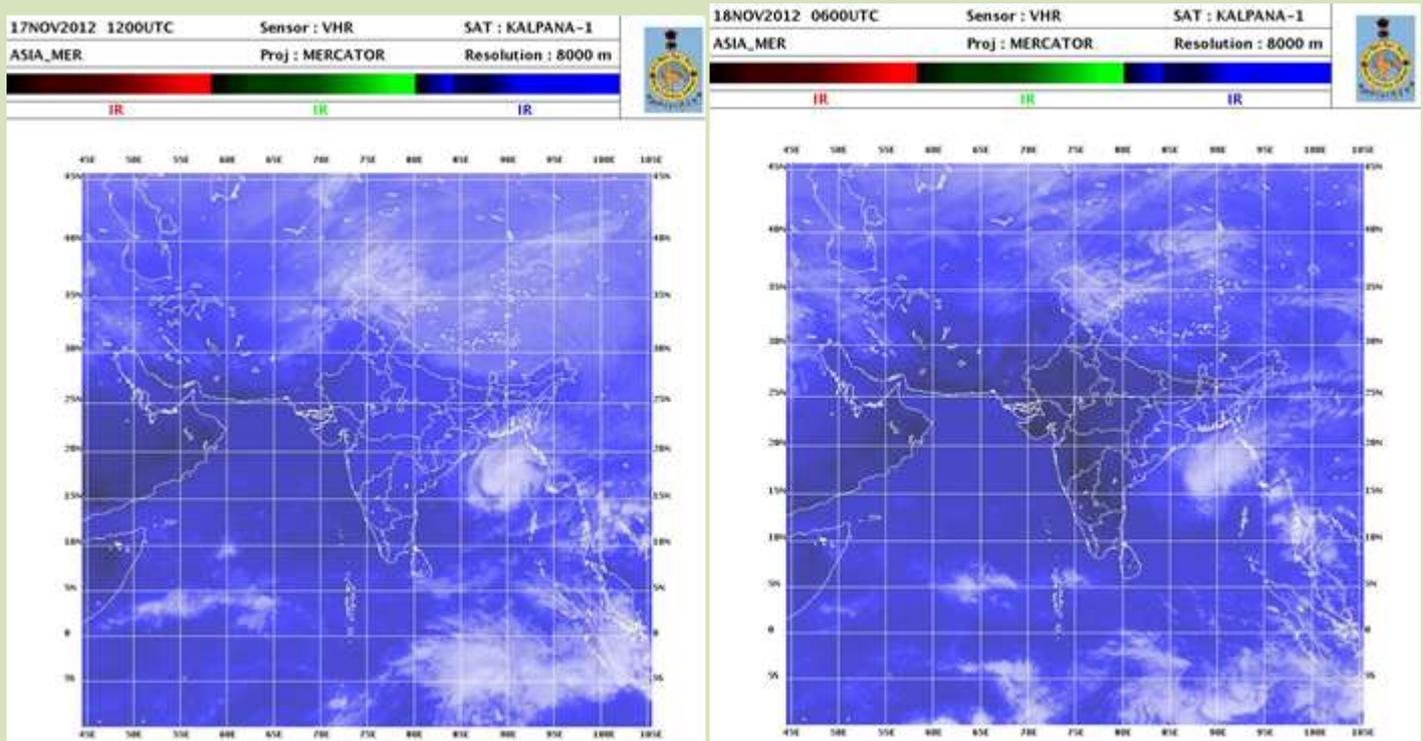




GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
INDIA METEOROLOGICAL DEPARTMENT

Preliminary Report on Deep Depression over the Bay of Bengal
(17-19 November 2012)



Satellite imageries of Deep Depression over Bay of Bengal

CYCLONE WARNING DIVISION, NEW DELHI

NOVEMBER 2012

Deep depression over Bay of Bengal (17-19 November 2012)

1. Introduction:

A depression formed over the eastcentral Bay of Bengal from a remnant low pressure system of South China Sea, which emerged into Bay of Bengal across Thailand. It initially moved northwestwards and then westwards during 17 and 18 November. On 19th, it started moving west southwestwards over the westcentral Bay of Bengal. Due to entrainment of cold air from the Indian mainland in middle tropospheric levels and relatively colder sea, the deep depression weakened gradually to a low pressure area over southwest and adjoining west central Bay of Bengal off north Tamil Nadu and south Andhra Pradesh coast on 22nd November and became less marked on 23rd. It caused isolated heavy rainfall over south coastal Andhra Pradesh and Rayalaseema on 22nd November. The salient features of this system are given below.

- (i) It moved westwards initially and then west-southwestwards under the influence of the middle tropospheric steering ridge.
- (ii) It weakened over the sea due to entrainment of cold and dry air from Indian main land in middle tropospheric level.
- (iii) There existed a well defined low level circulation centre with banding features though the convection was significantly sheared to northeast under the influence of high wind shear on 18th and 19th November.

2. Monitoring of depression:

As the system was formed over deep sea (east central Bay) the system was mainly monitored by Satellite. The half hourly INSAT/ Kalpana imageries and products, Oceansat observations and microwave products from polar orbiting satellites were used for monitoring the location and intensity of the system. However, the available buoy and island observations helped in improving the satellite estimates of location and intensity. Various numerical weather prediction (NWP) models and dynamical-statistical models including IMD's global and meso-scale models were utilised to predict the track and intensity of the system. The 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. Genesis:

In association with an active inter-tropical convergence zone (ITCZ), a low pressure area formed over southeast Bay of Bengal on 15 November 2012. It moved west-northwestwards and became well marked over southeast and adjoining eastcentral Bay of Bengal on 16th November. It concentrated into a depression east central Bay of Bengal at 0600 UTC of 17 November 2012 near latitude 15.5⁰N and longitude 90.0⁰E.

Considering the environmental features, the favourable features for cyclogenesis included warmer sea surface temperature (SST), which was about 28-30⁰C over south

and central Bay of Bengal. The Ocean heat content was about 50-80 kJ/cm². Over southeast and adjoining east central Bay of Bengal, i.e. around the system centre. The upper tropospheric ridge ran along latitude 16°N and hence provided poleward outflow which is favourable for intensification of the system. The low level convergence and upper level divergence increased with increased in low level relative vorticity from 15th to 17th November. The vertical wind shear if horizontal wind was moderate (10-20 knots) in the morning of 17th.

The convective cloud clusters got organized gradually and also there was in deep convection. The lowest cloud top temperature was about -75°C in the morning of 17th. The vortex which was assigned the T1.0 in the morning of 16th, was upgraded to T1.5. The Madden Julian Oscillation (MJO) index lay over lay over phase 5 with amplitude greater than 1. The The MJO index at phase 5 is favourable for cyclogenesis over the Bay of Bengal.

4. Intensification and Movement:

The favourable conditions of 17th November morning, as mentioned in the previous section continued in the evening of the same day. In their association, the depression moved initially west-northwest wards and intensified into deep depression at 1200 UTC of 17th November over east central Bay of Bengal near latitude 16.0°N and longitude 89.0°E. However, as it was lying very close to the upper tropospheric ridge, the movement of the deep depression became slow thereafter. It moved westwards under the influence of the middle tropospheric steering ridge 1200 UTC of 18th. After remaining stationary for some time, it moved west-southwestward and weakened into a Depression at 0000 UTC of 19th. It further weakened further into a well marked low pressure over west central Bay of Bengal at 0300 UTC of 19th.

The weakening of the system could be attributed to (i) entrainment of dry and cold air into the system from the Indian land mass in the lower and middle tropospheric levels, (ii) gradual increase in the vertical wind shear resulting in the northeastward shearing of convection from the low level circulation centre. The track of this deep depression is shown below in Fig.1.



Fig.1.Track of deep depression over Bay of Bengal (17-19 Nov. 2012)

Table 1: Best track positions and other parameters of Deep Depression over the Bay of Bengal during 17-19 November, 2012

Date	Time (UTC)	Centre lat. ^o N/ long. ^o E	C.I. NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
17.11.2012	0600	11.5/90.0	1.5	1004	25	3	D
	1200	16.0/89.0	2.0	1002	30	5	DD
	1800	16.0/89.0	2.0	1002	30	5	DD
18.11.2012	0000	16.0/88.5	2.0	1002	30	5	DD
	0300	16.0/88.5	2.0	1002	30	5	DD
	0600	16.0/88.0	2.0	1002	30	5	DD
	1200	16.0/87.5	2.0	1002	30	5	DD
	1800	16.0/87.5	2.0	1002	30	5	DD
19.11.2012	0000	15.5/87.0	1.5	1004	25	3	D
	0300	15.0/86.5	1.5	1004	25	3	D
	0600	15.0/86.5	1.5	1004	25	3	D
	1200	15.0/86.0	1.5	1005	20	3	D
	1500	Weakened into a well marked low pressure area over west central Bay of Bengal					

Table 2. Crucial surface observations over Bay of Bengal during Deep Depression (17-19 November 2012)

Buoy	Time (UTC)	Position of Buoy	Observation
	171200	16.5 ^o N/88.0 ^o E	MSLP: 1004.2 hPa 24 hours Pressure fall: 2.9 hPa Wind: 050/25 kts
	180600	16.5 ^o N/88.0 ^o E	MSLP: 1005.4 hPa Wind: 070/27 kts
	180900	16.5 ^o N/88.0 ^o E	Wind: 090/30 kts
	181200	16.5 ^o N/88.0 ^o E	Wind: 100/25 kts
	190300	16.5 ^o N/88.0 ^o E	MSLP: 1008.4 hPa Wind: 070/18 kts
	191200	16.5 ^o N/88.0 ^o E	MSLP: 1007.6hPa Wind: 110/14 kts
		13.5 ^o N/84.0 ^o E	Wind: 340/16 kts
Microwave imagery	191138	F-16	Wind: 20-15 kts

The best track parameters are shown in Table 1. The crucial observations supporting the best track are given in Table 2. The typical satellite imageries of the system are shown in Fig.2. The NWP model analyses and forecasts based on 0000 UTC initial conditions of 17 and 18 November are shown in Fig.3.

5. Estimated central pressure (ECP) and maximum sustained surface wind (MSW)

The estimated central pressure (ECP) of the system decreased from 1004 hPa at genesis stage to 1002 hPa at the stage of deep depression. The maximum sustained surface wind (MSW) reached upto 30 knots during 1200 UTC of 17 to 1800 UTC of 18 November 2012. The MSW was also supported by available scatterometry wind observations from various satellites including Oceansat-II.

6. Realised Weather

Heavy rainfall occurred over Andhra Pradesh, Puducherry and Tamil Nadu due the remnant low pressure area of this depression. The chief amount of 24 hrs cumulative rainfall (5 cm or more) ending at 0300 UTC of date are given below.

22 November 12

Tamil Nadu & Puducherry: Sathanur Dam-10, Padalur-6, Sankarapuram-5,

23 November 2012

Coastal Andhra Pradesh: Tada-7,
Rayalaseema: Tirupati (AP)-14, Perumallapalli and Puttur-7 each, Tirupati and Rajampet-6 each, Pakala-5,
Tamil Nadu & Puducherry: Pallipattu-6,

24 November 2012

Tamil Nadu & Puducherry: Chengalpattu-14, Watrap and Tuticorin-10 each, Usilampatti, Bodinaickanur, Virudachalam-7 each, Coonoor-6, Viralimalai, Maduranthagam, Kothagiri, Ulundurpet, Vellore, Sirkali and Keeranur-5 each,

25 November 2012

Tamil Nadu & Puducherry: Manimutharu-14, Thenkasi-12, Shencottah and Maniyachi-6 each, Illuppur-5.

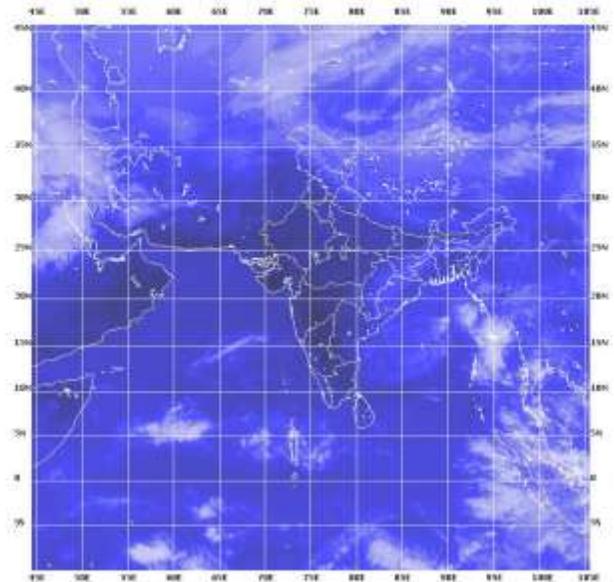
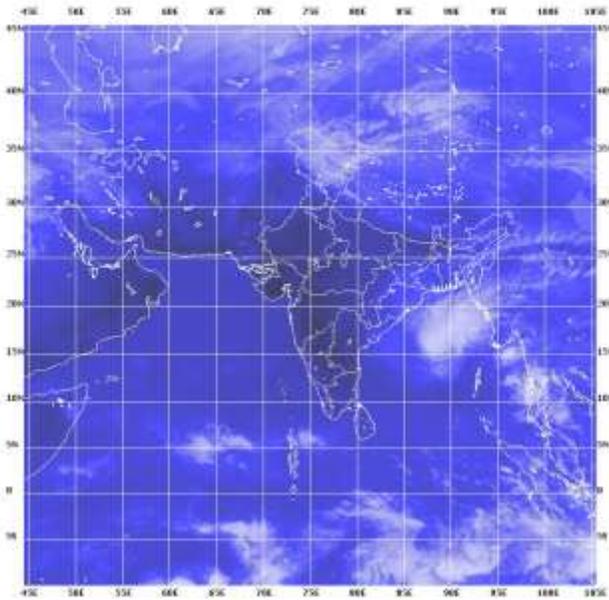
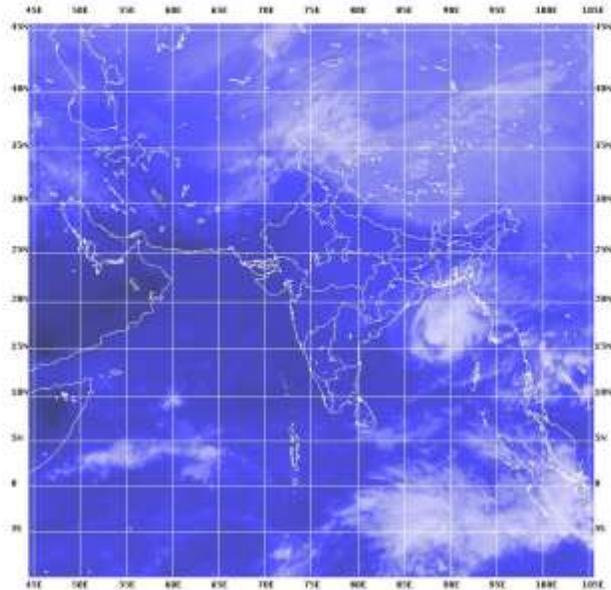
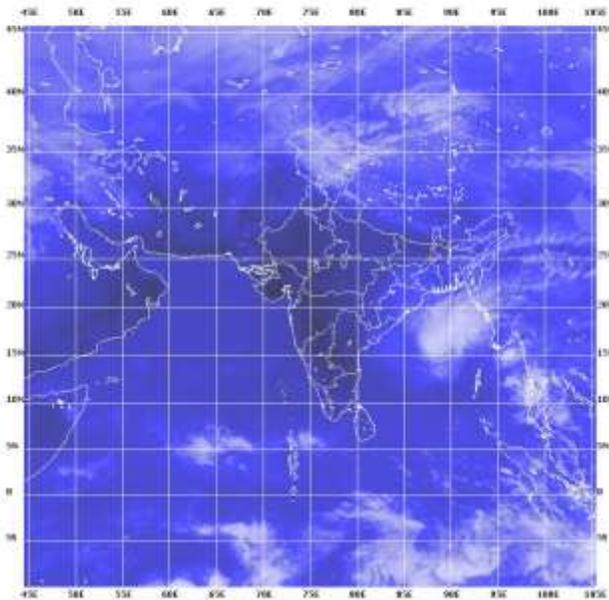


Fig.2. Typical satellite imageries showing genesis, intensification, movement and decay of the deep depression (17-19 November 2012)

7. NWP model performance

The analysis and forecast fields of mean sea level pressure and wind at 850, 500 and 200 hPa levels based on ECMWF and IMD GFS models for the period of deep depression are shown in Fig.3. The genesis, intensity and movement of the deep depression could be reasonably predicted by these two models. The circulation pattern further indicates that the system was steered by the middle tropospheric flow pattern.

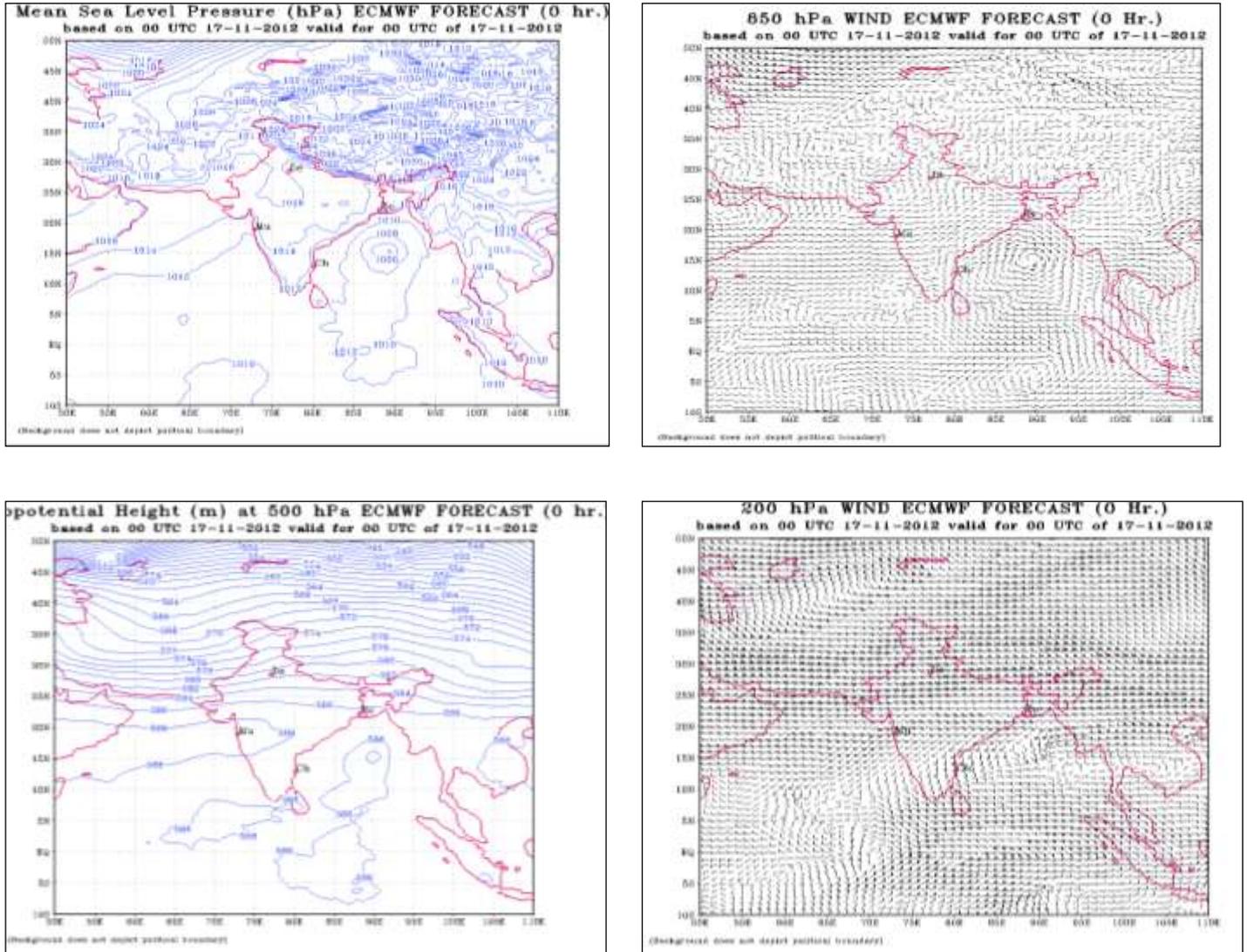


Fig.3(a). ECMWF model analyses of MSLP and wind at 850, 500 and 200 hPa levels based on 0000 UTC of 17 November 2012.

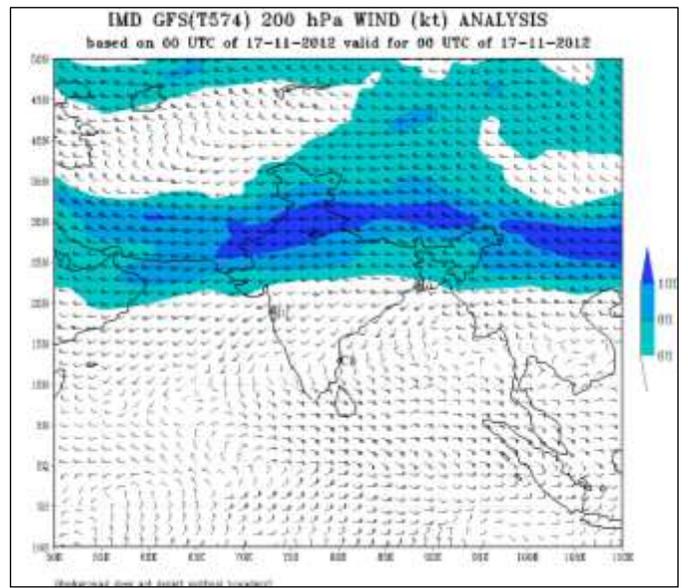
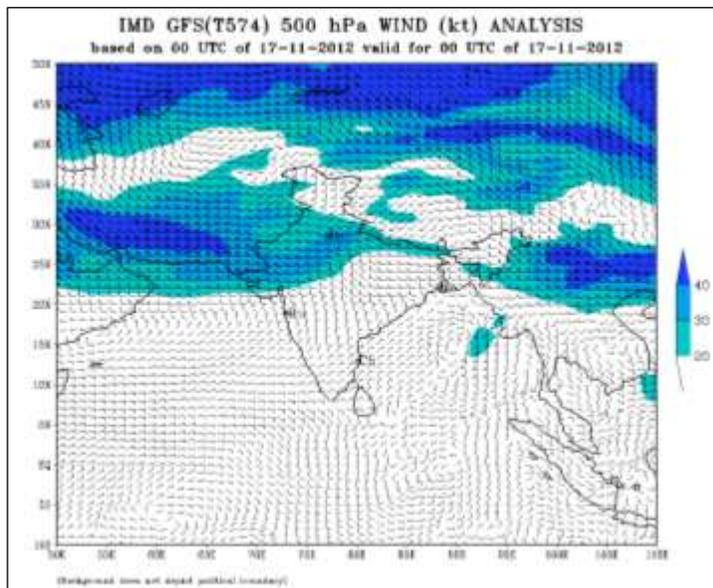
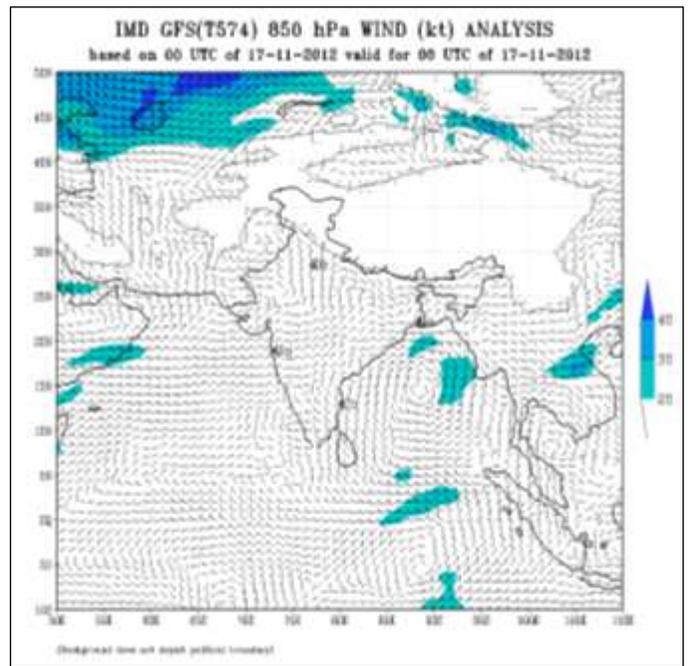
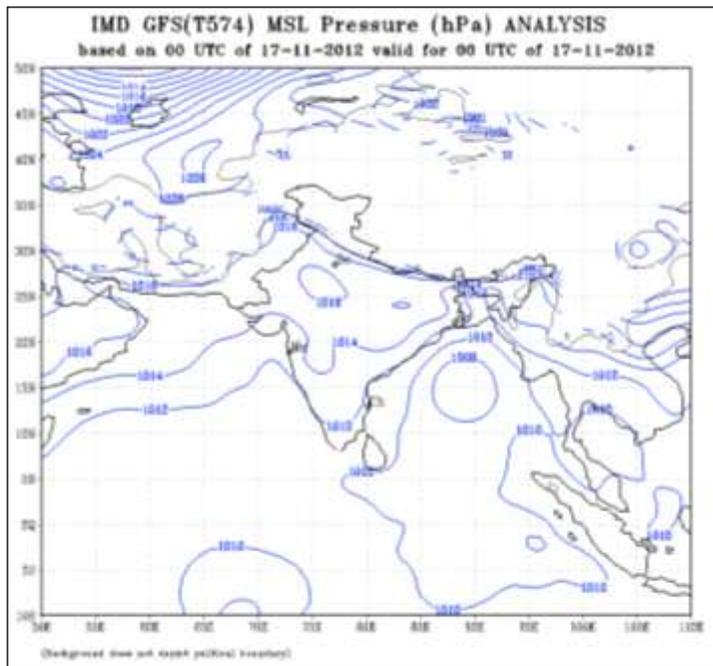


Fig.3(b). IMD GFS model analyses of MSLP and wind at 850, 500 and 200 hPa levels based on 0000 UTC of 17 November 2012.

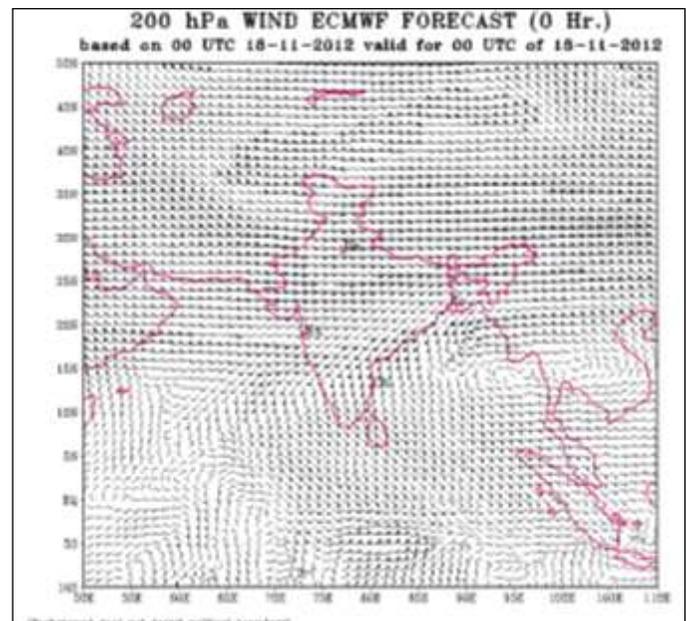
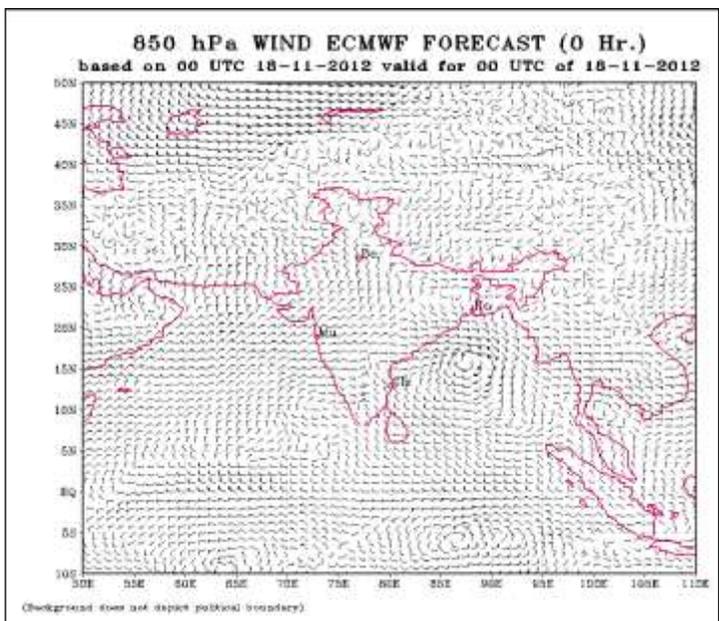
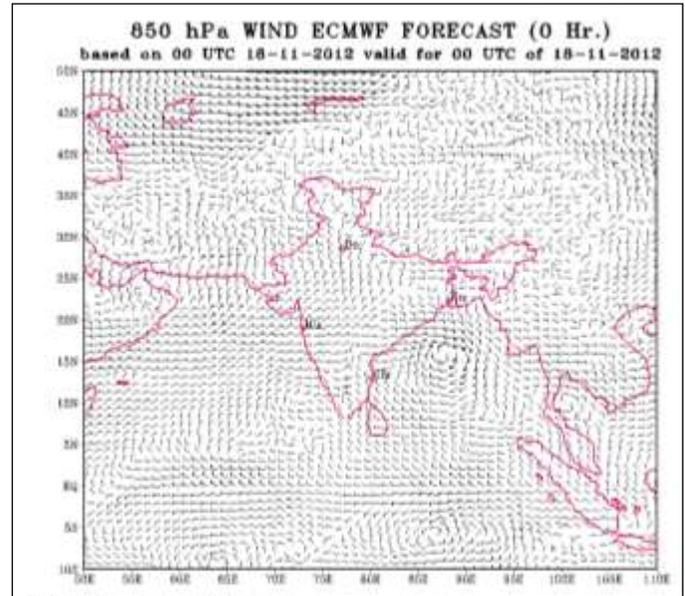
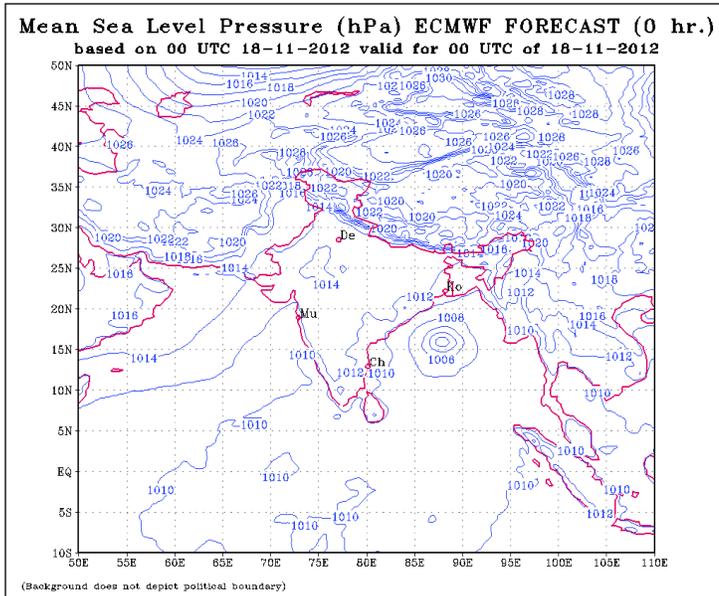


Fig.3(c). ECMWF model analyses of MSLP and wind at 850, 500 and 200 hPa levels based on 0000 UTC of 18 November 2012.

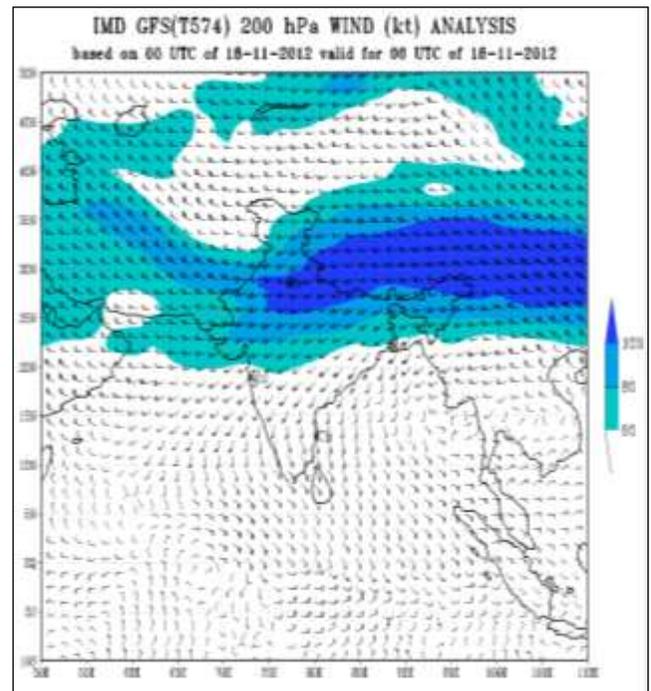
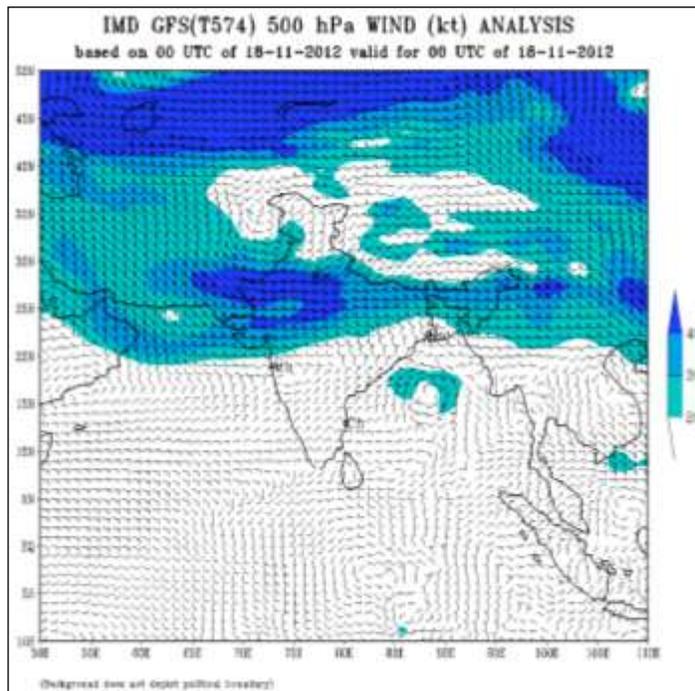
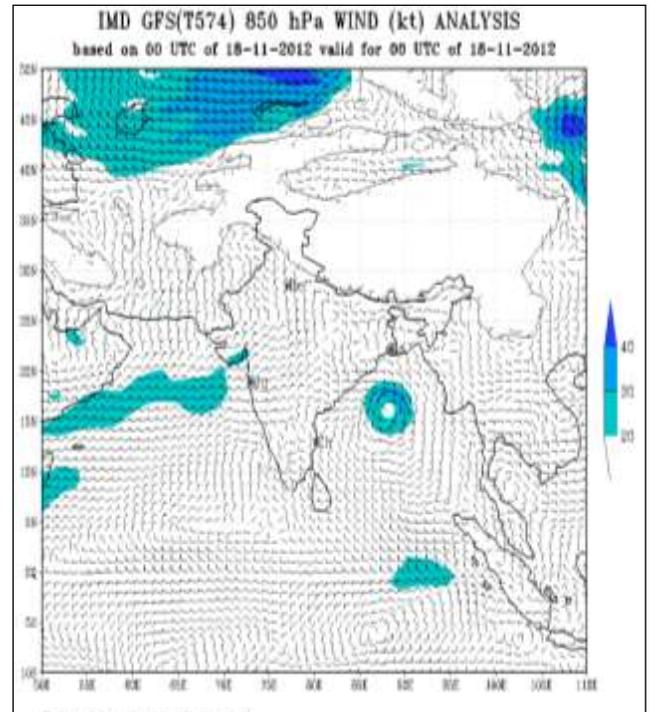
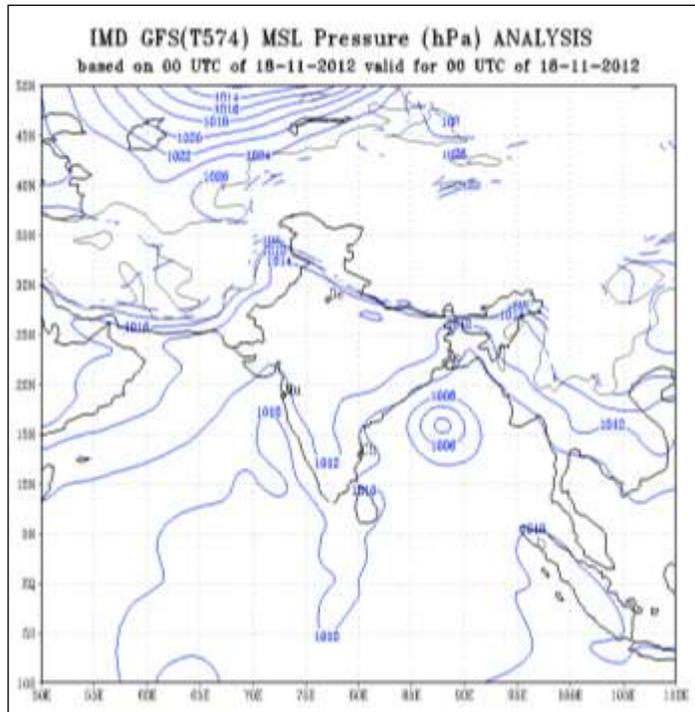


Fig.3(d). IMD GFS model analyses of MSLP and wind at 850, 500 and 200 hPa levels based on 0000 UTC of 18 November 2012.

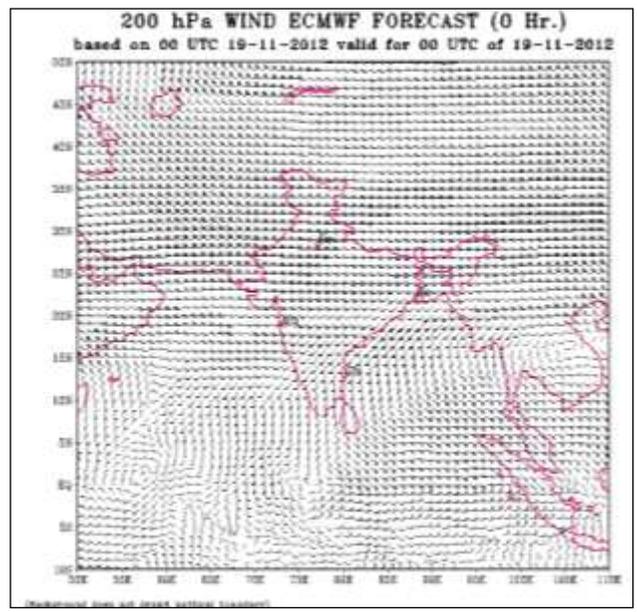
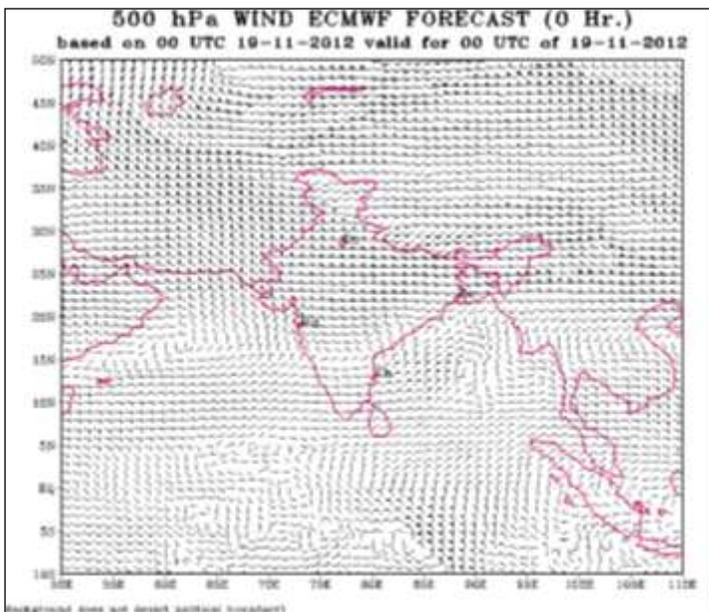
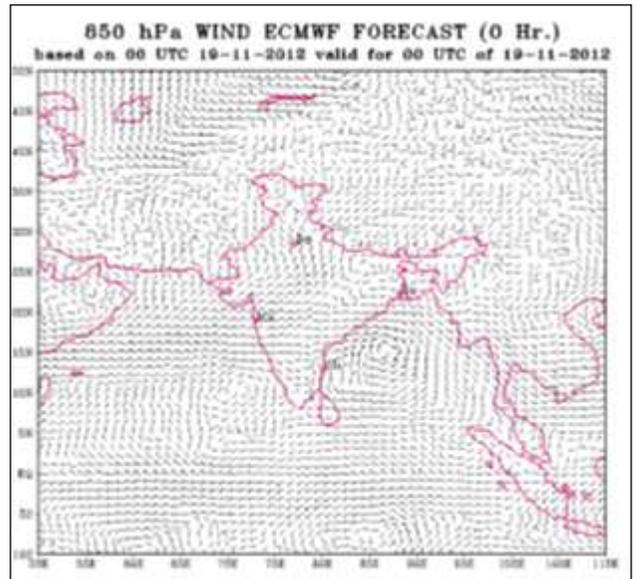
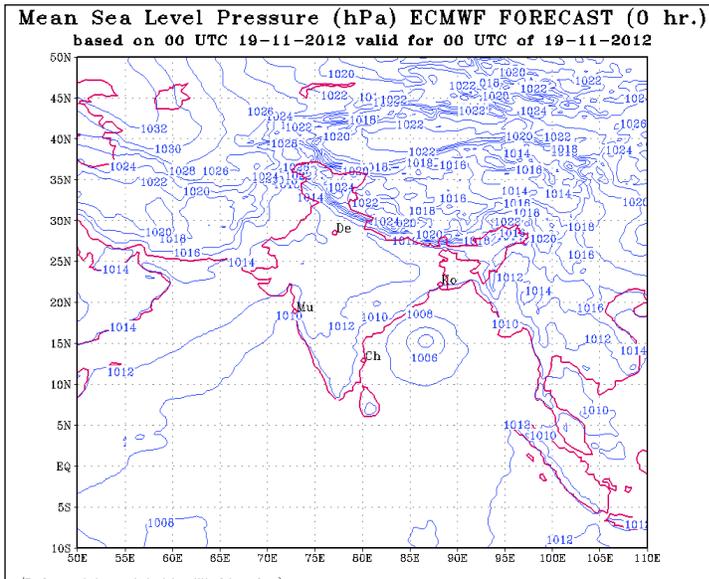


Fig.3(e). ECMWF model analyses of MSLP and wind at 850, 500 and 200 hPa levels based on 0000 UTC of 19 November 2012.

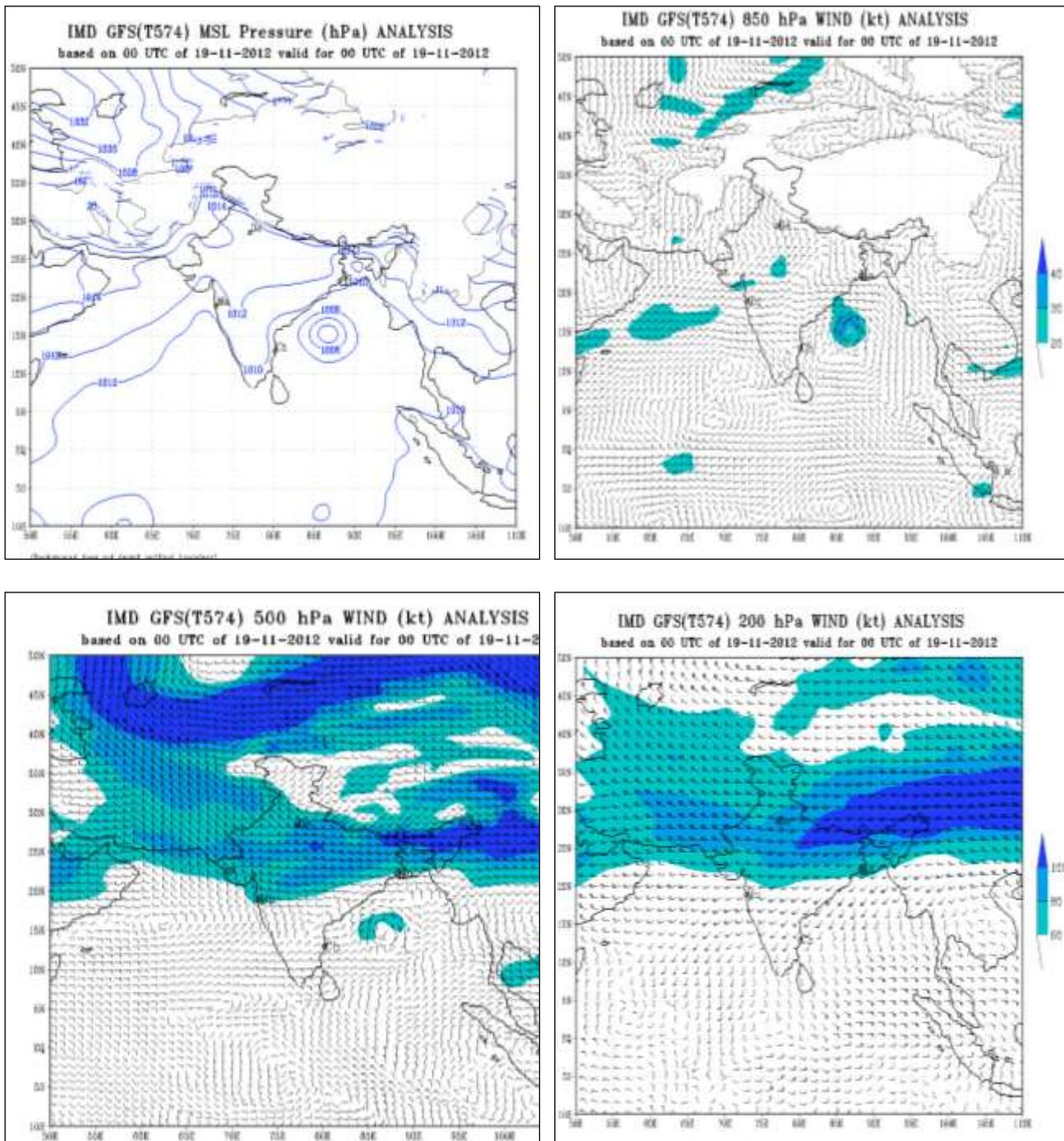


Fig.3(f). IMD GFS model analyses of MSLP and wind at 850, 500 and 200 hPa levels based on 0000 UTC of 19 November 2012.

8. Forecast and Warning Services

The bulletins were issued by Cyclone Warning Division and Regional Specialised Meteorological Centre (RSMC), New Delhi in regular intervals to WMO/ESCAP Panel countries and national disaster management agencies. Following is the statistics of bulletins issued during the life period of deep depression.

Number of bulletins issued for India coast : 14

Number of bulletins issued to WMO/ESCAP Panel countries : 09

8.1. Forecast Performance

8.1.1. Track and intensity

The track forecast error of 12, 24, 36 and 48 hours are 55, 66, 81 & 55 kms respectively which is significantly less than the average forecast errors in last five years. The average track forecast error for this deep depression is shown in Table 3 and Average intensity error is shown in Table 4. The average absolute error was about 15 kms & 10 kms for 24 & 48 hours forecast respectively.

Table 3. Average track forecast error of IMD for Deep Depression (17-19 November 2012)

Lead Period	Forecast Error in Kms
12	55 (6)
24	66 (5)
36	81 (3)
48	55 (1)

(Number in parenthesis indicates number of forecasts verified)

Table 4. Average intensity forecast error of IMD for Deep Depression (17-19 November 2012)

Lead Period of forecast	Intensity Error (knots)		No. of observations verified
	Absolute Average	RMS	
12	16.4	18.4	6
24	14.9	16.3	5
36	9.1	9.4	3
48	9.7	9.7	1

8.1.2. Heavy rainfall warning

Heavy rainfall warning verification given in Table.5

Table 5. Average Heavy rainfall warning forecast error of IMD for Deep Depression (17-19 November 2012)

Date and Time	Synoptic System	Forecast issued	Forecast Realised
17.11.2012 1130 hrs	A depression has formed over eastcentral Bay of Bengal and lay centred at 1130 hrs IST of today, the 17 th November 2012 near latitude 15.5 ⁰ N and longitude 90.0 ⁰ E, about 1050 km east-northeast of Chennai (Tamilnadu), 750 km east-southeast of Visakhapatnam and 650 km southeast of Paradip.	Rainfall at most places with isolated heavy rainfall would occur over Andaman and Nicobar Islands during next 24 hrs	Isolated rainfall occurred over Andaman & Nicobar island
18.11.2012 1730 hrs IST	The deep depression lay centred at 1730 hrs IST of today 18 th November 2012 over westcentral Bay of Bengal near latitude 16.0 ⁰ N and longitude 87.5 ⁰ E, about 800 km east-northeast of Chennai, 500 km east-southeast of Visakhapatnam and 500 km south-southeast of Paradip	Moderate rainfall would occur at many places over south coastal Andhra Pradesh, north coastal Tamilnadu and puducherry on 20 th and 21 st November with Isolated heavy rainfall on 21 st November	Isolated rainfall occurred over coastal Andhra Pradesh and coastal Tamil Nadu & Puducherry on 20.11.2012 & 21.11.2012 with isolated heavy fall over coastal Tamil Nadu & Puducherry.
19.11.2012 0830 hrs IST	The depression lay centred at 0830 hrs IST of today the 19 th November 2012 near latitude 15.0 ⁰ N and longitude 86.5 ⁰ E, about 700 km east-northeast of Chennai and 450 km southeast of Visakhapatnam.	Moderate rainfall would occur at many places over south coastal Andhra Pradesh, north coastal Tamilnadu and Puducherry on 20 th and 21 st November.	Isolated rainfall occurred over coastal Andhra Pradesh and coastal Tamil Nadu & Puducherry on 20.11.2012 & 21.11.2012 with isolated heavy fall over coastal Tamil Nadu & Puducherry.
19.11.2012	The depression lay	Moderate rainfall would	Isolated rainfall

1730 hours IST	centred at 1730 hrs IST of today the 19 th November 2012 over westcentral Bay of Bengal near latitude 15.0 ⁰ N and longitude 86.0 ⁰ E, about 650 km east-northeast of Chennai and 440 km southeast of Visakhapatnam.	occur at many places over south coastal Andhra Pradesh, north coastal Tamilnadu and Puducherry on 21 ST and 22 nd November.	occurred over coastal Andhra Pradesh, coastal Tamilnadu & Puducherry on 21.11.2012 and 22.11.2012 with isolated heavy fall over Tamil Nadu & Puducherry on 21.11.2012 and over Rayalseema on 22.11.2012 .
20.11.2012 0830 hours IST	The well marked low pressure area over westcentral Bay of Bengal persists over the same region at 0830 hrs IST of today the 20 th November 2012	Moderate rainfall would occur at many places with isolated heavy falls over south coastal Andhra Pradesh, north coastal Tamilnadu and Puducherry on 21 ST and over south coastal Andhra Pradesh, Rayalaseema, Puducherry and north Tamil Nadu on 22 nd November.	Isolated rainfall occurred over coastal Andhra Pradesh, coastal Tamilnadu & Puducherry on 21.11.2012 and 22.11.2012 with isolated heavy fall over Tamil Nadu & Puducherry on 21.11.2012 and over Rayalseema on 22.11.2012 .

9. Damage :

There was no damage due to the deep depression as, it weakened over the sea.