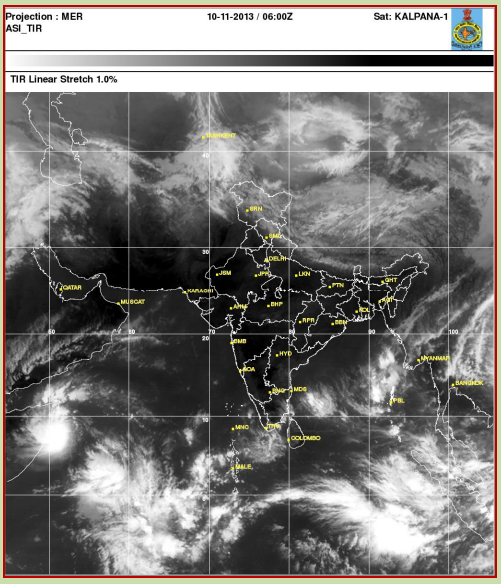
GOVERNMENT OF INDIA

MINISTRY OF EARTH SCIENCES

EARTH SYSTEM SCIENCE ORGANISATION

INDIA METEOROLOGICAL DEPARTMENT

A Preliminary Report on Deep Depression over Arabian Sea (08 -11 November, 2013)



KALPANA IMAGERY BASED ON 0600 UTC OF 10TH NOV

CYCLONE WARNING DIVISION, NEW DELHI

NOVEMBER 2013

1. Introduction

A depression formed over the southwest Arabian Sea in association with an active inter tropical convergence zone on 08 November 2013. It moved westwards and intensified into a deep depression on 09 November 2013 and crossed Somalia coast between 2300 UTC of 10 November and 0000 UTC of 11 November near lat. 8.2^0N and 50.0^0E. It then moved west-northwestwards and weakened gradually into a depression at 0600 UTC and into a well marked low pressure area over Somalia at 1200 UTC of 11 November 2013. The salient features of this cyclone are given below.

(i) The deep depression maintained its intensity, though it moved across colder Sea near Somalia coast.

(ii) The low vertical wind shear around the depression centre throughout its life period helped it to maintain the intensity of deep depression at the time of landfall

2. Monitoring and prediction

The deep depression was mainly monitored by satellite. The half hourly INSAT/ Kalpana imageries, and products, Oceansat-II surface winds along with the products from newly launched INSAT-3D satellite and other internationally available satellite products were used for monitoring of this deep depression. Various numerical weather prediction (NWP) models and dynamical-statistical models including IMDôs global and meso-scale models were utilized to predict the genesis, track and intensity of the deep depression. Tropical Cyclone Module in the digitized forecasting system of IMD was utilized for analysis and comparison of various observational and NWP models products and decision making process.

3. Climatological characteristics

Considering the data during 1891-2013, there has been no genesis of cyclonic disturbance in the past over the Arabian Sea to the west of 60^0E in the month of November prior to the deep depression during 8-11 November 2013. The cyclonic disturbances formed over the Arabian Sea during November for the period of 1891-2012 are shown in Fig.1. It indicates that about two third of cyclonic disturbances

developing over south Arabian Sea during the month of November moved westwards/west-northwestwards. Considering the landfalling disturbances, Somalia experienced all the disturbances, which could make landfall over Arabia-Africa.

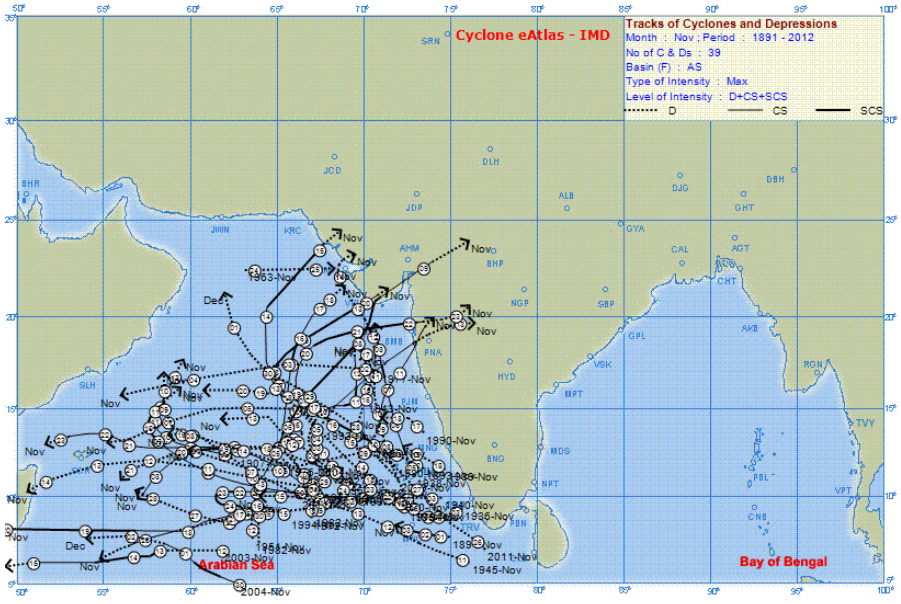


Fig.1. Tracks of cyclonic disturbances formed over the Arabian Sea during the month of November over the period of 1891-2012.

The brief history of the genesis, intensification and movement of this storm are discussed in following sections.

4. Genesis

Under the influence of an active inter-tropical convergence zone, a low pressure area formed over the southeast Arabian Sea on 08 November 2013. It moved westwards and became well marked over southeast and adjoining southwest Arabian Sea on 07 November. Continuing to move westwards, it concentrated into a depression at 0600 UTC of 08 November 2013 and lay centred over southwest Arabian Sea near lat. 8.0^{0}N and long. 56.5^{0}E, about 680 km east-southeast of Ras Binnah (Somalia).

During the genesis phase, the Madden Julian Oscillation index lay in phase 2 with amplitude approximately one. The phase 2 is favourable for genesis and intensification of the cyclonic disturbances over the Arabian Sea. The sea surface temperature (SST) over the southwest Arabian Sea and adjoining areas was 28-30

degree C. The Ocean heat content (OHC) was 88-100 KJ/cm^2 over the area. The lower level convergence and relative vorticity as well as upper level divergence increased from 07 to 08 November. The upper tropospheric ridge lay along 12^{0}N and hence provided poleward out flow in association with an anticyclonic circulation located to the northeast of the system centre. The vertical wind shear between 200 and 850 hPa levels was low to moderate (05-15 knots) around the system centre. Considering all these, the environmental parameters were favourable for genesis and intensification of the system.

5. Intensification and movement

As the depression lay to the south of the upper tropospheric ridge and the steering winds at middle and upper tropospheric levels were easterly the system moved nearly westwards till landfall. It intensified into a deep depression and lay centred at 0000 UTC of 09 November 2013 over southwest Arabian Sea near lat. 8.0^{0}N and long. 53.0^{0}E, about 400 km south-southeast of Ras Binnah, Somalia as the favourable environmental conditions as mentioned in the previous section continued on 09 November 2013.

On 09 November, the convection increased in the northwest sector with increase in low level relative vorticity. The low to moderate wind shear continued to prevail over the region. Under these circumstances, the deep depression moved westwards and maintained its intensity as deep depression till landfall, though the system was moving over a relatively colder sea area. On 24 December, as the system came closer to Somalia coast, it experienced further colder sea with Ocean thermal energy of < 40 KJ/$^{cm-2}$ and sea surface temperature of 26-28^{0}C. The vertical wind shear of horizontal wind however decreased and was low (about 5-10 knots) around the system centre. The dynamical statistical models of IMD indicated the system to attain the intensity of marginal cyclone and most of the NWP models indicated gradual weakening of the system. The system crossed Somalia coast as a deep depression between 2300 UTC of 10 November and 0000 UTC of 11 November near lat. 8.2^{0}N and 50.1^{0}E. It then moved west-northwestwards to northwestwards and weakened into a depression at 0600 UTC and into a well marked low pressure area over Somalia at 1200 UTC of 11 November 2013.

Table 1: Best track positions and other parameters of the Deep Depression over the Arabian Sea during 08-11 November, 2013

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
08-11-2013	0600	8.0/56.5	1.5	1006	25	3	D
	1200	8.0/55.0	1.5	1004	25	3	D
	1800	8.0/54.0	1.5	1004	25	3	D
09-11-2013	0000	8.0/53.0	2.0	1002	30	5	DD
	0300	8.0/52.5	2.0	1002	30	5	DD
	0600	8.0/52.5	2.0	1002	30	5	DD
	1200	8.0/51.5	2.0	1002	30	5	DD
	1800	8.0/51.5	2.0	1002	30	5	DD
10-11-2013	0000	8.0/51.5	2.0	1002	30	5	DD
	0300	8.0/51.5	2.0	1002	30	5	DD
	0600	8.0/51.0	2.0	1002	30	5	DD
	1200	8.0/51.0	2.0	1002	30	5	DD
	1800	8.1/50.5	2.0	1002	30	5	DD
	Deep Depression crossed Somalia coast near lat. 8.2°N and long. 50.1^{0}E between 2300 UTC of 10-11-2013 and 0000 UTC of 11-11-2013						
11-11-2013	0000	8.2/50.0	2.0	1002	30	5	DD
	0300	8.4/49.6	2.0	1002	30	5	DD
	0600	8.7/49.3	1.5	1004	25	3	D
	1200	**Weakened into a well marked low pressure area over Somalia**					

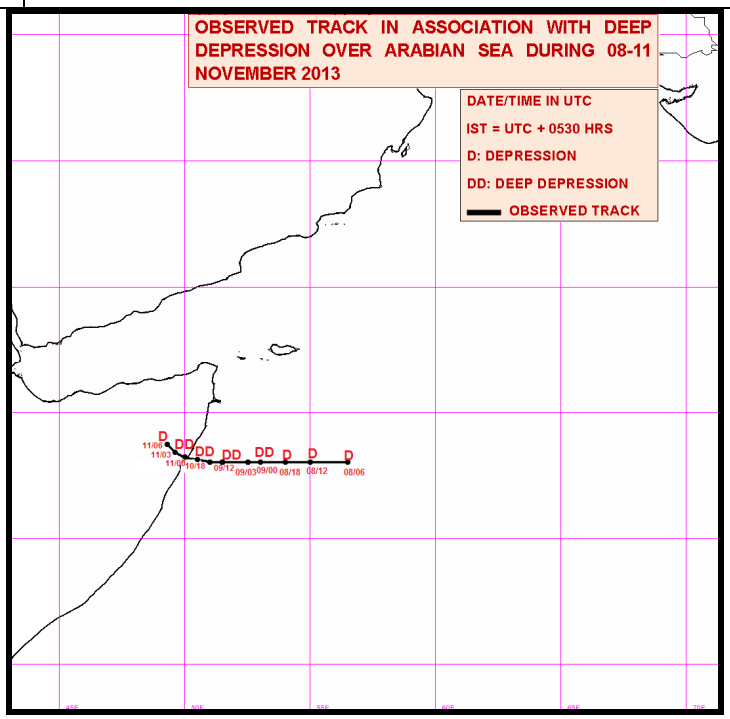


Fig.2. Track of Deep Depression over the Arabian Sea (08-11 November, 2013)

The track of the system is shown in Fig.2. The best track parameters are shown in Table 1. The typical infrared and visible satellite imageries of deep depression are shown in Fig.3 and Fig.4 respectively.

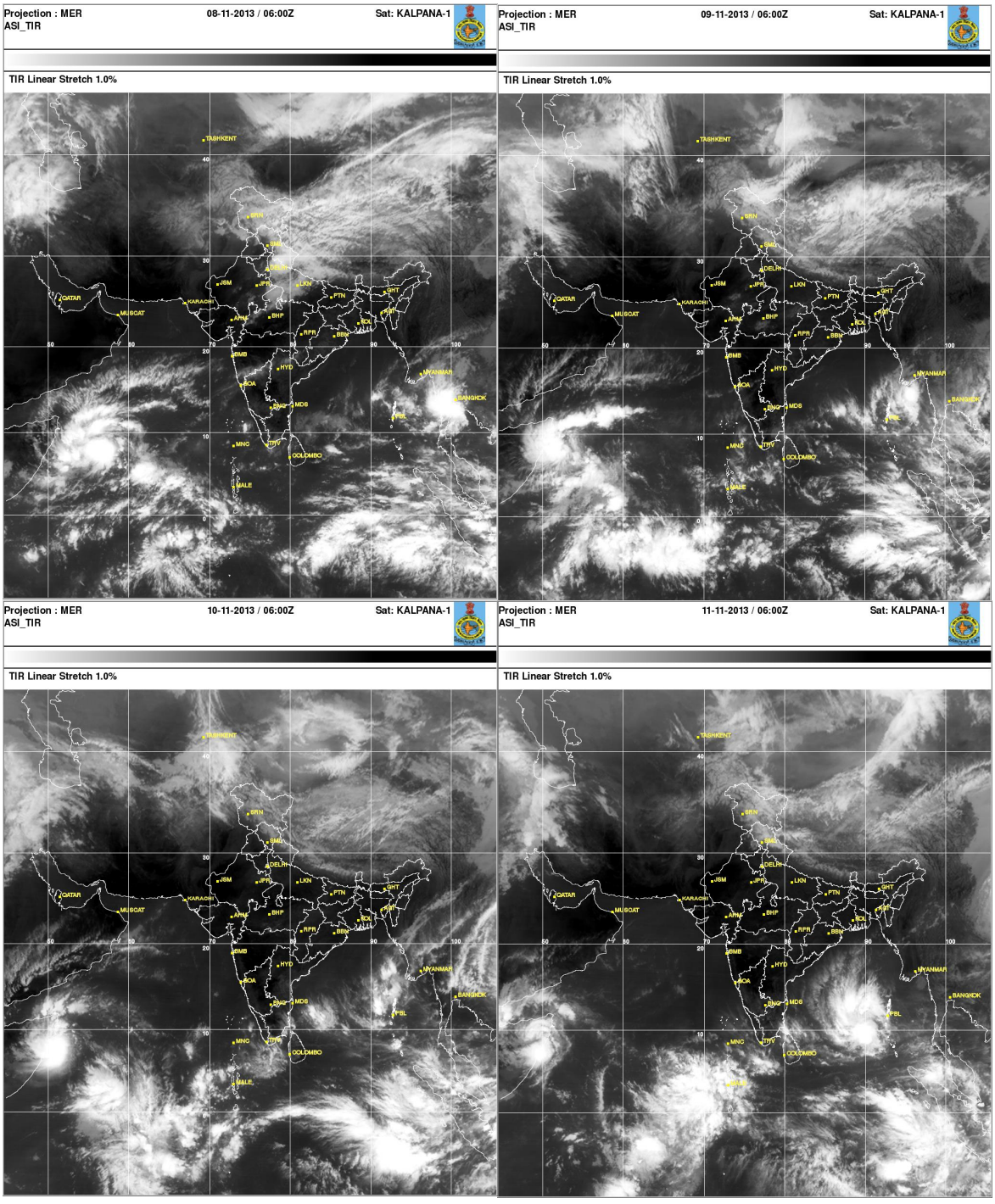


Fig.3. Kalpana-1 satellite IR imageries of deep depression over the Arabian Sea at 0600 UTC of 8-11 November 2013

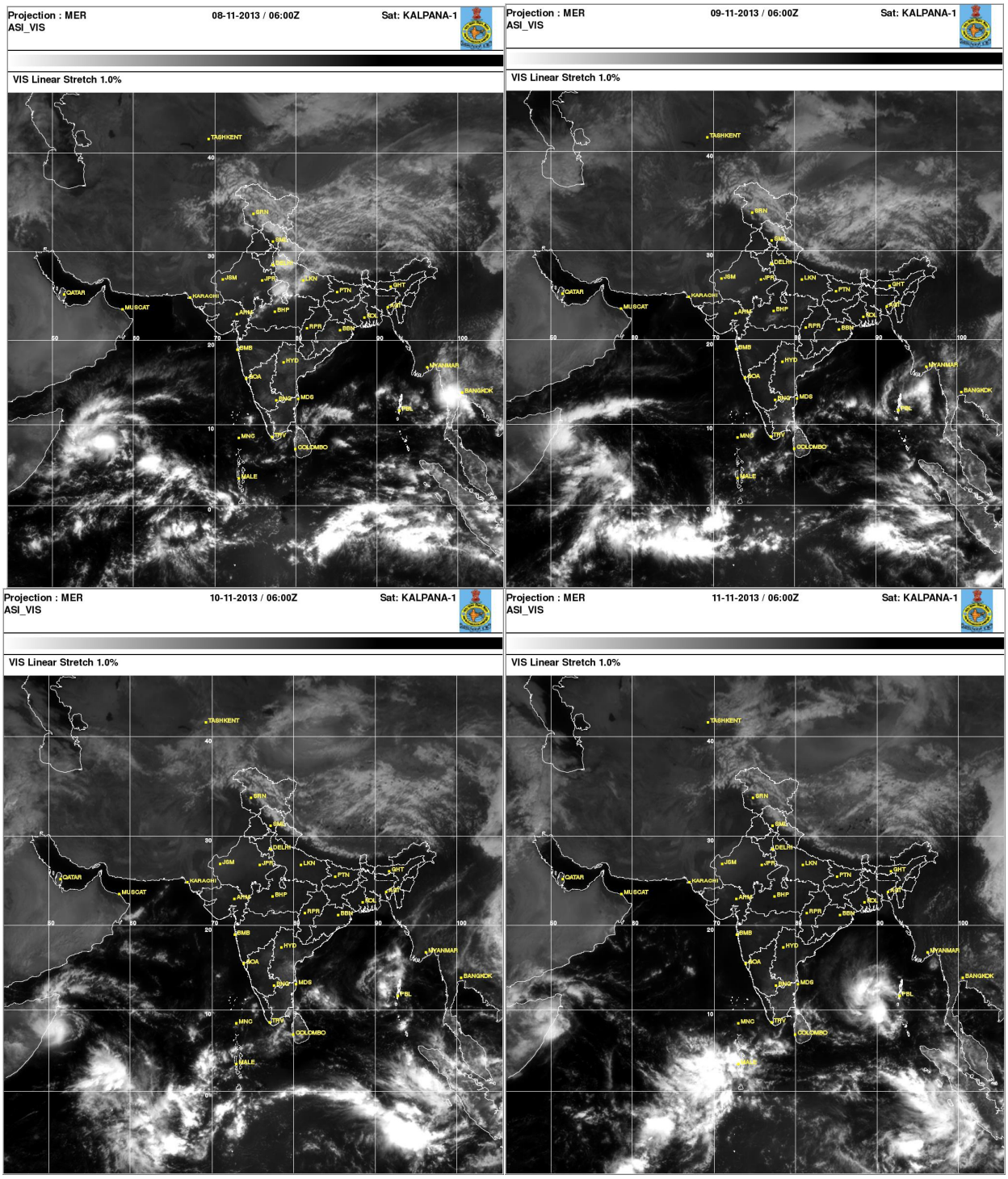


Fig.4. Kalpana-1 satellite IR imageries of deep depression over the Arabian Sea at 0600 UTC of 8-11 November 2013

6. Realised Weather

As estimated by satellite imagery and products, the sustained maximum wind of 30 knots prevailed along and off Somalia coast, when the deep depression crossed this coast. There was no meteorological observations available from Somalia to estimate the actual intensity and adverse weather due to this deep depression.

7. Forecast and Warning Services

The bulletins were issued by Regional Specialised Meteorological Centre (RSMC), New Delhi in regular intervals to WMO/ESCAP Panel countries. As Somalia and Yemen are not members of this Panel, the bulletins were sent to them through the WMO. The bulletins were also issued to Meteorological Watch Offices in Asia Pacific region and middle east countries by the Tropical Cyclone Advisory Centre (TCAC, New Delhi) located at RSMC, New Delhi as per the requirement of international civil aviation. Following is the statistics of bulletins issued during this deep depression

Number of bulletins issued to WMO/ESCAP Panel countries and Somalia and Yemen:	13
Number of TCAC bulletins issued international civil aviation :	09

8. Forecast performance verification

On the first bulletin issued at 0900 UTC of 08 November (64 hrs before the landafall of deep depression over Somalia), it was predicted that the system would intensify into a depression and cross Somalia coast on 10 November around 1200 UTC.

The landfall point forecast error was about 4 km for 24 hr lead perid and about 50 km for both 36 and 48 hr lead periods (Table 1). Hence, the landfall point could be well predicted 48 hrs in advance. To illustrate the above facts, the forecast and actual tracks based on 0000 UTC of 09 and 10 November are shown in Fig.5.

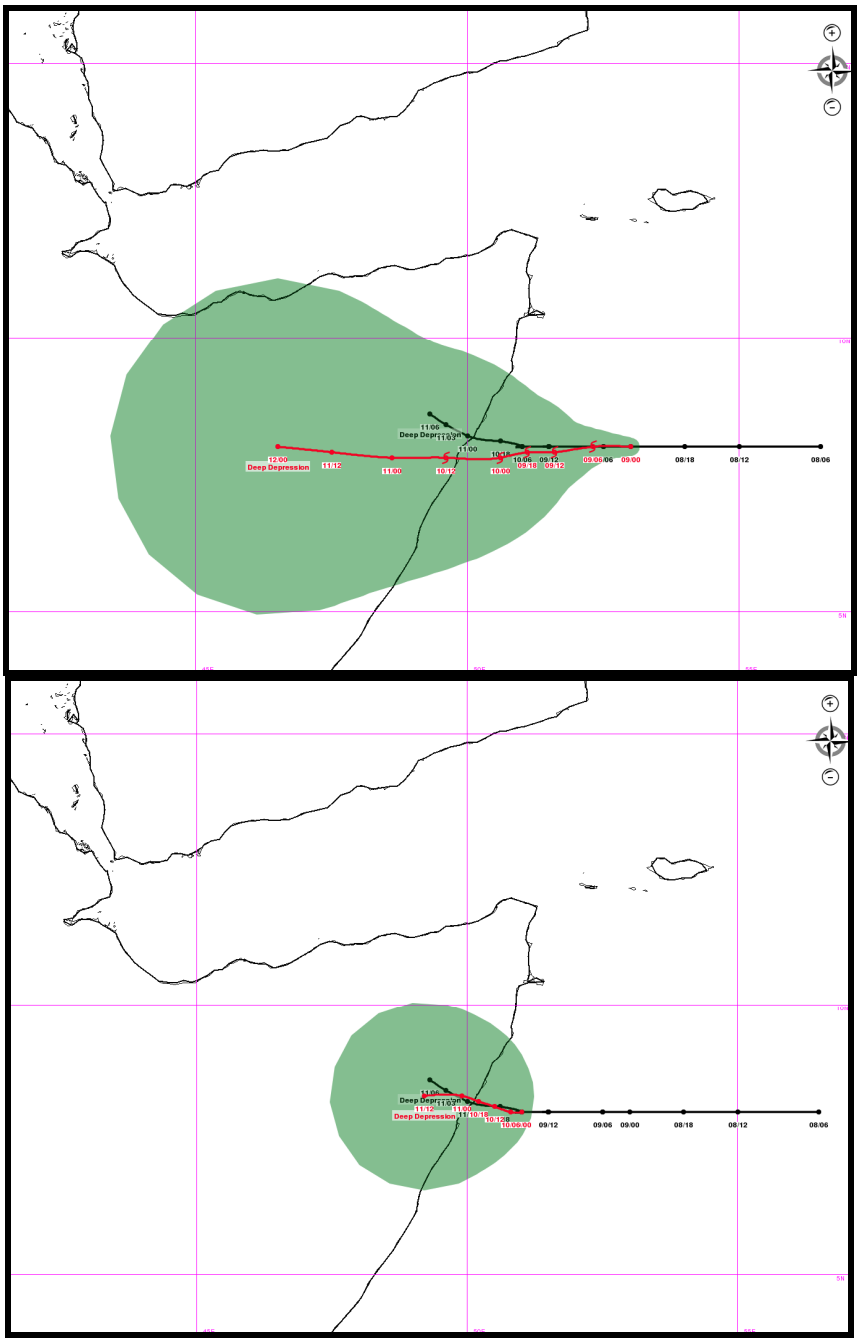


Fig.5. Track and intensity forecasts issued by RSMC, New Delhi based on the initial condition of 0000 UTC of 09 and 10 November 2013 along with the actual track. Red line is the forecast track and black line is the actual track. Date and time are given in UTC.

The average track forecast error is shown in Table 2. It was 54 km, 93 km and 163 km respectively for 12, 24 and 48 hrs forecast period. This error is significantly less than the average forecast errors in last five years. Considering the intensity

forecast error, the realized wind speed at the time of landfall was about 30 knots as estimated by satellite observations and it was same as the predicted value.. There was no observation available over Somalia to estimate the intensity at the time of landfall. Considering average absolute error (AE) and root mean square error in wind forecast, they were about 5-10 knots for all forecast tomes of 12 to 48 hrs (Table 2)

Table 1. Operational Landfall forecast errors Average track and intensity forecast error of IMD in case of deep depression (08-11 November, 2013)

Leads Period (hrs)	Landfall point and time forecast Error in Km	
	Landfall point error (km) (Forecast landfall point- Actual landfall point)	Landfall time error in hrs (Forecast landfall time- Actual landfall time)
12	04	+1.5
24	04	-4.5
36	53	-11.5
48	54	-09.5

Table 2. Operational average track and intensity forecast error of IMD in case of deep depression (08-11 November, 2012)

Lead Period (hrs)	Average track forecast error (km)	Intensity forecast error (knots)	
		Absolute error	Root mean square error
12	54	4.9	5.1
24	93	3.8	7.2
36	163	2.7	7.5
48	163	1.6	3.1

9. Damage

According to media report, the deep depression caused heavy damage to the Puntland region of Somalia. Hundreds of houses were damaged and livestocks died. About 140 people died due to this system due to heavy rain and flood.

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