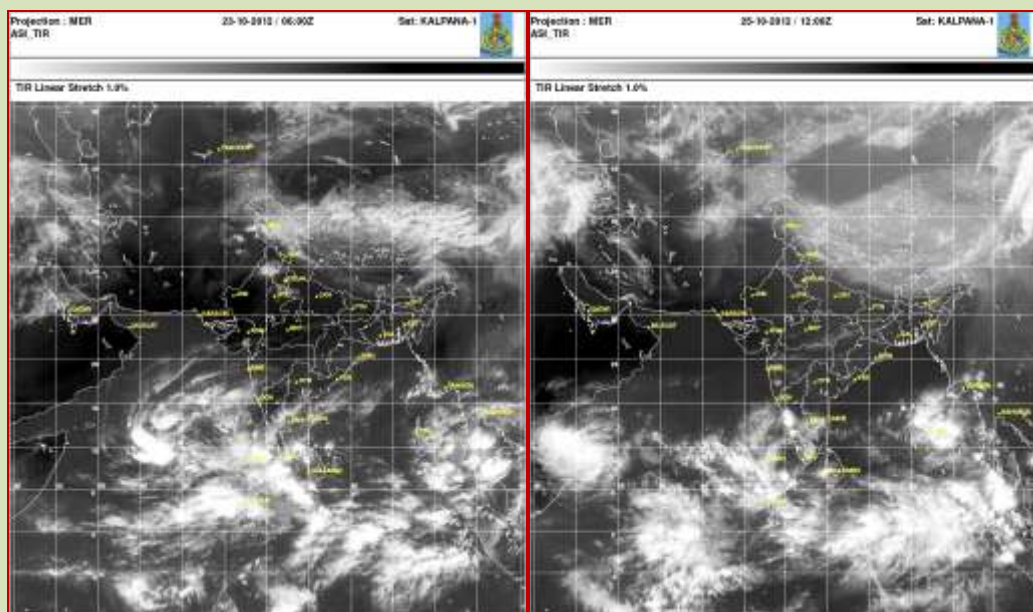




GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
INDIA METEOROLOGICAL DEPARTMENT

Preliminary Report on Deep Depression over the Arabian Sea
(22-25 December 2012)



Satellite imageries of Deep Depression over Arabian Sea

CYCLONE WARNING DIVISION, NEW DELHI
DECEMBER 2012

Deep Depression over Arabian Sea (22-25 December, 2012)

1. Introduction

A depression formed over the south Arabian Sea in association with an active inter tropical convergence zone on 22 December 2012. It moved initially westwards and intensified into a deep depression on 23 December 2012. However, as it moved west-southwestwards towards Somalia coast, it weakened into a depression in the evening of 24 December and further into a low pressure area in the morning of 25 December 2012 over the southwest Arabian Sea off Somalia coast. The salient features of this cyclone are given below.

- (i) It moved west-southwest wards and weakened over the sea
- (ii) It was the first cyclonic disturbance in the month of December after 1992, which affected Somalia coast. The last cyclonic disturbance with a maximum intensity of a depression crossed Somalia coast on 24 December 1992.

2. Monitoring and prediction

The cyclonic storm was mainly monitored by satellite. The half hourly INSAT/Kalpana imageries and products were used for monitoring of cyclonic storm. Various numerical weather prediction (NWP) models and dynamical-statistical models including IMD's global and meso-scale models were utilized to predict the track and intensity of the storm. Recently installed Tropical Cyclone Module in the digitized forecasting system of IMD was utilized for analysis and comparison of various NWP models and decision making process.

3. Climatological characteristics

Considering the data during 1891-2012, only one cyclonic disturbance upto a maximum intensity of depression has crossed Somalia coast in the month of December. The depression during 22-25 December, 2012 was the first cyclonic disturbance in the month of December after 1992, which affected Somalia coast. The last cyclonic disturbance with a maximum intensity of a depression crossed Somalia coast on 24 December 1992. The cyclonic disturbances formed over the Arabian Sea during December for the period of 1891-2011 are shown in Fig.1.

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

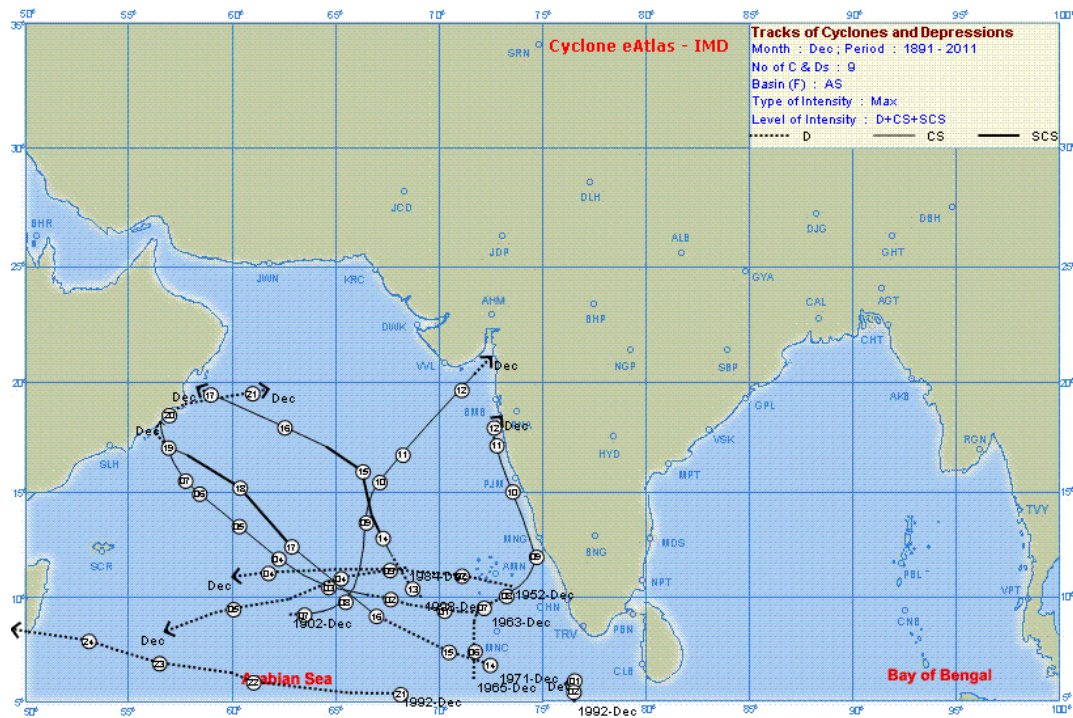


Fig.1. Tracks of cyclonic disturbances formed over the Arabian Sea during the month of December over the period of 1891-2011.

4. Genesis

Under the influence of an active inter-tropical convergence zone, a low pressure area formed over the Comorin area on 18 December 2012. It moved westwards and lay over Lakshadweep area on 19 and over southeast Arabian Sea on 20 December. Continuing to move westwards, it concentrated into a depression at 0900 UTC of 22 December 2012 and lay centred over southeast and adjoining southwest Arabian Sea near lat. 9.0°N and long. 63.0°E , about 100 km west-southwest of Amini Divi.

During the genesis phase, the Madden Julian Oscillation index lay in phase 2 with amplitude less than 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 southeast Arabian Sea and adjoining areas was $28\text{-}30^{\circ}\text{C}$. The Ocean heat content (OHC) was $50\text{-}80\text{ KJ/cm}^2$ over the area. The lower level convergence and relative vorticity as well as upper level divergence increased from 22nd to 23rd October. The upper tropospheric ridge lay along 13°N and hence provided the upper level divergence for intensification. The vertical wind shear between 200 and 850 hPa levels was low to moderate (05-15 knots) around the system centre on 22 and 23 December. Considering all these, the environmental parameters were favourable for genesis and intensification of the system. However, most of the numerical weather prediction (NWP) models could not detect/predict the genesis of this depression.

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 to east-northeasterly, the system initially moved westwards and then west-southwestwards. It intensified into a deep depression and lay centred at 0300 UTC of 23 December 2012 over southwest Arabian Sea near lat. 9.0°N and long. 60.0°E , about 1000 km east-southeast of Ras Binnah, Somalia as the favourable environmental conditions as mentioned in the previous section continued on 23 December 2012.

On 23 December, the convection increased in the southwest sector with increase in low level relative vorticity in this sector and the steering ridge to the north weakened leading to west-southwestward movement. However, the low to moderate wind shear continued to prevail over the region. Under these circumstances, the deep depression moved west-southwest wards and maintained its intensity, 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 $< 40 \text{ KJ/cm}^2$ and sea surface temperature of $26\text{-}28^{\circ}\text{C}$. The vertical wind shear of horizontal wind increased and became high (about 25 knots) around the system centre. It also interacted with land surface as it lay close to Somalia coast and there was cold and dry air incursion over the area from Arabia and Africa. Under these circumstances, the deep depression weakened into a depression and lay centred at 1200 UTC of 24 December 2012 over southwest Arabian Sea near lat. 7.0°N and long. 52.0°E , close to Somalia coast. 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 low pressure area and became less marked.

The track of the system is shown in Fig.2. The best track parameters are shown in Table 1. The typical satellite imagery of deep depression over Somalia coast is shown in Fig.3(a-b). The MSLP analysis and wind pattern based on 0000 UTC ECMWF and IMD GFS models analyses of 22-25 December 2012 are shown in Fig.4(a-h)

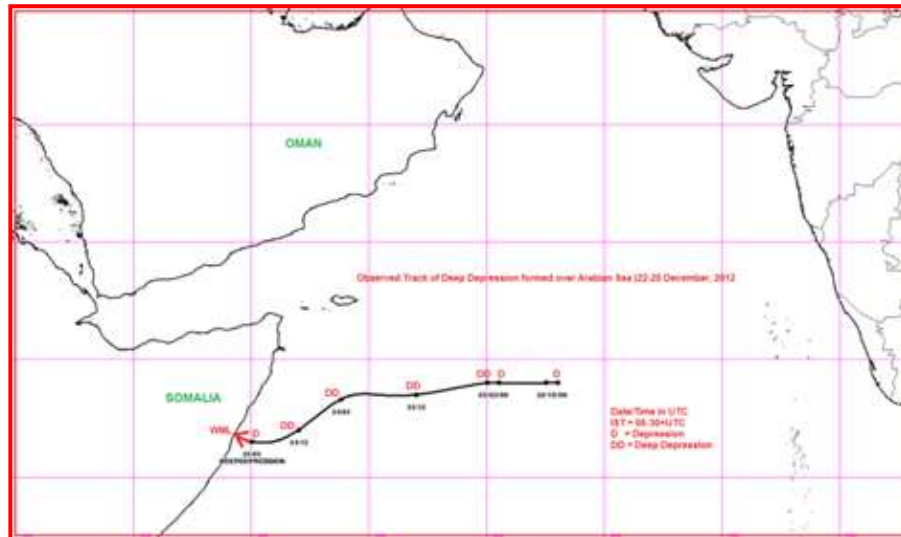


Fig.2. Track of deep depression over the Arabian Sea (22-25 December, 2012)

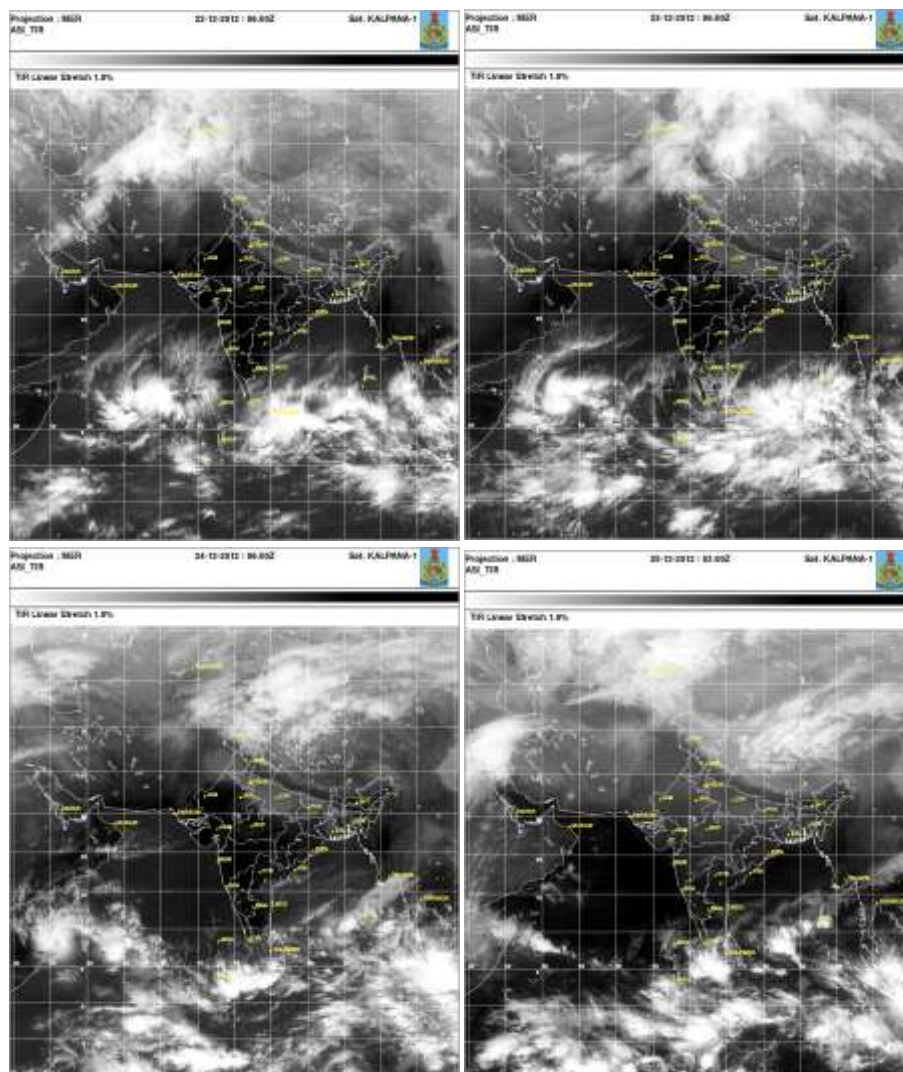


Fig.3(a). Typical satellite imagery of deep depression over Arabian Sea (22-25 December, 2012)

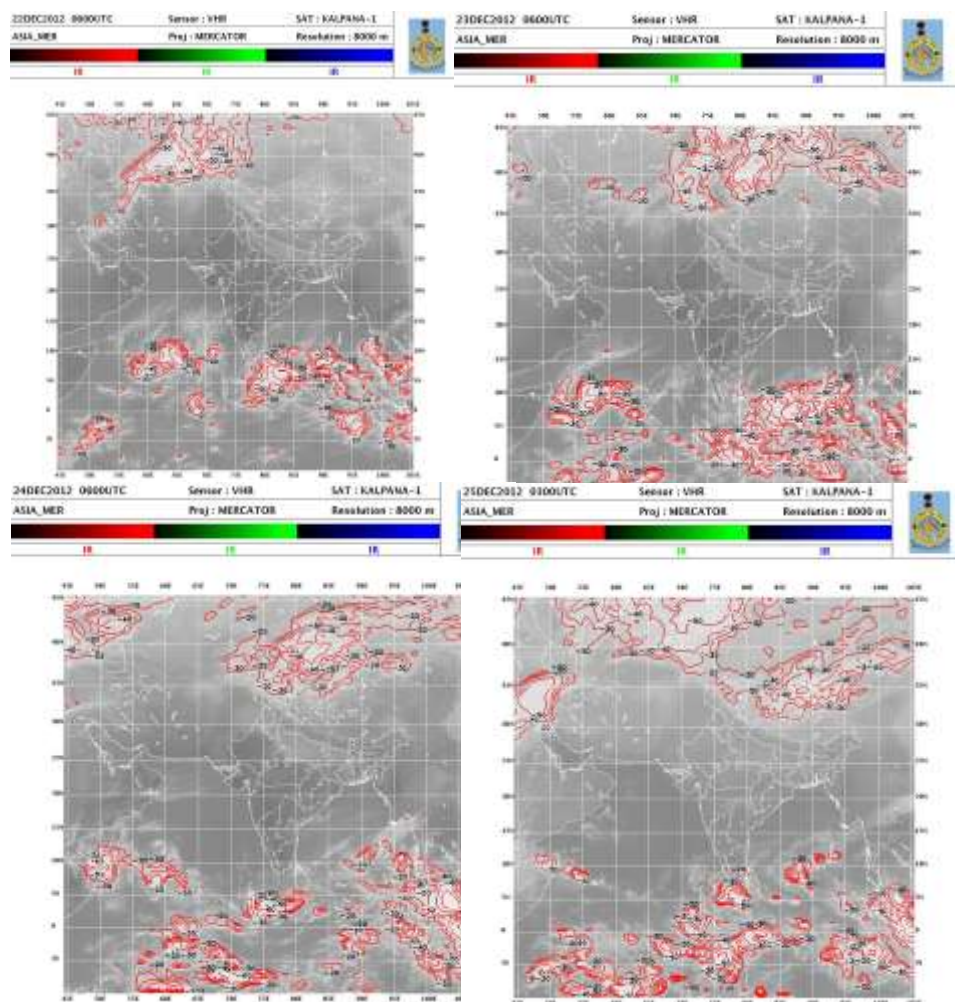


Fig.3(b). Typical satellite imagery of deep depression over Arabian Sea (22-25 December, 2012) with cloud top temperatures

Table 1: Best track positions and other parameters of the deep depression over the Arabian Sea during 22-25 December, 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
22-12-2012	0900	9.0/63.0	1.5	1004	25	3	D
	1200	9.0/62.5	1.5	1003	25	4	D
23-12-2012	0000	9.0/60.5	2.0	1002	30	5	DD
	0300	9.0/60.0	2.0	1002	30	5	DD
	1200	8.5/57.0	2.0	1002	30	5	DD
24-12-2012	0300	8.0/54.0	2.0	1002	30	5	DD
	1200	7.0/52.0	1.5	1004	25	3	D
25-12-2012	0000	6.5/50.0	1.5	1005	20	3	D
	0300	Weakened into a low pressure area over southwest Arabian Sea off Somalia coast					

6 Realised Weather

As estimated by satellite imagery and products, the sustained maximum wind of 15-20 knots prevailed along and off Somalia coast, when the depression lay close to this coast. There was no meteorological observations available from Somalia to estimate the actual intensity of the system near this coast.

7 Forecast and Warning Services

(i) Bulletins issued by IMD

The bulletins were issued by Cyclone Warning Division and 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. Following is the statistics of bulletins issued during this deep depression

Number of bulletins issued to WMO/ESCAP Panel countries and Somalia and Yemen : 08
Number of bulletins issued for India coast : 07

(ii) Forecast verification

On the first bulletin issued at 1730 hrs IST of 22 December, 2012 (60 hrs before the system lay close to Somalia), it was predicted that the system would move westwards towards Somalia.

The average track forecast error is shown in Table 2. It was 55, 121, 167 and 201 km respectively for 12, 24, 36 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 as estimated by satellite observations as there was no observation available over Somalia to estimate the intensity.

Table 2. Average track and intensity forecast error of IMD in case of deep depression (22-25 December, 2012)

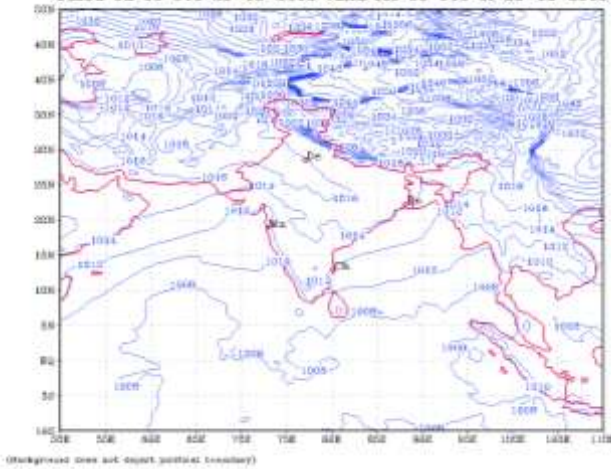
Leads Period	Track forecast error(km)	Intensity forecast error (knots)	
		Absolute error	RMS error
12	55 (5)	10.0(5)	10.4
24	121 (4)	13.0(4)	13.2
36	167 (3)	17.2(3)	17.3
48	201.(2)	23.0(2)	23.1

(Numbers in parenthesis indicates number of forecast verified)

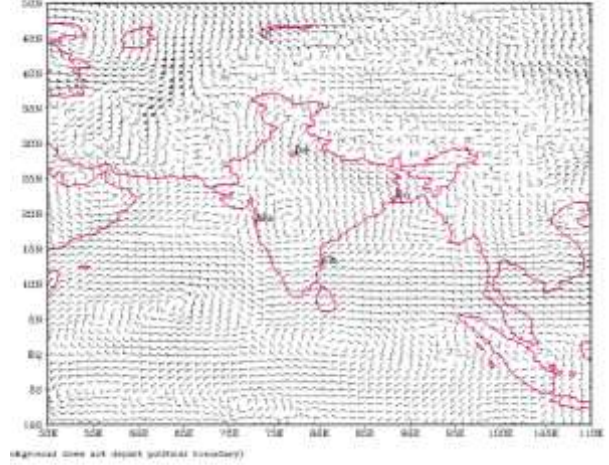
8 NWP Guidance

The genesis, track and intensity of the deep depression were reasonably captured by most of the models. The NWP model MSLP analysis and wind at 850, 500 and 200 hPa levels based on 0000UTC of 22-25 October 2012 for ECMWF and IMD-GFS models are shown in Fig.4(a-h).

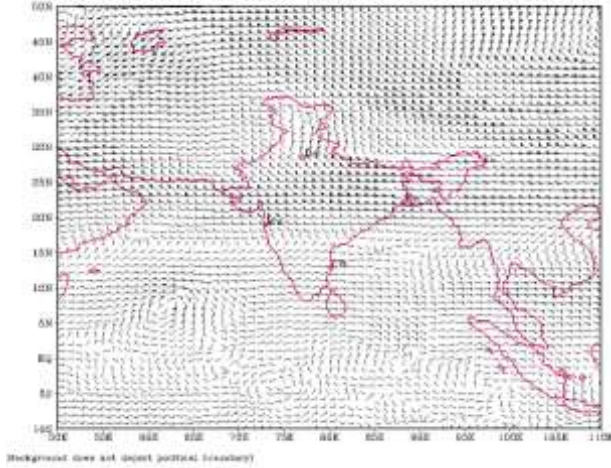
Mean Sea Level Pressure (hPa) ECMWF FORECAST (0 hr.)
based on 00 UTC 22-12-2012 valid for 00 UTC of 22-12-2012



850 hPa WIND ECMWF FORECAST (0 Hr.)
based on 00 UTC 22-12-2012 valid for 00 UTC of 22-12-2012



500 hPa WIND ECMWF FORECAST (0 Hr.)
based on 00 UTC 22-12-2012 valid for 00 UTC of 22-12-2012



200 hPa WIND ECMWF FORECAST (0 Hr.)
based on 00 UTC 22-12-2012 valid for 00 UTC of 22-12-2012

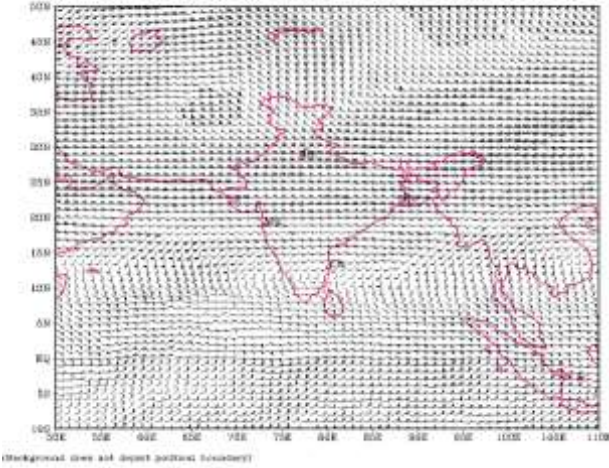


Fig. 4(a) ECMWF MSLP & Winds at 850, 500 and 200, hPa based on 0000 UTC of 22nd December, 2012

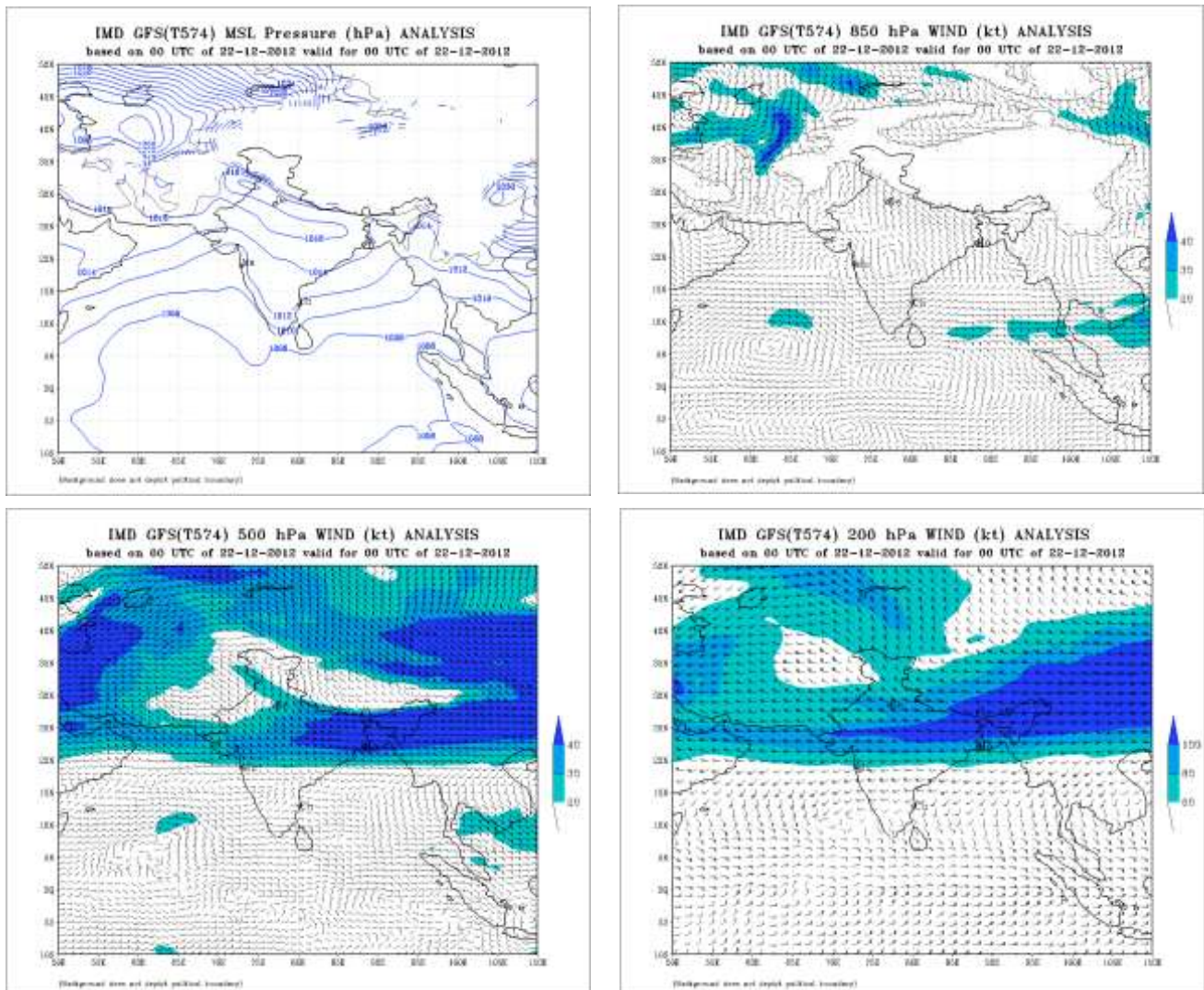
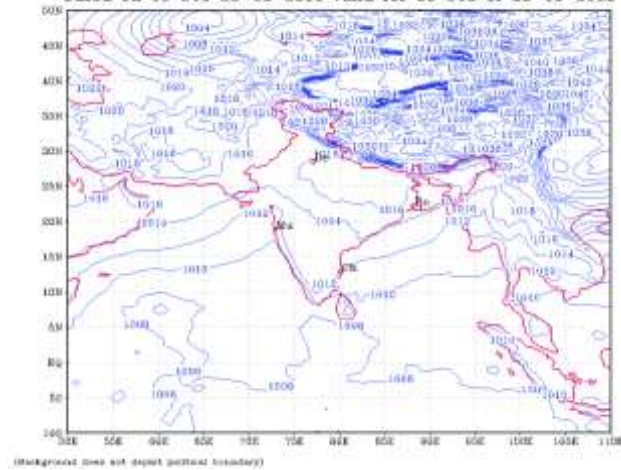
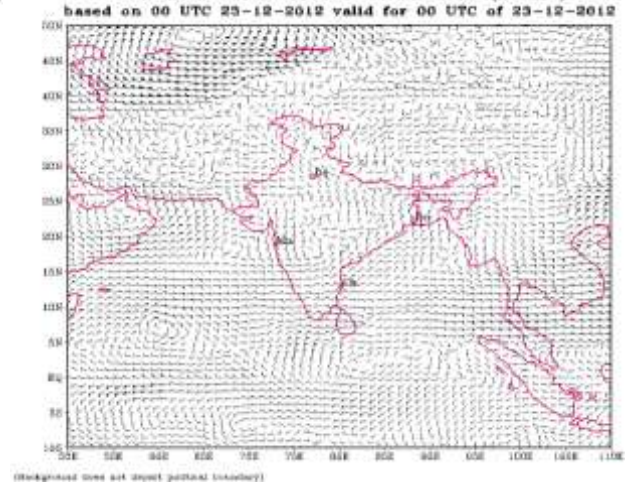


Fig. 4(b) IMD-GFS MSLP Analysis & Winds at 850 and 500 hPa based on 0000 UTC of 22nd December, 2012

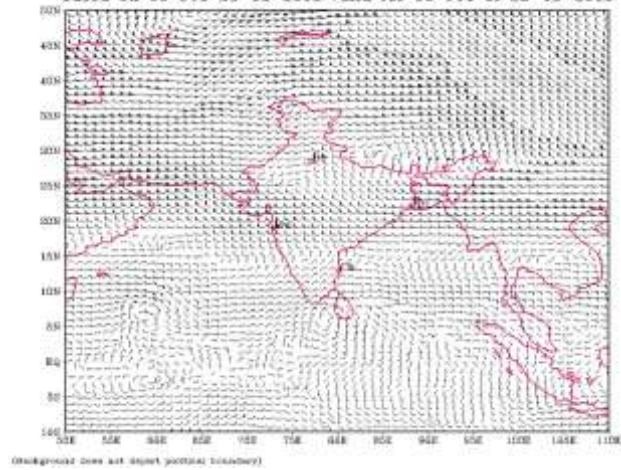
Mean Sea Level Pressure (hPa) ECMWF FORECAST (0 hr.)
based on 00 UTC 23-12-2012 valid for 00 UTC of 23-12-2012



850 hPa WIND ECMWF FORECAST (0 Hr.)
based on 00 UTC 23-12-2012 valid for 00 UTC of 23-12-2012



500 hPa WIND ECMWF FORECAST (0 Hr.)
based on 00 UTC 23-12-2012 valid for 00 UTC of 23-12-2012



200 hPa WIND ECMWF FORECAST (0 Hr.)
based on 00 UTC 23-12-2012 valid for 00 UTC of 23-12-2012

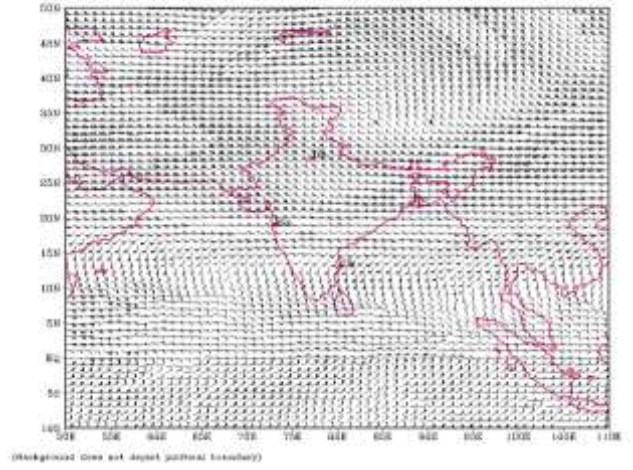


Fig. 4(c) ECMWF MSLP & Winds at 850, 500 and 200, hPa based on UTC of 23rd December, 2012

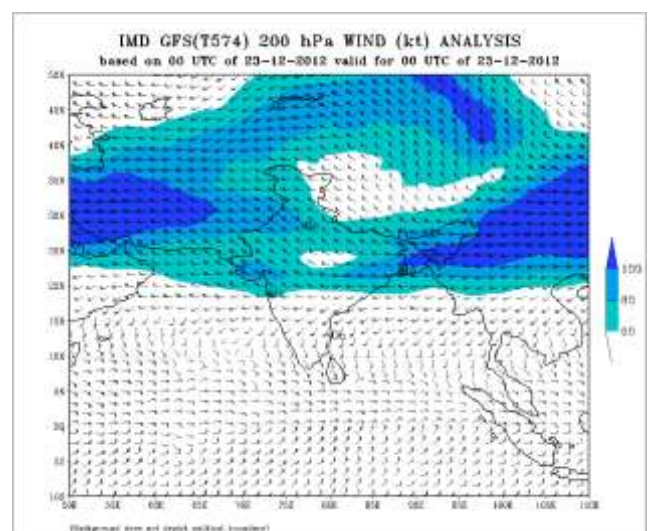
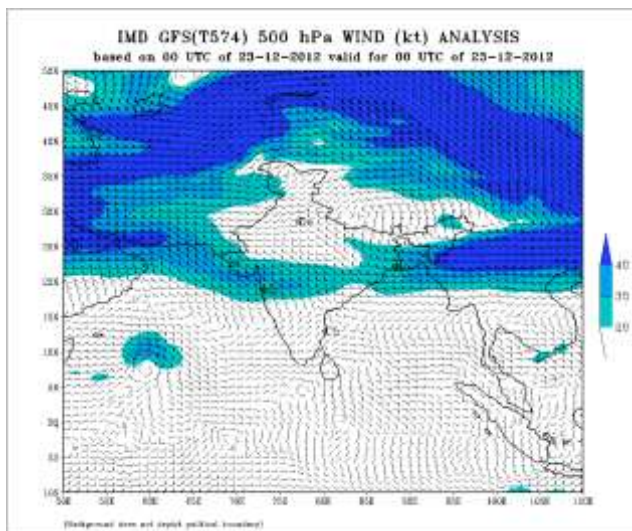
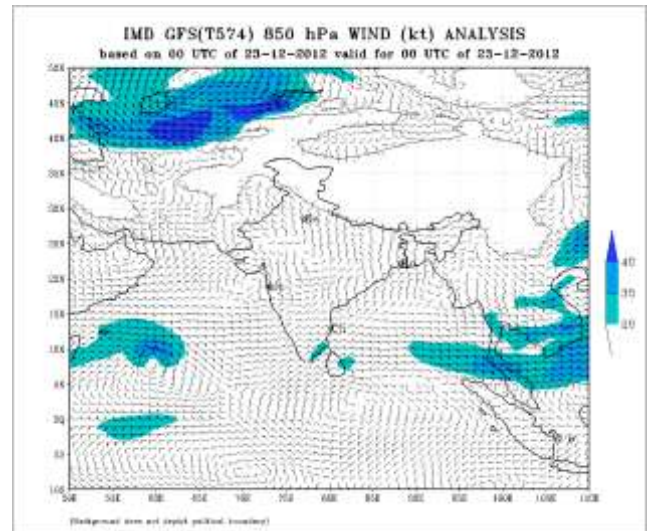
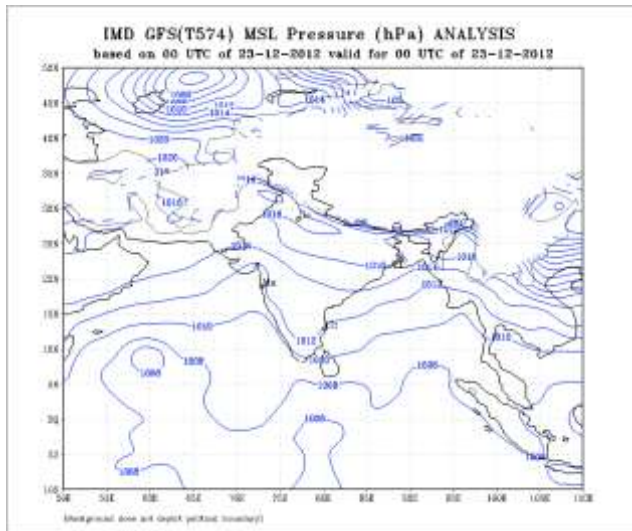
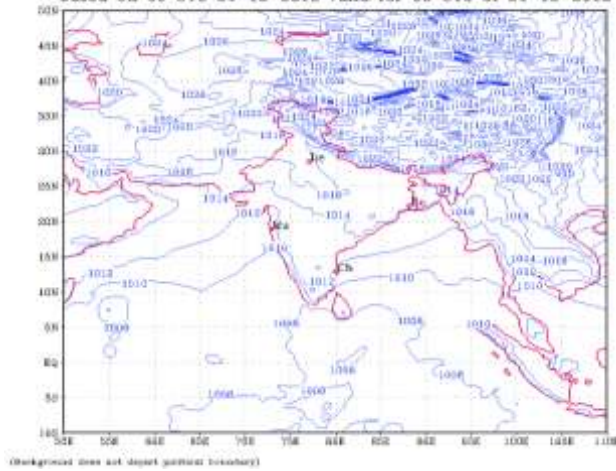
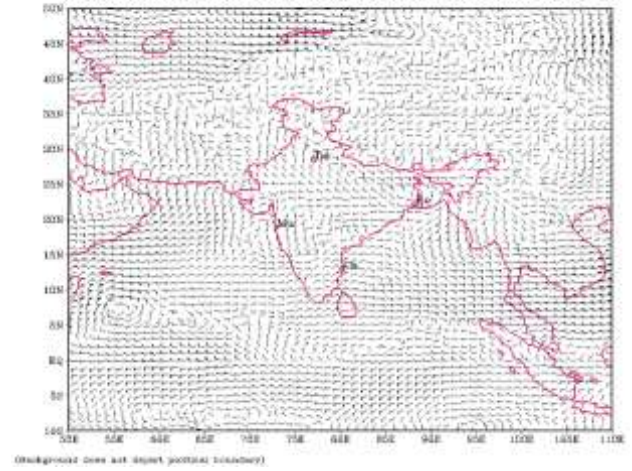


Fig. 4(d) IMD-GFS MSLP Analysis & Winds at 850 and 500 hPa based on 0000 UTC of 23rd December, 2012

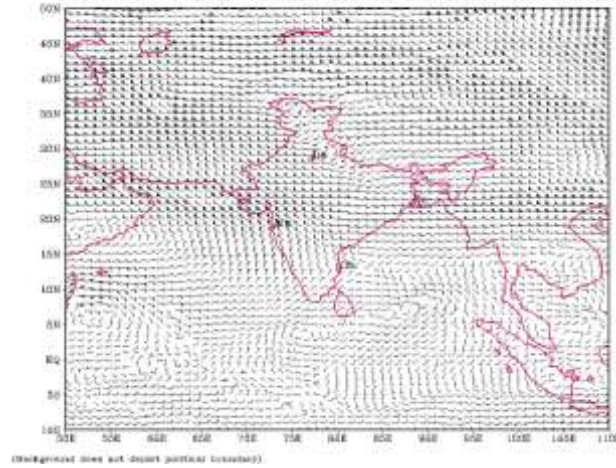
Mean Sea Level Pressure (hPa) ECMWF FORECAST (0 hr.)
based on 00 UTC 24-12-2012 valid for 00 UTC of 24-12-2012



850 hPa WIND ECMWF FORECAST (0 Hr.)
based on 00 UTC 24-12-2012 valid for 00 UTC of 24-12-2012



500 hPa WIND ECMWF FORECAST (0 Hr.)
based on 00 UTC 24-12-2012 valid for 00 UTC of 24-12-2012



200 hPa WIND ECMWF FORECAST (0 Hr.)
based on 00 UTC 24-12-2012 valid for 00 UTC of 24-12-2012

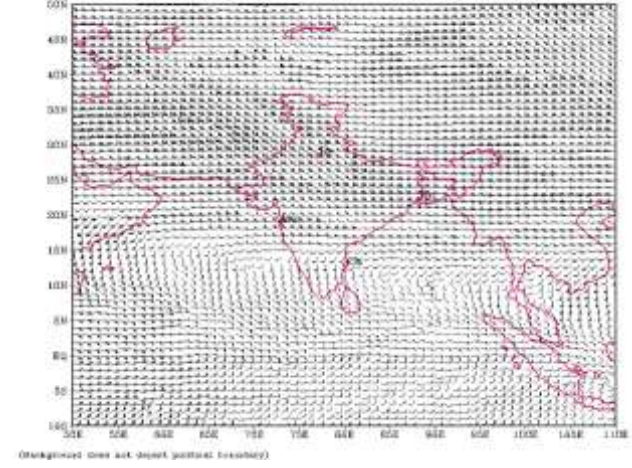


Fig. 4(e) ECMWF MSLP & Winds at 850, 500 and 200, hPa based on UTC of 24th December, 2012

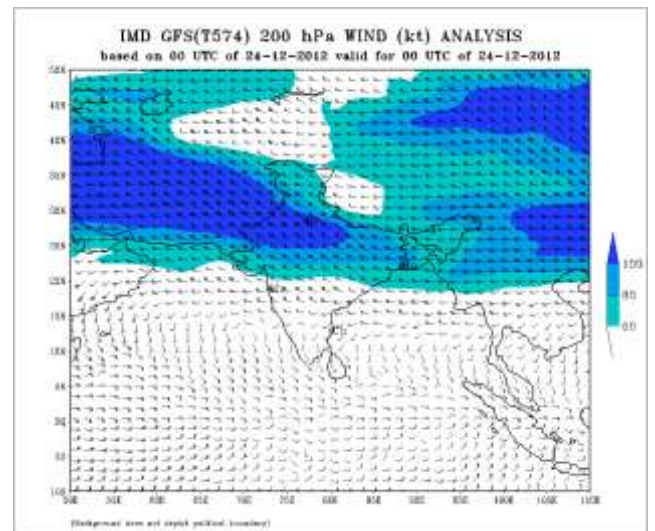
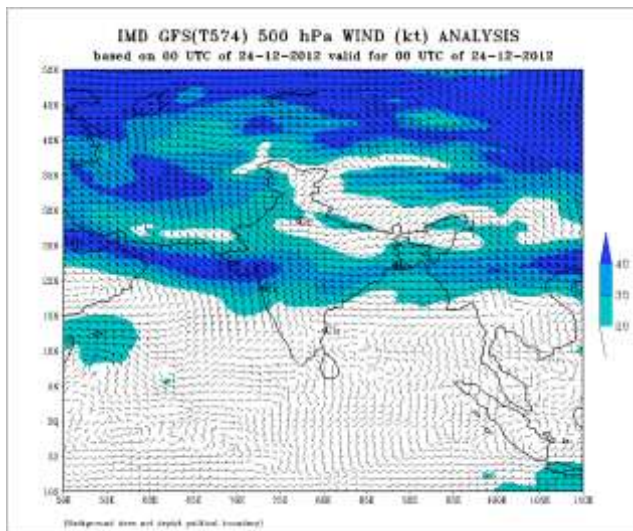
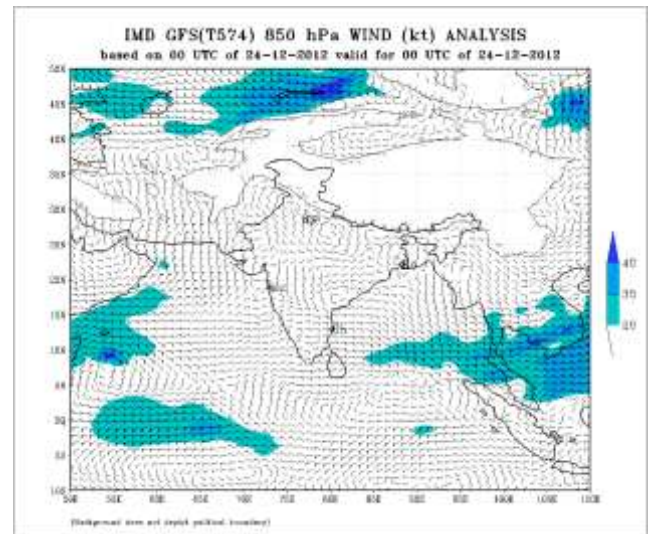
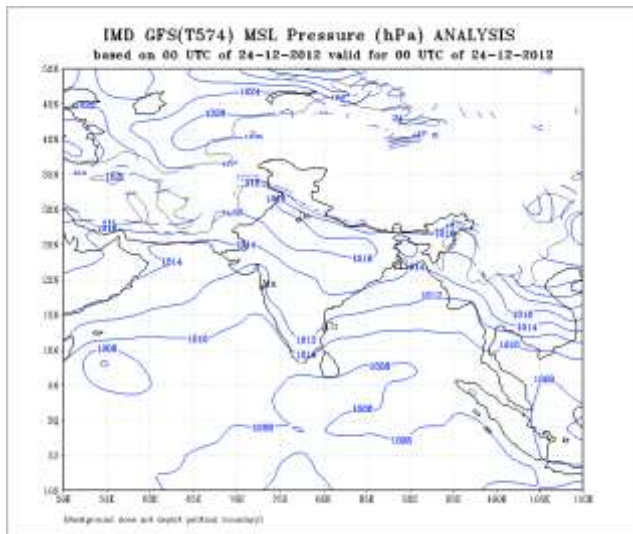
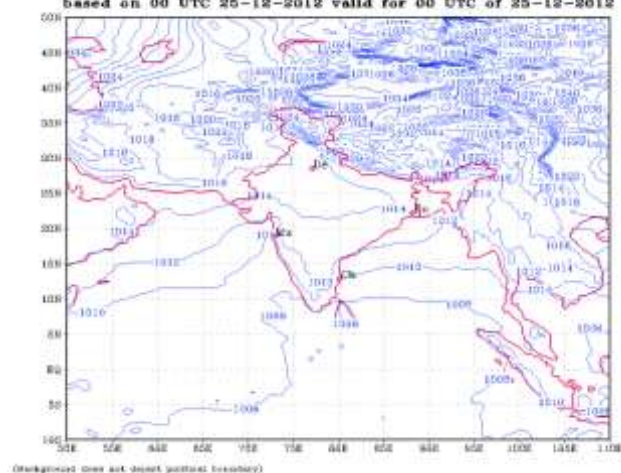


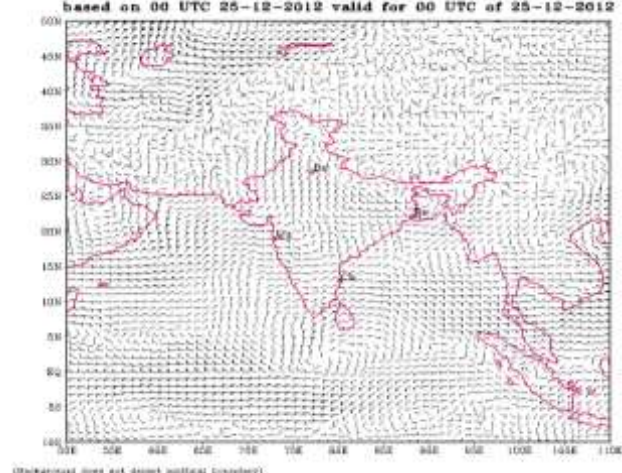
Fig. 4(f) IMD-GFS MSLP Analysis & Winds at 850 and 500 hPa based on 0000 UTC of 24th December, 2012



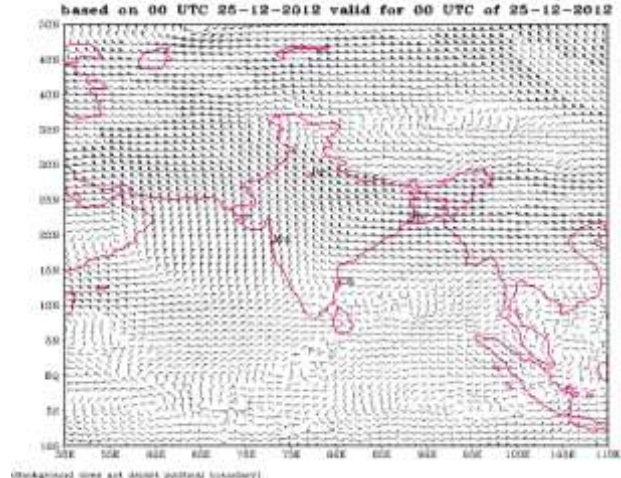
based on 00 UTC 25-12-2012 valid for 00 UTC of 25-12-2012



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based on 00 UTC 25-12-2012 valid for 00 UTC of 25-12-2012

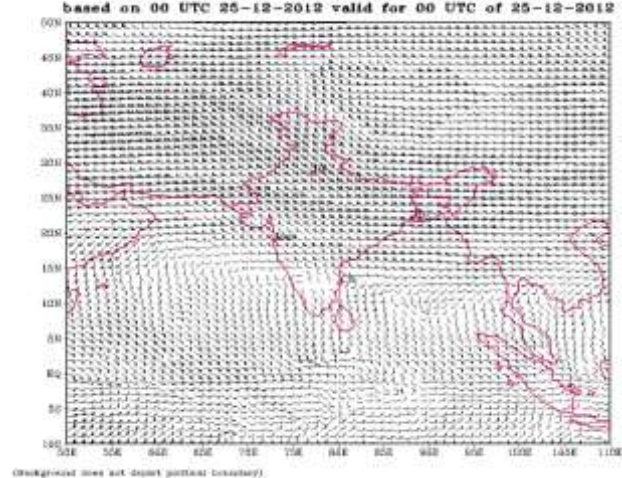


Fig. 4(g) ECMWF MSLP & Winds at 850, 500 and 200, hPa based on UTC of 25th December, 2012

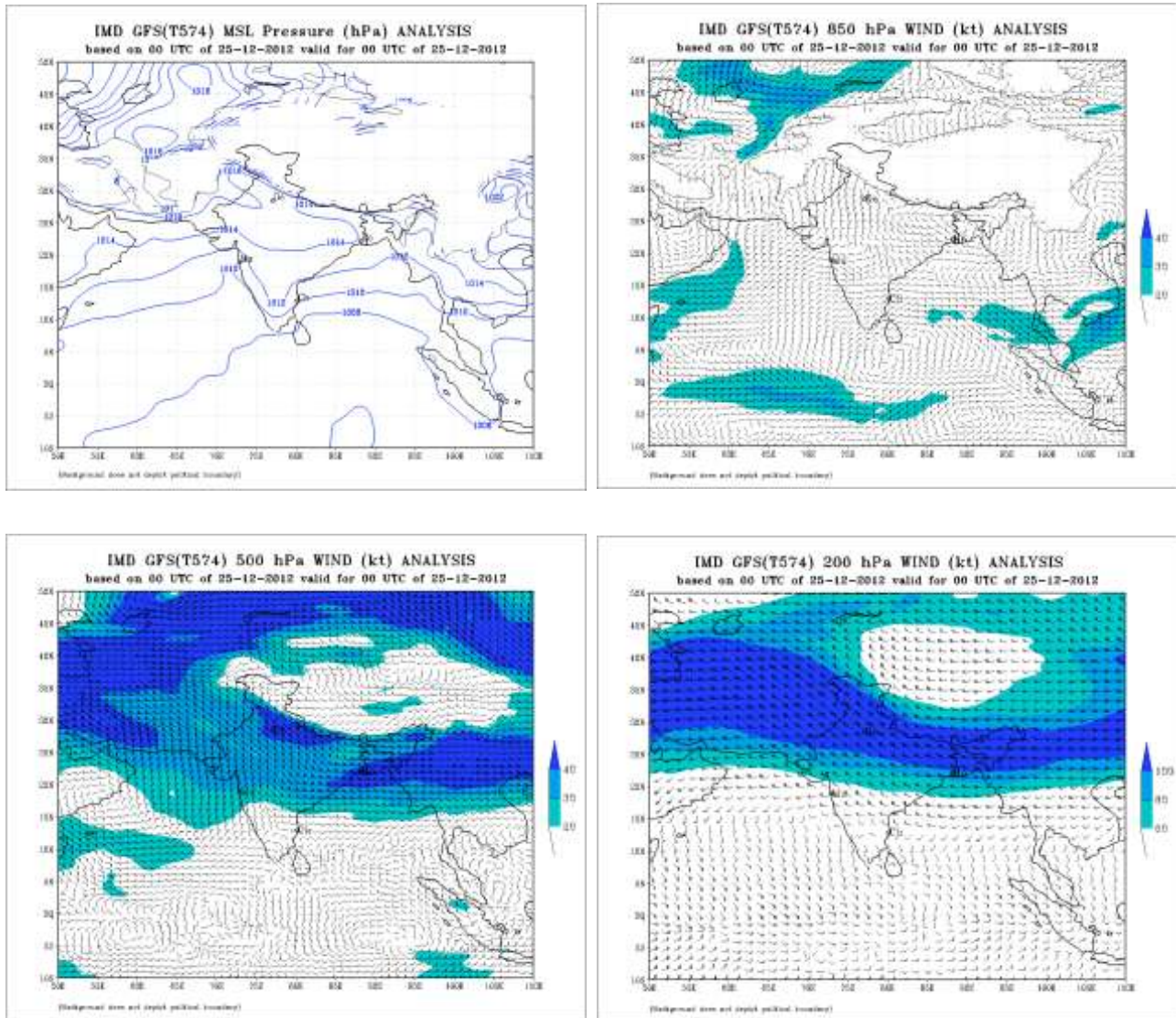


Fig. 4(h) IMD-GFS MSLP Analysis & Winds at 850 and 500 hPa based on 0000 UTC of 25th December, 2012

Damage

No damage report has been received from Somalia.