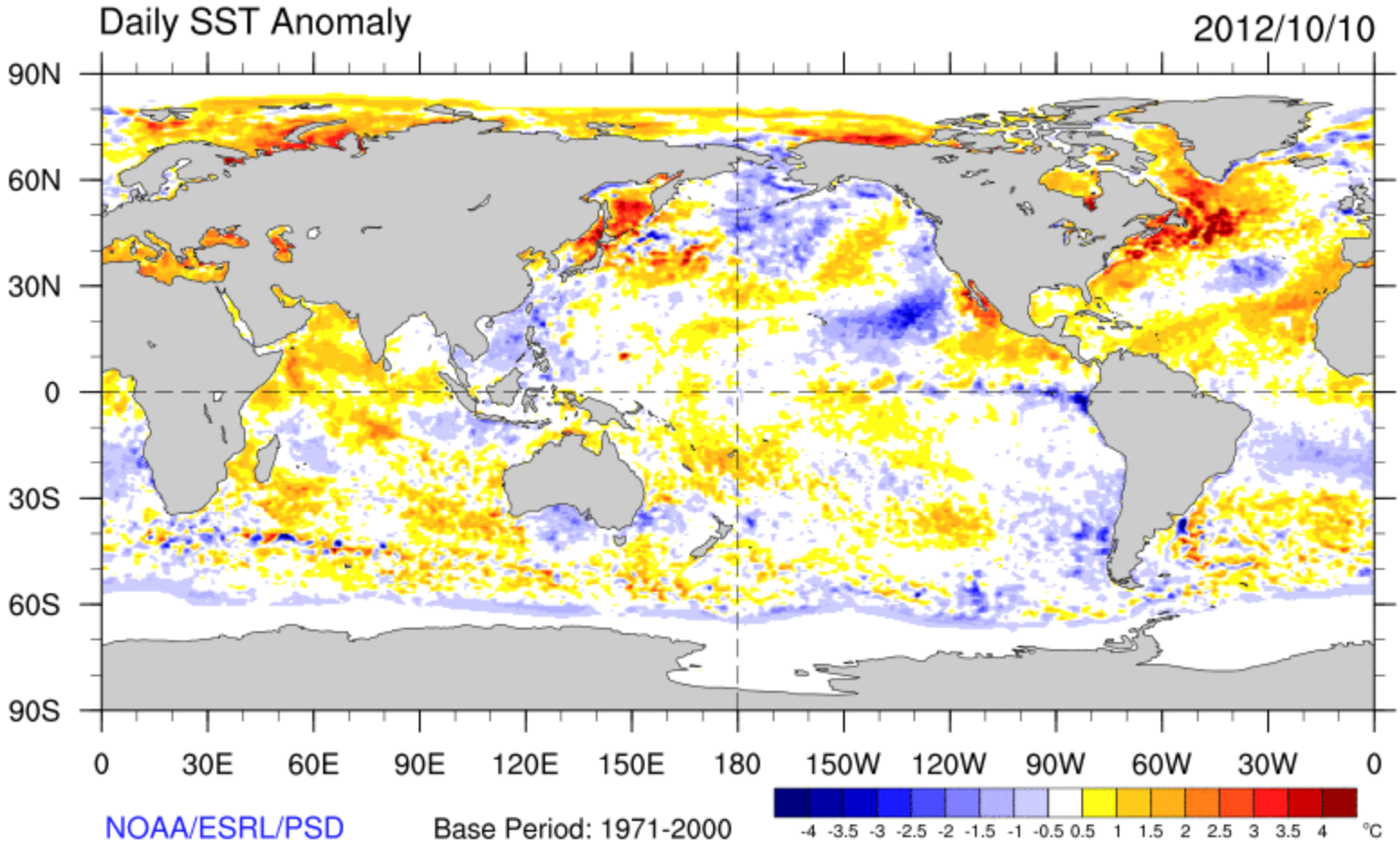
COX'S BAZAR RADAR, BANGLADESH



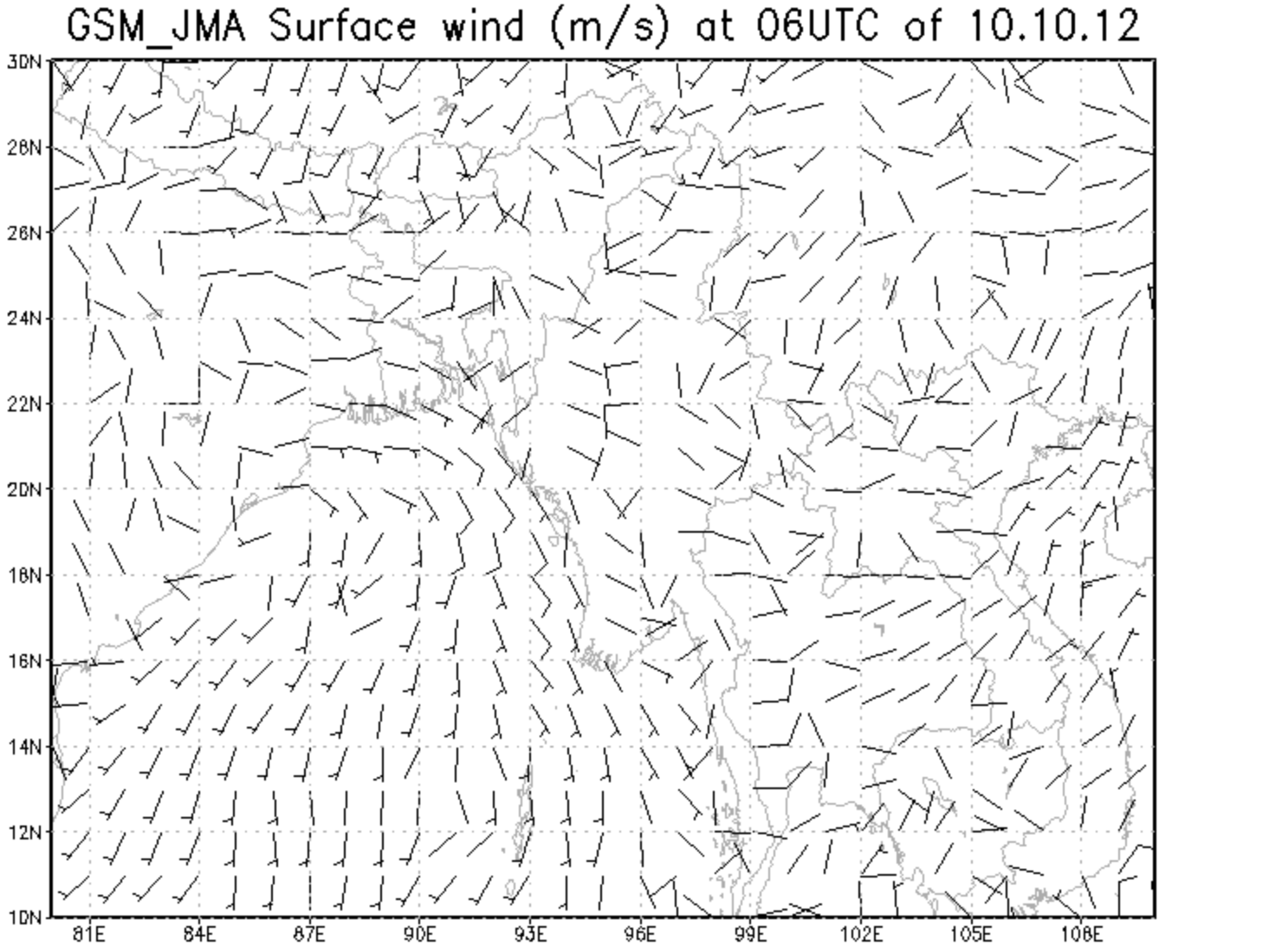
Sea Surface Temperature

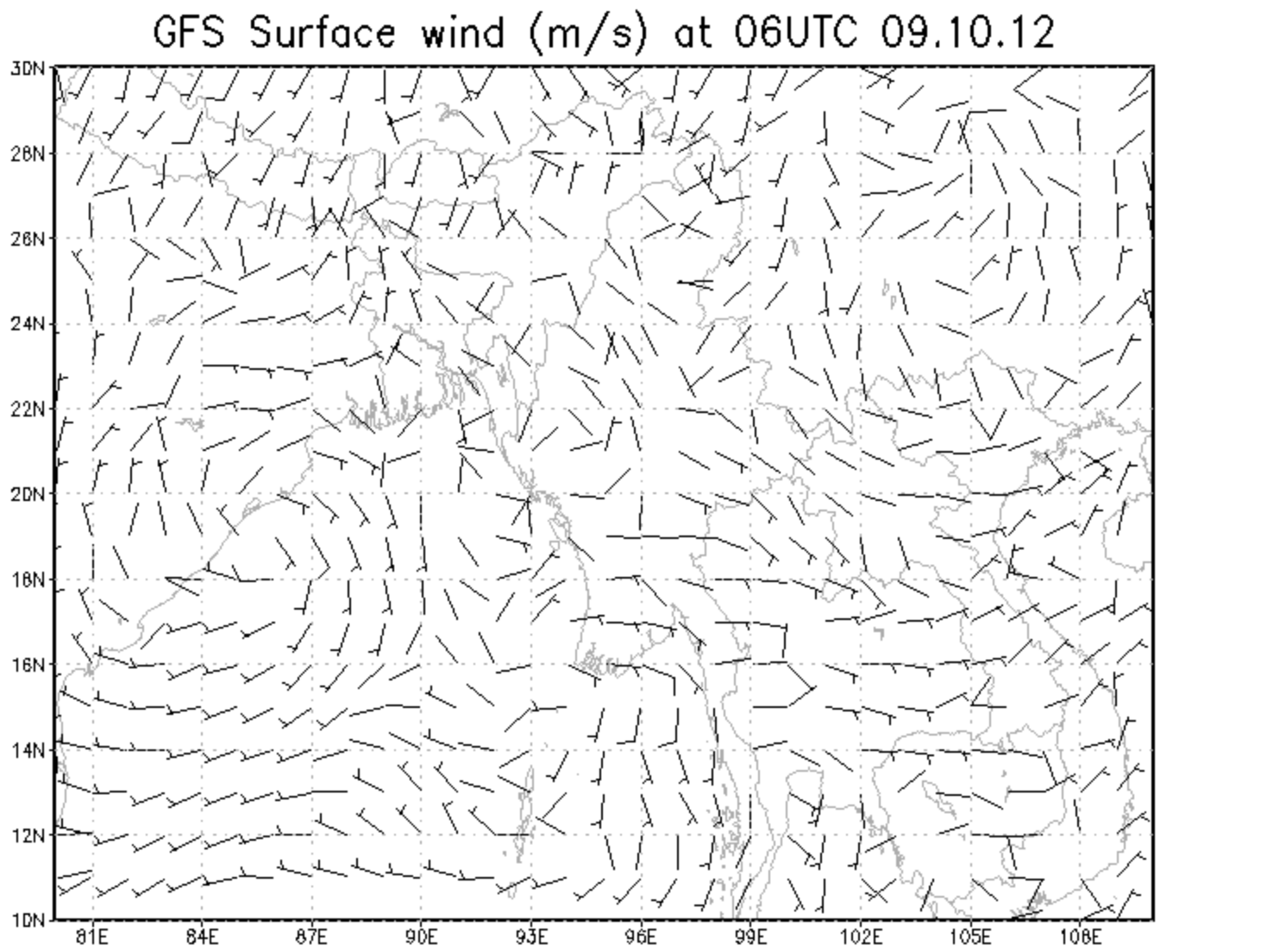


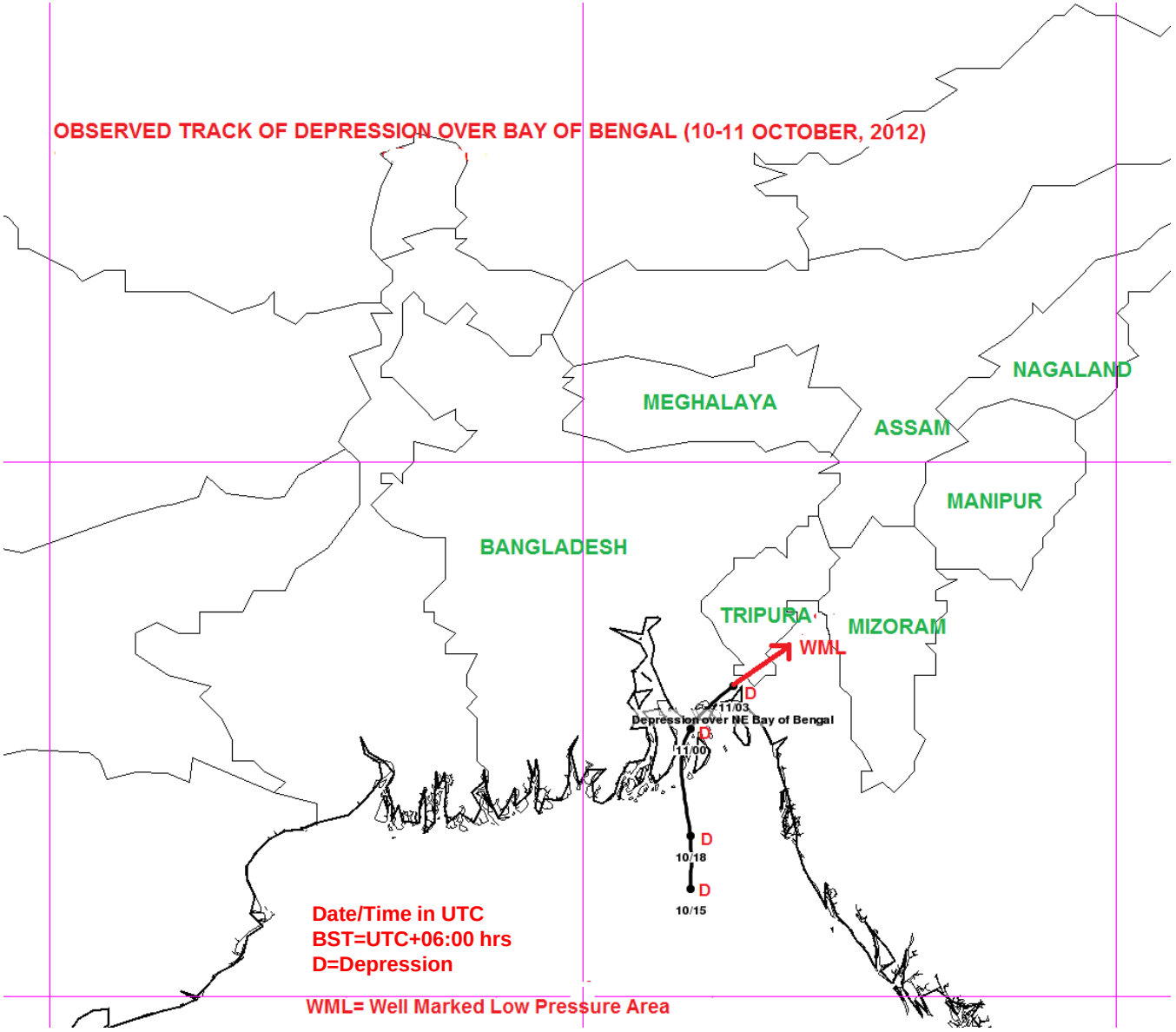
SST Anomaly



Source: http://www.esrl.noaa.gov/psd/map/clim/sst.shtml


GSM_JMA Surface wind (m/s) at 06UTC of 10.10.12
30N
28N
26N
24N
22N
20N
18N
16N
14N
12N
10N
81E
84E
87E
90E
93E
96E
99E
102E
105E
108E
GrADS: COLA/IGES
2012-10-15-12:24

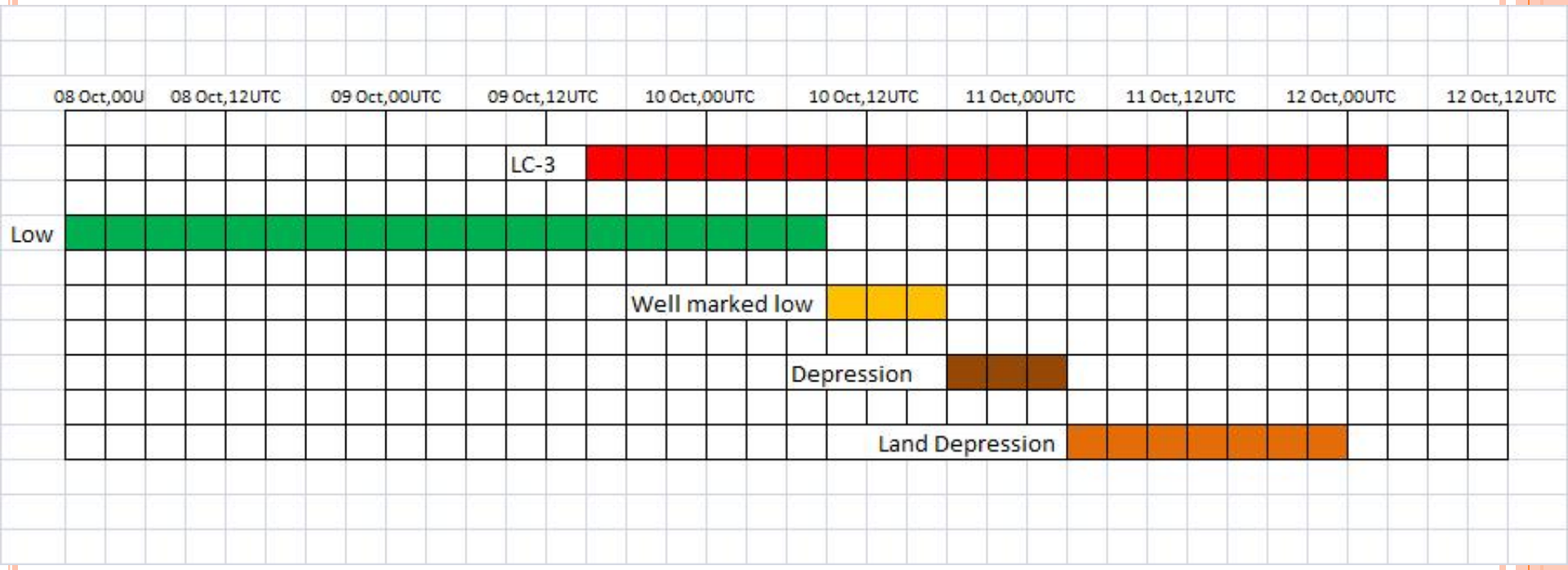

GFS Surface wind (m/s) at 06UTC 09.10.12
30N
28N
26N
24N
22N
20N
18N
16N
14N
12N
10N
81E
84E
87E
90E
93E
96E
99E
102E
105E
108E
GrADS: COLA/IGES
2012-10-15-12:46


OBSERVED TRACK OF DEPRESSION OVER BAY OF BENGAL (10-11 OCTOBER, 2012)
NAGALAND
MEGHALAYA
ASSAM
MANIPUR
BANGLADESH
TRIPURA
MIZORAM
WML
D
11/03
Depression over NE Bay of Bengal
D
11/00
D
10/18
D
10/15
Date/Time in UTC
BST=UTC+06:00 hrs
D=Depression
WML= Well Marked Low Pressure Area

Depression Summary

Sl no.	Status	Position	Message	Issue Date and Time	Signal for Maritime ports	Issue Date and Time Signal for River ports		Wind Driven Surge
01	Low	North-West Bay and adjoining area	Warning Message	09, 2230 BST	Local Cautionary Signal no.3	09,2100 BST	Local Cautionary Signal no.1	
02	Well Marked Low	North Bay and adjoining area	Warning Message	10, 1500 BST	Local Cautionary Signal no.3	10,1530 BST	Riverine Warning Signal no.2	01-03 Feet
03	Depression	North- East and adjoining area	Special Weather Bulletin-01	11, 0030 BST	Local Cautionary Signal no.3	11,0530 BST	Riverine Warning Signal no.2	01-03 Feet
04	Coast crossing Depression	North- East Bay off CTG coast near Hatiya-Sandwip	Special Weather Bulletin-02	11, 0630 BST	Local Cautionary Signal no.3	11,0930 BST	Riverine Warning Signal no.2	01-03 Feet
05	Land Depression	Feni and adjoining area	Special Weather Bulletin-03	11, 0930 BST	Local Cautionary Signal no.3	11,1700 BST	Riverine Warning Signal no.2	
06	Latest Weather Situation: Lower Signal for Maritime ports issued at 12, 0930 BST.							

Depression Summary



Conclusion

- The life span of the depression was only 15 hrs.
- Forecast lead time of the landfall of the deep depression was very short (less than 6 hrs).
- Intensification of the system couldn't be predicted well in advance by RSMC.
- The weather event was declared as depression at mid-night on October 10, 2012 . It was very difficult for the disaster management authority to take necessary pre-cautionary measures to reduce loss of lives.

THANK YOU