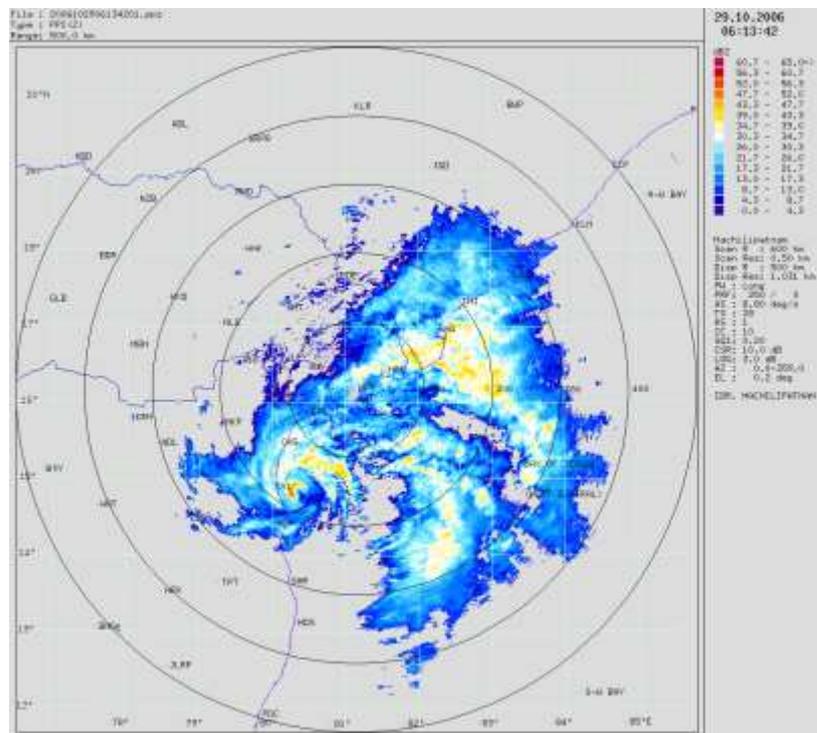




भारत मौसम विज्ञान विभाग INDIA METEOROLOGICAL DEPARTMENT

REPORT ON CYCLONIC DISTURBANCES OVER NORTH INDIAN OCEAN DURING 2006



Doppler Weather Radar Chennai imagery of cyclonic storm, 'OGANI' of 0613 UTC of 29 October, 2006

RSMC-TROPICAL CYCLONES, NEW DELHI

JANUARY 2007



INDIA METEOROLOGICAL DEPARTMENT

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INTRODUCTION

Regional Specialized Meteorological Centre (RSMC) - Tropical Cyclones, New Delhi has the responsibility of issuing Tropical Weather Outlook and Tropical Cyclone Advisories for the benefit of the countries in the WMO/ESCAP Panel region bordering the Bay of Bengal and the Arabian Sea, namely, Bangladesh, Maldives, Myanmar, Sultanate of Oman, Pakistan, Sri Lanka and Thailand.

Cyclone Warning Division

As per the recommendations of the Cyclone Review Committee (CRC) set up by the Government of India, a Cyclone Warning Directorate, co-located with RSMC Tropical Cyclones - New Delhi, was established in 1990 in the India Meteorological Department (IMD), New Delhi to co-ordinate and supervise the cyclone warning in the country.

Functions

The broad functions of RSMC- Tropical Cyclones New Delhi are as follows:

- Round the clock watch over weather situations over the entire north Indian Ocean.
- Analysis and processing of global meteorological data for diagnostic and prediction purposes.
- Detection, tracking and prediction of cyclonic disturbances in the Bay of Bengal and the Arabian Sea.
- Running of numerical models for tropical cyclone track and storm surge prediction.
- Interaction with Disaster Management Agencies to provide timely information and warnings for emergency support services.
- Implementation of the Regional Cyclone Operational Plan of WMO/ESCAP Panel.
- Issue of Tropical Weather Outlook and Tropical Cyclone Advisories to the Panel countries.
- Issue of Tropical Cyclone Advisories for International Aviation.
- Collection, processing and archival of all data pertaining to cyclonic disturbances viz. wind, storm surge, pressure, rainfall, satellite information etc. and their exchange with Panel countries.
- Preparation of comprehensive annual reports on cyclonic storms and tropical depressions over North Indian Ocean every year.
- Research on storm surge, track and intensity prediction techniques.

CHAPTER- I

Activities of Regional Specialized Meteorological Centre – Tropical Cyclones, New Delhi

Area of responsibility

The area of responsibility of RSMC Tropical Cyclones, New Delhi (hereafter referred to as RSMC- New Delhi) covers sea areas of north Indian Ocean north of equator between 45⁰ E and 100⁰ E and includes the member countries of WMO/ESCAP Panel on Tropical Cyclones viz, Bangladesh, India, Maldives, Myanmar, Pakistan, Sri Lanka, Sultanate of Oman and Thailand as shown in fig. 1.1. The centre issues Tropical Weather Outlook daily at 0600 UTC in normal weather and Cyclone Advisories on tropical cyclones (at three hourly intervals) when they develop over the north Indian Ocean. RSMC New Delhi has also been issuing Tropical Cyclone Advisories for Aviation as per requirements of International Civil Aviation Organisation (ICAO).

RSMC- New Delhi has started of naming of Tropical Cyclones formed over north Indian Ocean with effect from 2004.

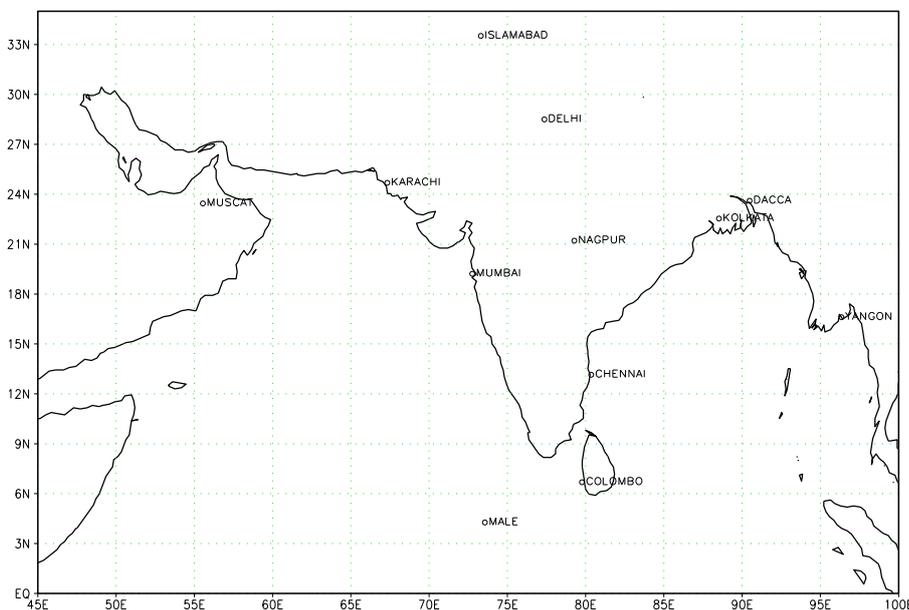


Figure 1.1 Area of responsibility of RSMC New Delhi

Analysis

Surface analysis of tropical disturbances is performed four times daily at 00, 06, 12, and 18 UTC. During cyclone period, synoptic charts are prepared and analysed every three hour to monitor the tropical cyclones that form over the north Indian Ocean.

Cloud imageries from Geostationary Meteorological Satellites INSAT-3A and METSAT (Kalpana-1) are the main sources of information for the analysis of tropical cyclones over the data-sparse region of north Indian Ocean in addition to

boundary conditions are derived based on global model (T-80) forecasts obtained online from the National Centre for Medium Range Weather Forecasting (NCMRWF), India. The model is run twice a day based on 00 UTC and 12 UTC initial conditions to provide 6 hourly track forecasts valid up to 72 hours. The track forecast products are disseminated as a World Weather Watch (WWW) activity of RSMC, New Delhi.

(b) Limited Area Model (LAM)

The operational forecasting system known as Limited Area Forecast System (LAFS), is a complete system consisting of data decoding and quality control procedures, 3-D multivariate optimum interpolation scheme for objective analysis and a semi-implicit semi-Lagrangian multi-layer primitive equation model. The model is run twice a day based on 00 UTC and 12 UTC observations. The horizontal resolution of the model is $0.75^{\circ} \times 0.75^{\circ}$ lat. / long. with 16 sigma levels in the vertical. First guess and boundary conditions for running the LAFS are obtained online from global forecast model being operated by the NCMRWF. The forecast products are disseminated as a World Weather Watch activity of RSMC, New Delhi.

(c) Non-hydrostatic Meso-scale Model MM-5 (Version 3.6)

The non-hydrostatic model MM-5 is being run on operational basis daily once based on 00 UTC initial conditions for the forecast upto 72 hours. The horizontal resolution of the model is 45 km with 23 sigma levels in the vertical. The domain of integration covers the area between lat. 25° S to 45° N and long. 30° E to 120° E. National Centre for Environmental Prediction (NCEP) analysis and six hourly forecasts are used as initial and boundary conditions to run the model. The forecast products are disseminated as a WWW activity of RSMC, New Delhi.

(d) Storm Surge Model

For the operational storm surge prediction India Meteorological Department (IMD) uses both nomograms developed by IMD and Dynamical Storm Surge Model developed by Indian Institute of Technology (IIT), Delhi. The nomograms are based on the numerical solution to the hydro dynamical equations governing motion of the Sea. The nomograms are prepared relating peak surge with various parameters such as pressure drop, radius of maximum wind, vector motion of the cyclone and offshore bathymetry. The dynamical model of IIT Delhi is fully non-linear and is forced by wind stress and quadratic bottom friction following the method of numerical solution to the vertically integrated mass continuity and momentum equations. The updated version of the model currently in operational use covers an analysis area lying between lat. 2° N and 22.25° N and long. 65° E and 100° E. The method uses a conditionally stable semi-implicit finite difference stair step scheme with staggered grid for numerical solution of the model equation. The bottom stress is computed from the depth-integrated current using conventional quadratic equation. The bathymetry of the model is derived from Naval Hydrographic charts applying cubic spline technique.

Products generated by RSMC New Delhi

RSMC New Delhi prepares and disseminates the following RSMC bulletins via Global Telecommunication System (GTS) and Aeronautical Fixed Telecommunication Network (AFTN).

(I) Tropical Weather Outlook

Tropical Weather Outlook is issued daily at 0600 UTC in normal weather for use of the member countries of WMO/ESCAP Panel. This contains description of synoptic systems over north Indian Ocean along with information on significant cloud systems as seen in satellite imageries. In addition, a special weather outlook is also issued at 1700 UTC during situations when a tropical depression is formed and **expected to intensify and attain cyclone intensity**. These bulletins are transmitted through GTS.

(ii) Global Maritime Distress Safety System (GMDSS)

Under Global Maritime Distress Safety System (GMDSS) scheme, India has been designated as one of the 16 services in the world for issuing sea area bulletins for broadcast through GMDSS for MET AREA VIII (N), which covers a large portion of north Indian Ocean. As a routine, two GMDSS bulletins are issued at 0900 and 1800 UTC. During cyclonic situations, additional bulletins (up to 4) are issued for GMDSS broadcast. In addition, coastal weather and warning bulletins are also issued for broadcast through NAVTEX transmitting stations located at Mumbai and Chennai.

(iii) Tropical Cyclone Advisories

Tropical cyclone advisories are issued at 3 hourly intervals. These bulletins contain the current position of the cyclone, satellite description, expected direction and speed of movement, estimated central pressure and forecast of winds, squally weather and state of the sea in and around the system. Tropical cyclone advisories are transmitted to panel member Countries and are also made available on real time basis through internet at IMD's website: <http://www.imd.ernet.in> and <http://www.imd.gov.in>.

(iv) Tropical Cyclone Advisories for Aviation

Tropical Cyclone Advisories for aviation are issued for international aviation as soon as any disturbance over the north Indian Ocean attains or likely to attain the intensity of cyclonic storm within next six hours (sustained wind speed ≥ 34 knots). These bulletins are issued at six hourly intervals based on 00, 06, 12, 18 UTC synoptic charts and the time of issue is HH+03 hrs. These bulletins containing present status of cyclone like lat./long., max surface wind, movement and estimated central pressure and 24 hrs forecast position and message in coded form. The tropical cyclone advisories are transmitted on real time basis through GTS and AFTN channels to designated addresses.

Satellite Monitoring

India has launched an exclusive Meteorological Geo-stationary Satellite METSAT, now named KALPANA-I, on September 2002 purely for meteorological purposes. It is positioned over the equator at 74° E. Another Geostationary satellite under INSAT series (INSAT-3A) was launched in April 2003 with the meteorological payloads identical to those of INSAT-2E which became operational since May 2003. It is positioned over the equator at 93.5° E. Both these satellites provide imageries in visible (VIS), Infrared (IR) and Water Vapour (WV) channels. In addition INSAT-3A is also equipped with Charged Coupled Device (CCD) cameras capable of providing imageries in VIS, Near IR (NIR) and Short-Wave IR (SWIR) channels with greater resolution.

During cyclone situation, data from KALPANA-1 are processed at hourly intervals to assess the location and intensity of cyclonic disturbances out at sea. Similar processing of data from INSAT-3A is done at 3-hourly intervals.

In addition to above, the following products are also generated on operational mode and posted in website of IMD.

- Outgoing Long wave Radiation (OLR)
- Quantitative Precipitation Estimates (QPE)
- Sea Surface Temperatures (SST)
- Cloud Motion Vector (CMV) in 3 levels

Meteorological Data Dissemination

IMD transmits processed imagery, meteorological and facsimile weather charts to field forecasting offices distributed over the country using the Meteorological Data Dissemination (MDD) facility, through INSAT in broadcast mode using C & S band transponders. Synoptic bulletins providing description of the cloud organization and coverage are also sent as advisory to forecasting offices every synoptic hour. When cyclones are detected in satellite imagery, these bulletins are sent every hour. Such advisories are also transmitted to the neighbouring countries.

Processed satellite imagery, analyzed weather charts and conventional synoptic data are up-linked to the satellite in C-band. Satellite broadcasts these data to MDD stations in S-band. MDD stations analyse weather imagery and other data to generate required forecast. The processing system is also being used for generating analogue type of cloud imagery data which are transmitted through INSAT-3C to field station using S-band broadcast capability of the satellite alongwith other conventional meteorological data and FAX charts. This scheme is called Meteorological Data Dissemination (MDD). There are about 33 MDD receiving stations in the country being operated by different agencies. Two MDD receiving stations are also operating in neighbouring countries at Sri Lanka and Male. In general, the processed images are sent to these stations every hour during cyclone periods. These stations are receiving direct broadcast of cloud imagery, weather facsimile charts and meteorological data on an

operational basis. The frequency of transmission from ground to satellite (uplink) is 5899.225 MHz and that of downlink is 2599.225 MHz.

Cyclone Warning Dissemination System

For quick dissemination of warning against impending disaster from approaching cyclones, IMD has installed specially designed receivers within the vulnerable coastal areas for transmission of warnings to the concerned officials and people using broadcast capacity of INSAT satellite. This is a direct broadcast service of cyclone warning in the regional languages meant for the areas affected or likely to be affected by the cyclone. There are 250 stations along the Indian coast that provide this useful service. The IMD's Area Cyclone Warning Centres (ACWCs) at Chennai, Mumbai and Kolkata and Cyclone Warning Centre (CWCs) at Bhubaneswar, Visakhapatnam and Ahmedabad are responsible for originating and disseminating the cyclone warnings through CWDS. In this system, concerned ACWC/ CWC for the areas affected or likely to be affected by the cyclone every hour generates the cyclone warning bulletin. The cyclone warning bulletin is up-linked to the INSAT Satellite in C band. For this service the frequency of transmission from ground to satellite (uplink) is 5859.225 MHz and downlink is at 2559.225 MHz. The warning is selective and will be received only by the affected or likely to be affected stations. The service is unique in the world and helps the public in general and the administration, in particular, during the cyclone season. It is a very useful system and has saved millions of lives and enormous amount of property from the fury of cyclones.

Recently, a digital CWDS scheme has been implemented along the Andhra Pradesh coast. One hundred digital receiver stations with an uplink station at IMD, Chennai have been installed. These have shown good results.

CHAPTER –II

1. Cyclonic activities over north Indian Ocean during 2006

The year-2006 was a year of near normal cyclonic activity over north Indian Ocean. The basin witnessed the formation of twelve disturbances against a normal of fifteen (Table 2.1). Out of twelve disturbances, three (against a normal of five to six) intensified into cyclonic storms and three concentrated into deep depressions. There was one land depression during the year. Tracks of the systems are shown in Fig. 2.1.

As usual, the Arabian Sea was less active as compared to the Bay of Bengal. Only one cyclonic storm and one depression formed over the Arabian Sea, which dissipated over the sea itself. The Bay of Bengal was more active with formation of two cyclonic storms, two deep depressions and five depressions during the year 2006.

MALA: The very severe cyclonic storm “MALA” developed over southeast Bay of Bengal as a low-pressure area and intensified into a depression in the morning of 25 April 2006. It was located about 350 km southwest of Port Blair. Moving initially in a westerly direction, it intensified into a deep depression in the afternoon and into a cyclonic storm in the evening. The cyclonic storm continued to move in a northerly direction for some time and thereafter in a northeasterly direction and intensified into a severe cyclonic storm in the forenoon of 27 April. It further intensified into a very severe cyclonic storm and continued to move in a northeasterly direction and crossed Arakan coast about 100 km south of Sandoway, Myanmar around noon of 29 April 2006 as a very severe cyclonic storm. After landfall, the system weakened gradually.

MUKDA: The severe cyclonic storm “MUKDA” developed over east central Arabian Sea as a depression and it lay centered at 0300 UTC of 21 September 2006 about 450 kms southwest of Porbandar. It intensified into a cyclonic storm over eastcentral Arabian Sea at 0000 UTC of September 22 and lay centred about 400 km southwest of Porbandar. It remained practically stationary upto 0900 UTC of 22 and then moved slightly northeastwards and intensified into a severe cyclonic storm and lay centered at 1500 UTC of Sept 22 about 350 kms southwest of Porbandar. The system remained over the same area about 36 hours and dissipated around midnight of September 24, 2006 over sea itself.

OGNI: The third cyclonic storm “OGNI” developed over west central Bay of Bengal as a low pressure area off Andhra Pradesh coast in the evening of October 28, 2006. It intensified into a depression and lay centred about 50 km east of Nellore in the morning of October 29. Moving slowly in a northerly direction it further intensified into a deep depression in the afternoon and cyclonic storm in the evening of same day and lay centred about 50 km east of Kavali. The system slightly moved northwards till the morning of October 30. The movement of the system was very slow and it was about 30 km east of Kavali. Doppler Weather Radars at Machilipatnam showed band features with small core. The cyclonic storm, moving northwestwards, weakened into a deep depression and crossed the coast near Bapatla around noon of October 30,

2006, and then to a depression in the afternoon of same day. The depression further weakened into a well-marked low pressure over north Andhra Pradesh and adjoining areas in the evening of October 30, 2006.

Comprehensive information on tropical cyclone activity over the north Indian Ocean for last ten years is given in Table 2.2.

Some of the characteristic features of these cyclonic disturbances are given in Table 2.3. The statistical data pertaining to the monthly frequencies, total life time (days), frequency distribution (intensity-wise and basin-wise) are given in Table 2.4.

RSMC, New Delhi mobilized all its resources, both technical and human, to track these tropical disturbances that formed over the north Indian Ocean and issued timely advisories to WMO / ESCAP Panel countries.

Table 2.1
List of cyclonic disturbances formed over north Indian Ocean
during 2006

1.	Deep depression over the Arabian Sea, January 13-15
2.	Very severe cyclonic storm over Bay of Bengal, “ MALA ” April 25-29
3.	Deep depression over the Bay of Bengal, July 02- 05
4.	Deep depression over the Bay of Bengal, August 02-05
5.	Depression over the Bay of Bengal, August 12-13
6.	Depression over the Bay of Bengal, August 16-18
7.	Depression over the Bay of Bengal, August 29- September 01
8.	Depression over the Bay of Bengal, September 03-05
9.	Land depression, September 21-24
10.	Severe cyclonic storm “ MUKDA ” over the Arabian Sea, September 21 –24
11	Depression over the Bay of Bengal, September 28-30
12	Cyclonic storm “ OGNI ” over the Bay of Bengal, October 29-30

Table 2.2
Cyclonic disturbances formed over north Indian Ocean and adjoining region during 1997-2006

Year		D	DD	CS	SCS	VSCS	Total
1997	BOB	1	4	1	1	1	8
	ARB	1					1
1998	BOB		3		1	2	6
	ARB		1	1	1	1	4
1999	BOB	1	3	1		2	7
	ARB					1	1
2000	BOB	1	--	3	--	2	6
	ARB	--	--	--	--	--	-
2001	BOB	2	--	1	--	--	3
	ARB	--	--	2	--	1	3
2002	BOB	1	1	2	1	--	5
	ARB	--	--	1	--	--	1
2003	BOB	2	2	--	1	1	6
	ARB	--	--	--	1	--	1
2004	BOB	2	--	--	--	1	3
	ARB	--	2	--	3	--	5
	LAND	2	--	--	--	--	2
2005	BOB	2	3	4	--	--	9
	ARB	2	--	--	--	--	2
	LAND	1	--	--	--	--	1
2006	BOB	5	2	1	--	1	9
	ARB	--	1		1	--	2
	LAND	1	--	--	--	--	1

D: Depression **DD:** Deep Depression, **CS:** Cyclonic Storm
SCS: Severe Cyclonic Storm **VSCS:** Very Severe Cyclonic Storm
BOB: Bay of Bengal **ARB:** Arabian Sea

Table 2.3
Some Characteristic features of cyclonic disturbances formed over north Indian Ocean and adjoining region during 2006

Cyclonic Storm / Depression	Date, Time (UTC) & Lat.^oN / Long. ^oE of genesis	Date, Time (UTC) place of landfall/ dissipation	Estimated lowest central pressure, Date & Time (UTC) & lat.^oN / long.^oE	Estimated Maximum wind speed (kt), Date & Time	Max. T. No. Attained
Deep depression over Arabian Sea, January 13-14	January 13, 1200 UTC near 5.0/ 77.0	Weakened over Arabian Sea at 03 UTC of January 15	1004 hPa at 0900 UTC of January 14 near 7.0/73.0	30 kt at 0300 UTC of January 14	T 2.0
Very severe cyclonic storm "MALA" over Bay of Bengal April 25-29	April 25, 0300 UTC near 9.5 / 90.5	Crossed the Arakan Coast 100 Km south of Sandoway around 0700 UTC of April 29 as Very Severe Cyclonic Storm	954 hPa at 0900 UTC of April 28 near 15.3/92.3)	100 kt at 0900 UTC of April 28	T 5.5
Deep depression over Bay of Bengal July 02 -05	July 02, 0000 UTC near 20.0 / 89.5	Crossed Orissa coast between Paradip and Chandbali around 1500 UTC of July 02	982 hPa at 0300 UTC of July 02 near 20.5/87.0	30 kt at 0300 UTC of July 02	T 2.0
Deep depression over Bay of Bengal August 02-05	August 02, 0300 UTC near 20.5 / 87.5	Crossed Orissa coast between Puri and Gopalpur around 0300 UTC of August 03	986 hPa at 1200 UTC of August 02 near 20.0/86.5	30 kt at 0900 UTC of August 02	T 2.0
Depression over Bay of Bengal, August 12-13	August 12, 0300 UTC near 21.0 / 88.0	Crossed Orissa coast near Balasore around 15 UTC of August 12	992 hPa at 0300 UTC of August 12 Near 21.0/88.0	25 kt at 0300 UTC of August 12	1.5
Depression over Bay of Bengal August 16-18	August 16, 0300 UTC near 20.5/ 88.0	Crossed north Orissa coast near Chandbali around 1430 UTC of August 16	988 hPa at 1500 UTC of August 16 Near 20.5/86.5	25 kt at 0300 UTC of August 16	T 1.5
Depression over Bay of Bengal, August 29- September 01	August 29 0300 UTC near 20.5 / 87.5	Crossed north Orissa coast near Paradip around noon of August 29	990 hPa at 1200 UTC of August 29 Near 21.0/85.0	25 kt at 0300 UTC of August 29	T 1.5

Depression over Bay of Bengal September 03-04	September 03, 1200 UTC near 20.5/88.5	Crossed north Orissa coast near Chandbali around 01 UTC of September 04	992 hPa at 1200 UTC of September 03, Near 20.5/88.5	25 kt at 0300 UTC of September 03	T 1.5
Land depression September 21- 24	September 21, 0300 UTC near 23.0/ 86.5	-----	996 hPa at 0000 UTC of September 21 Near 23.0/86.5	25 kt at 0300 UTC of September 21	
<i>Severe Cyclonic Storm, "MUKDA" over Arabian Sea September 21- 24</i>	<i>September 21, 0300 UTC near 19.5/66.0</i>	<i>Weakened over the east-central Arabian Sea around mid-night of September 24</i>	<i>988 hPa at 2100 UTC of September 22, Near 20.5/66.5</i>	<i>55 kt at 1500 UTC of September 23</i>	<i>T 3.5</i>
Depression over Bay of Bengal September 28- 30	September 28, 0900 UTC near 18.0/89.0	Crossed Orissa coast close to Gopalpur around 12 UTC of September 29	1002 hPa at 0900 UTC of September 28, Near 18.0/89.0	25 kt at 0900 UTC of September 28	T 1.5
<i>Cyclonic storm "OGNI" over Bay of Bengal October 29-30</i>	<i>October 29, 0300 UTC near 14.5/80.5</i>	<i>Crossed Andhra Pradesh coast close to Bapatla around 0730 UTC of October 30</i>	<i>988 hPa at 1200 UTC of October 29, near 15.0/80.5</i>	<i>45 kt at 1200 UTC of October 29,</i>	<i>T 2.5</i>

Table 2.4
Statistical data relating to cyclonic disturbances over the north Indian Ocean during 2006

A) Monthly frequencies and total lifetime of cyclonic disturbances (CI \geq 1.5)

S.No	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Life Time in (Days)
1.	D								↔ ↔ ↔	↔ ↔ ↔*				15.75
2.	DD	↔						↔	↔					6.25
3.	CS										↔			3.38
4.	SCS									↔				2.00
5.	VSCS				↔									1.96
6.	SuCS													---

* Land depression

B) Frequency distribution of cyclonic disturbances of different intensities based on satellite assessment.

CI No.	≥ 1.5	≥ 2.0	≥ 2.5	≥ 3.0	≥ 4.0	≥ 5.0	≥ 6.0	≥ 7.0
No. Of Disturbances	12	6	3	2	1	1	-	-

C) Basin-wise distribution of cyclonic disturbances

Bay of Bengal	9
Arabian Sea	2
Land depression	1

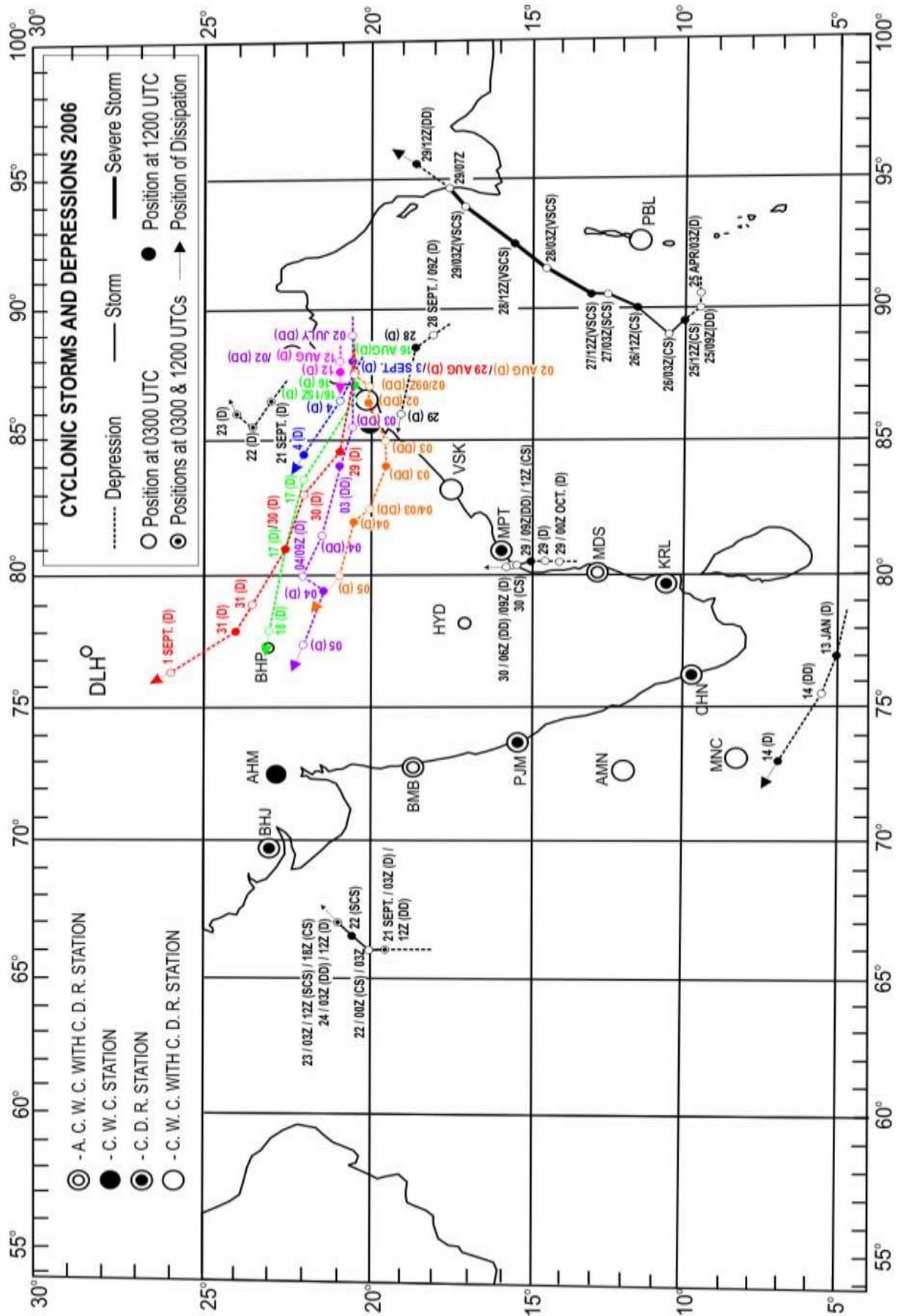


Fig -2.1

Brief description of the systems

2.1 Deep depression over the southeast Arabian Sea 13-14 January, 2006

A low pressure area formed over southeast Arabian Sea in the morning of 13 January 2006. Intense convection developed over it, which remained over the same area for two-three days. The system intensified into a depression in the evening of same day and lay centred at 1200 UTC near lat. 5.0°N /long. 77.0°E . System initially moved westward and further intensified into a deep depression, which was located at 0300 UTC of 14 January near Lat. 5.5°N / Long. 75.5°E . Satellite imagery of 0300 UTC showed the development of intense convection in the northwest sector of the system. The system moved northwestwards upto 0900 UTC of same day. At this time system came under the influence of east-west shear zone. Satellite imagery of 0900 UTC indicated the disorganization of clouds associated with the system. The system moved westwards and lay centred at 1200 UTC near Lat. 7.0°N and Long. 73.0°E and weakened into a depression. System continued to move west-northwest wards and entered in drier air region which resulted into weakening further weakening into a well-marked low pressure area in the morning of 15 January 2006.

The track of the system is given in Fig. 2.1. The best track and other parameters are given in Table 2.1.1. Wind shear on Jan. 13, 2006 is shown in Fig. 2.1.1. A few KALPANA-1 cloud imageries of the system are shown in Fig. 2.1.2 (a-c).

REALISED WEATHER: During Jan. 13-14, 2006 coastal Kerala and Lakshadweep realised scattered light rainfall.

DAMAGES: No damage has been caused by the system.

Table-2.1.1
Best track positions and other parameters for Arabian Sea deep depression January 13-15, 2006

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
13-01-2006	1200	5.0/77.0	1.5	1006	25	4	D
14-01-2006	0000	5.0/76.0	1.5	1006	25	4	D
	0300	5.0/75.5	2.0	1006	30	4	DD
	0600	7.0/74.0	2.0	1006	30	4	DD
	0900	7.0/73.5	2.0	1004	30	4	DD
	1200	7.0/73.0	2.0	1004	25	4	D
	1500	7.0/72.5	1.5	1004	25	4	D
	1800	7.0/72.5	1.5	1004	25	4	D
	2100	7.0/72.0	1.5	1006	25	4	D

The system weakened into a well-marked low pressure area around 0000 UTC of 15 January 2006.

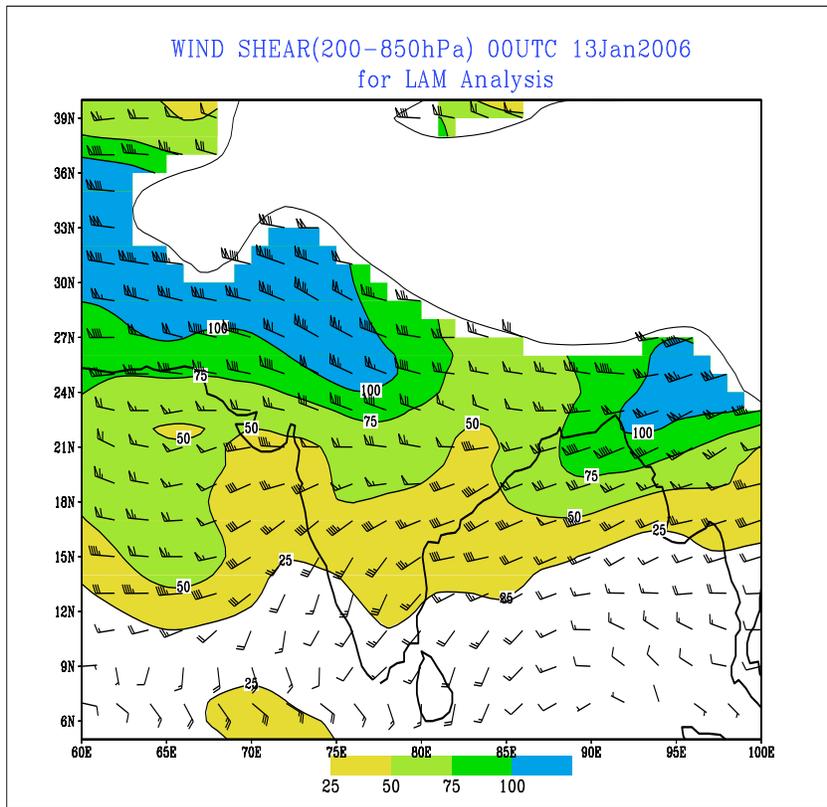


Fig. 2.1.1. Wind shear over RSMC, New Delhi region on 13 January 2006.

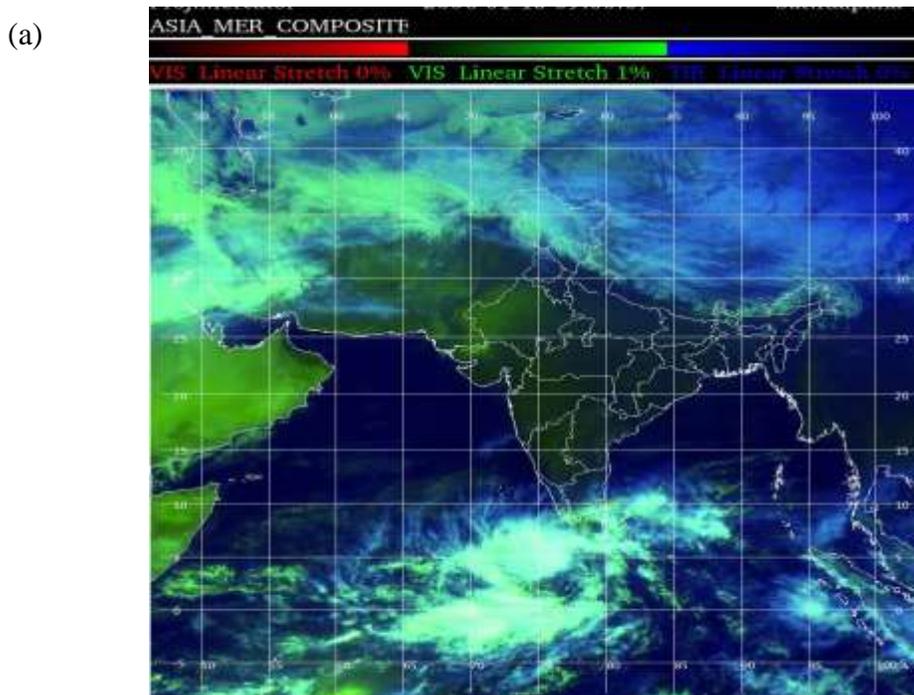
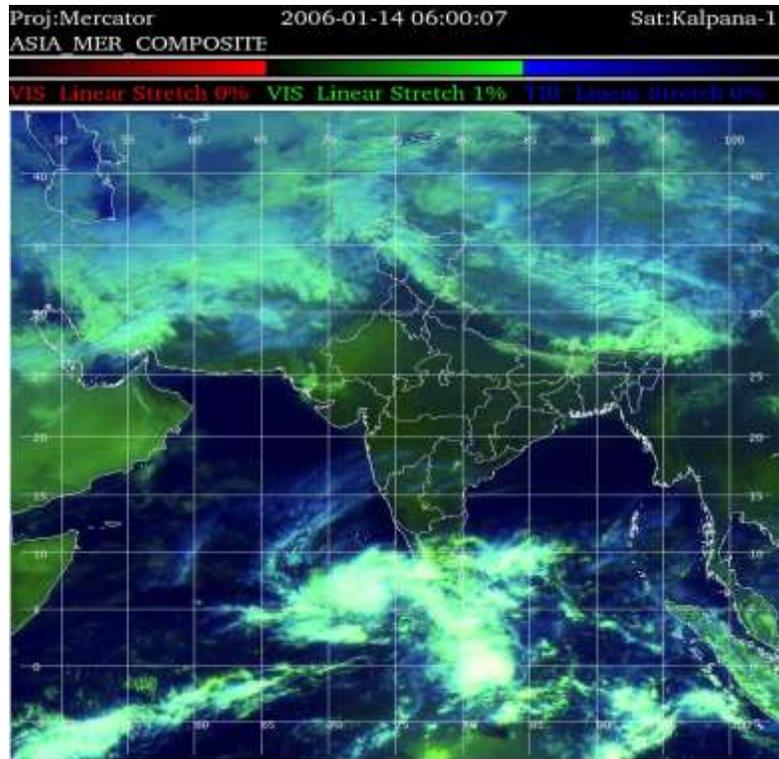


Fig. 2.1.2(a) Satellite KALPANA-1 imagery at 0900 UTC of Jan.13, 2006 showing the organisation of the vortex over southeast Arabian Sea.

(b)



(c)

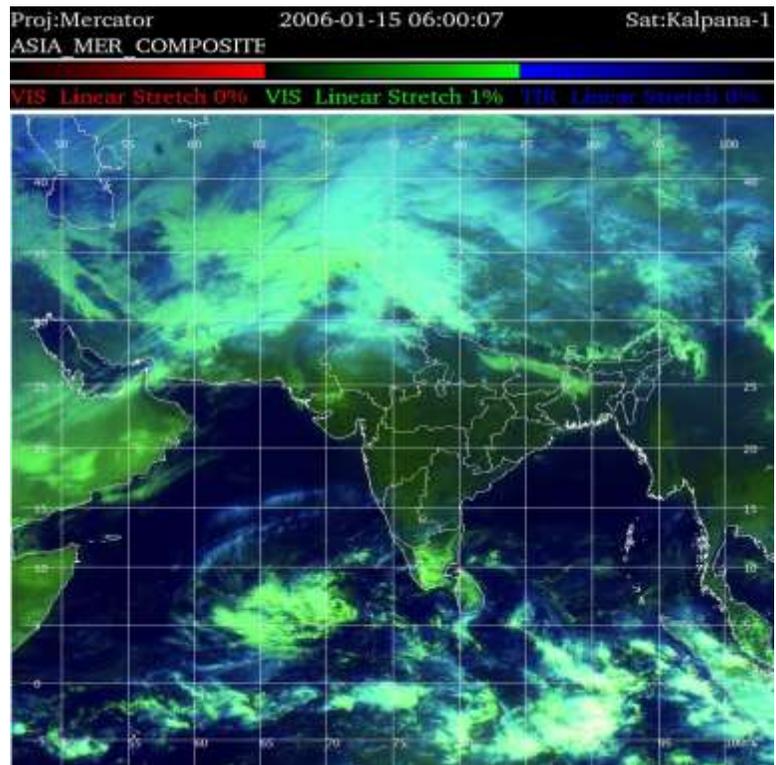


Fig. 2.1.2 (b) Satellite KALPANA-1 imagery at 0600 UTC of Jan. 14 shows dense cloud mass around the system centre, when the intensity was deep depression and (c) imagery at 0600 UTC of Jan. 15 shows the system shown as a low pressure area over southeast Arabian Sea.

2.2 Very severe cyclonic storm, “MALA” over the Bay of Bengal 25-29 April 2006

A low pressure area formed over southeast Bay of Bengal and neighborhood in the morning of 24 April, which intensified into a depression in the morning of 25th and lay centred near lat. 9.5⁰N/ long 90.5⁰E about 350 km southwest of Port Blair. Moving in a northwesterly direction, it intensified into a deep depression at 0900 UTC and lay centred near lat. 10.0⁰N/ long. 89.5⁰E. The system continued to move in a northwesterly direction and intensified into a cyclonic storm “MALA” in the evening of same day and lay centred at 1200 UTC near lat.10.5⁰N/long.89.0⁰E. The cyclonic storm continued to move in a northwesterly direction till 00 UTC of 26 April. Thereafter, the cyclonic storm changed its course and moved northeastward. It further intensified into a severe cyclonic storm in the morning of April 27 and lay centred at 0300 UTC near lat. 12.5⁰N/long. 90.0⁰E when CDO pattern was seen in satellite imageries. Moving in the same direction it further intensified into a very severe cyclonic storm and lay centred near lat. 13.0⁰N/long. 90.0⁰E at 1200 UTC of April 27. At 0900 UTC ‘eye’ was seen in the satellite imageries for some time. Continuing to move in a northeasterly direction the system crossed Arakan coast as a very severe cyclonic storm about 100 km south of Sandoway (48080), Myanmar around noon of 29 April. After landfall, the system weakened gradually and it was seen as a low pressure area in the morning of 30 April.

The track of the system is given in Fig. 2.1. The best track and other parameters are given in Table 2.2.1. Wind shear on 25 April 2006 over RSMC region is given in Fig. 2.2.1. A few KALPANA-1 cloud imageries of the system are shown in Fig. 2.2.2 (a-d).

WEATHER REALISED: Widespread to fairly widespread rainfall with isolated heavy falls occurred over Andaman & Nicobar Islands from 25 to 29 April. The significant amounts of rainfall (cm) are given below:

25 April, 2006	Nancowry 7
27 April, 2006	Car Nicobar 10
28 April, 2006	Hut Bay 6
29 April, 2006	Port Blair 6

DAMAGES: The system did not cause any loss to life and property over Andaman Islands of Indian territory.

Table 2.2.1
Best track positions and other parameters for Bay of Bengal Very Severe Cyclonic Storm,
'MALA' April 25-29, 2006

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
25-04-2006	0300	9.5/90.5	1.5	996	25	4	D
	0600	9.5/90.5	1.5	996	25	4	D
	0900	9.5/90.0	2.0	996	30	4	DD
	1200	10.0/89.5	2.5	996	35	5	CS
	1500	10.0/89.5	2.5	996	35	5	CS
	1800	10.0/89.5	2.5	996	35	5	CS
	2100	10.0/89.5	2.5	996	35	5	CS
	26-04-2006	0000	10.5/89.0	3.0	994	45	6
	0300	10.5/89.0	3.0	994	45	6	CS
	0600	11.0/89.0	3.0	994	45	6	CS
	0900	11.0/89.5	3.0	994	45	6	CS
	1200	11.5/90.0	3.0	994	45	6	CS
	1500	12.0/90.5	3.0	994	45	6	CS
	1800	12.0/90.5	3.0	994	45	6	CS
	2100	12.0/90.5	3.0	994	45	6	CS
27-04-2006	0000	12.0/90.5	3.0	994	45	6	CS
	0300	12.5/90.5	3.5	990	55	8	SCS
	0600	12.5/90.5	3.5	990	55	10	SCS
	0900	12.5/90.5	3.5	990	55	10	SCS
	1200	13.0/90.5	4.0	984	65	14	VSCS
	1500	13.0/90.5	4.0	984	65	20	VSCS
	1800	13.0/90.5	4.0	984	65	22	VSCS
	2100	13.5/90.5	4.0	984	65	22	VSCS
28-04-2006	0000	14.0/91.0	4.0	984	65	22	VSCS
	0300	14.5/91.5	4.5	976	80	30	VSCS
	0600	15.0/92.0	5.0	964	90	40	VSCS
	0900	15.3/92.3	5.5	954	100	52	VSCS
	1200	15.5/92.5	5.5	954	100	52	VSCS
	1500	16.0/93.0	5.5	954	100	52	VSCS
	1800	16.0/93.0	5.5	954	100	52	VSCS
	2100	16.5/93.5	5.5	954	100	52	VSCS
29-04-2006	0000	16.5/93.5	5.5	954	100	52	VSCS
	0300	17.0/94.0	5.5	954	100	52	VSCS
	0600	17.5/94.5	5.0	966	90	40	VSCS
	The very severe cyclonic storm crossed Arakan coast about 100 kms south of Sandoway (48080) around 0700 UTC.						
	0900	18.0/95.0	-	-	-	-	SCS
	1200	18.5/95.5	-	-	-	-	SCS
	1500	18.5/95.5	-	-	-	-	SCS
	1800	19.0/96.0	-	-	-	-	CS

The system weakened into a well-marked low pressure area over Myanmar in the morning of 30 April 2006.

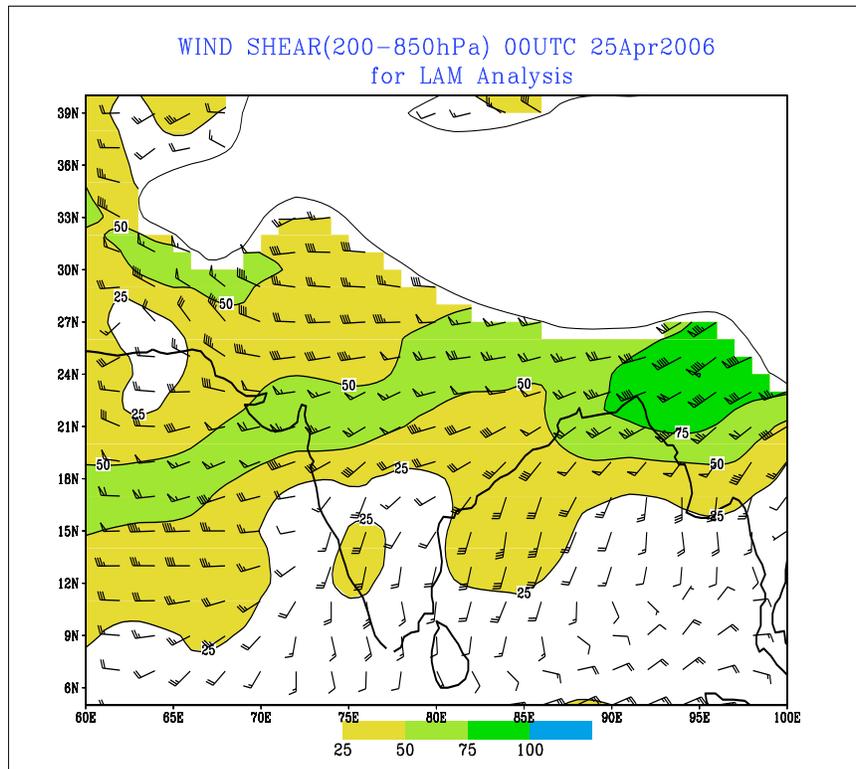


Fig. 2.2.1: Wind shear over RSMC, New Delhi region on 25 April 2006

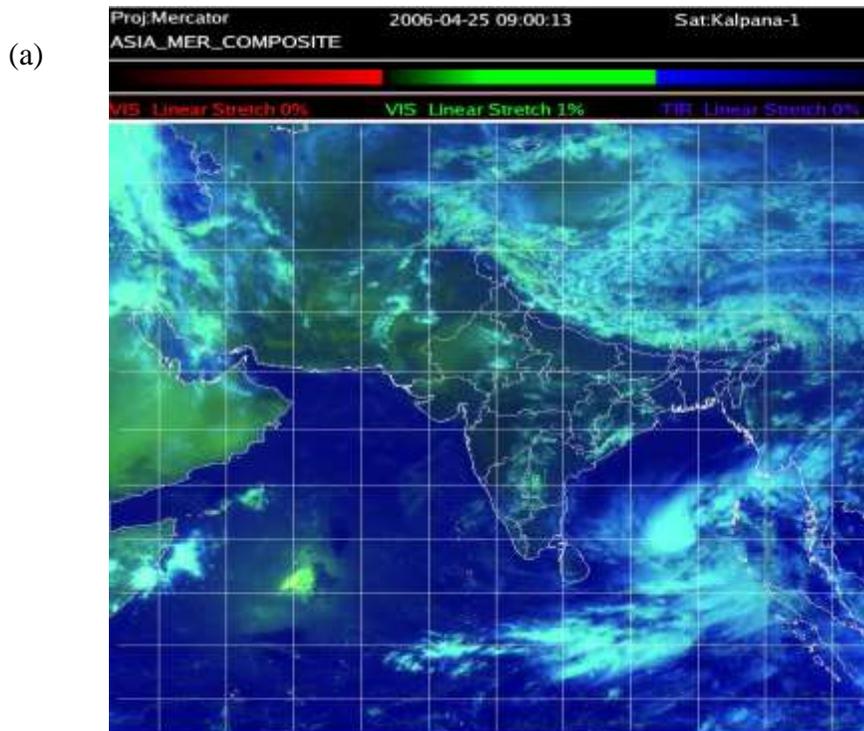
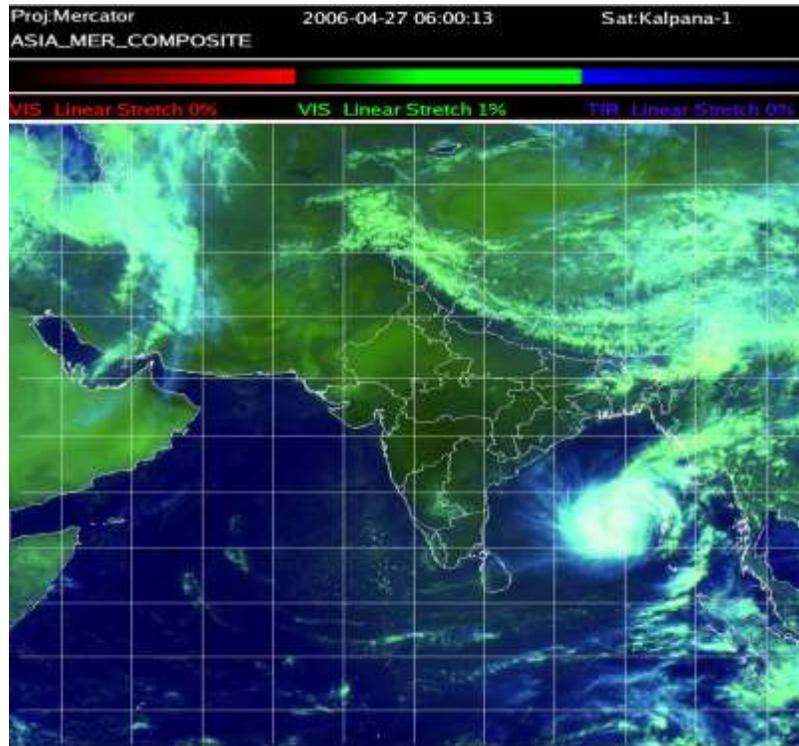


Fig. 2.2.1 (a) Satellite KALPANA-I imagery at 0900 UTC of 25 April 2006 shows organisation of a vortex.

(b)



(c)

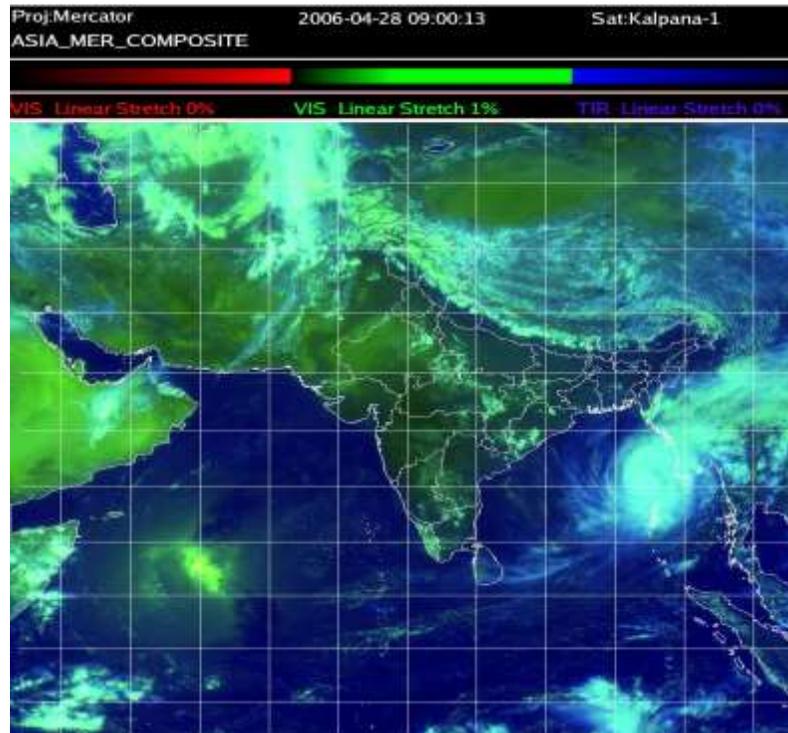


Fig. 2.2.1 (b) Satellite KALPANA-I imagery at 0600 UTC imagery of 27 April shows banding features of the cyclone (c) imagery of 0900 UTC of 28 April shows 'eye' of the system and cloudiness elongated towards northeast due to strong westerlies.

(d)

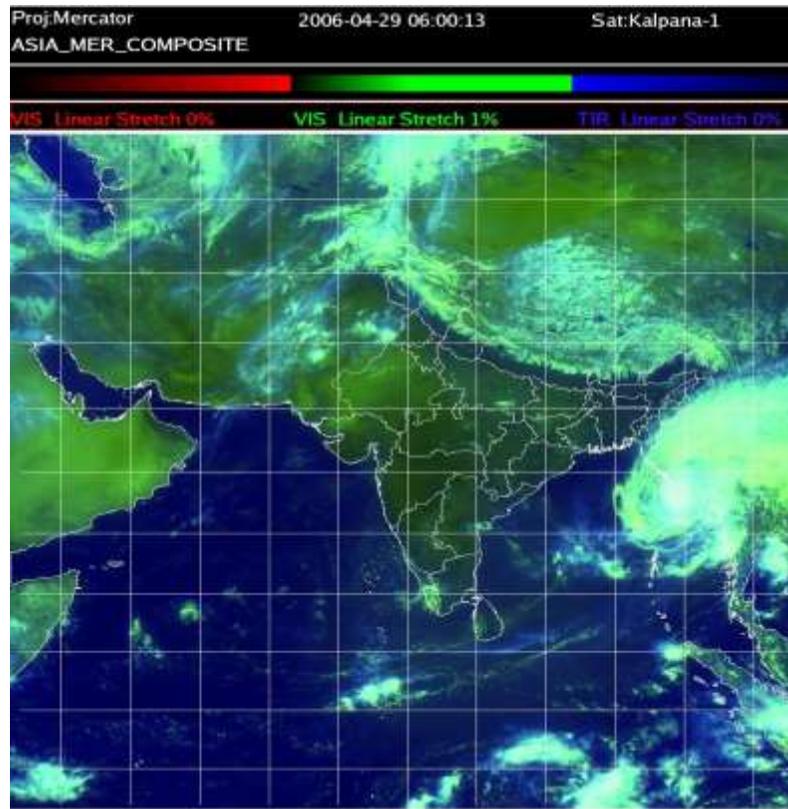


Fig. 2.2.1 (d) Satellite KALPANA-I imagery at 0600 UTC of 29 April shows the system crossing the Arakan coast and cloud mass ahead of the system in direction of the movement of the system i.e. northeastwards.

2.3 Deep depression over Bay of Bengal July 2- 5, 2006

A low pressure area formed over northwest Bay of Bengal, which became well-marked in the morning of July 01 over the same area. In the morning of July 02 it intensified into a depression and lay centred near Lat. 20.0°N /Long. 89.5°E at 0000 UTC. The depression further intensified rapidly into a deep depression and moving in a west-northwesterly direction it lay centred near Lat. 20.5°N /Long. 89.0°E at 0300 UTC of same day. Moving in a westerly direction it crossed the Orissa coast between Paradip (42976) and Chandbali (42973) around 1500 UTC of July 02 and lay centred near Lat. 20.0°N /Long. 86.0°E, close to Puri (43053). At this time the system was south of the upper air ridge. Moving in a westerly direction till 0300 UTC of July 03 it lay centred near Lat. 20.0°N/Long.85.5°E. The system took the northerly component and moved northwestward for some time and lay centred 1200 UTC near Lat. 21.0°N /Long. 84.0°E. The system continued to move westwards and weakened into a depression at 0900 UTC of July 04 and lay centred near Lat. 21.0°N /Long. 80.0°E close to Gondia (42871) in Vidarbha. It further weakened into a well-marked low pressure area over west Madhya Pradesh and adjoining southeast Rajasthan around afternoon of July 05. It became less marked on 6 July.

The track of the system is given in Fig. 2.1. The best track and other parameters are given in Table 2.3.1. Wind shear over the RSMC region is shown in Fig. 2.3.1. A few Kalpana-1 cloud imageries of the system are shown in Fig. 2.3.2(a-d). The Doppler Weather Radar (DWR) pictures of the system taken by DWR Machilipatnam are shown in Fig.2.3.3 (a-b).

REALISED WEATHER: Heavy to very heavy rainfall with extremely heavy at isolated places occurred over Orissa, Chhattisgarh and Madhya Pradesh during depression period. The significant amounts of rainfall (cm) are given below:

1 July, 2006: ORISSA: Nimapara-23, Kakatpur-19, Alipingal-9, Belgaon-7

2 July, 2006: ORISSA: Puri-27, Alipingal-15, Nimapara-15, Athagarh-12, Mohana-11, Chhatrapur-11, Bhubaneshwar-11, Paradip-9, Naraj-9, Gopalpur-9, Berhampur-8, Cuttack-7, Mahendargarh-7, Purusottampur-7, Banpur-7, Tangi-7, Bolangir-7.

3 July, 2006: ORISSA: Nawarangpur-38, Rayagada-30, Gunupur-27, R. Udaigiri-25, Jeypore-25, Banpur-25, Chhatrapur-23, Junagarh-23, Puri-23, Kotagarh-23, Cuttack-23, Gudari-22, Gopalpur-19, Purusottampur-19, Koraput-19, Tangi-19, Madhabarida-18, Krishnaparsad-18, Daringibadi-17, Mohana-16, Aska-16, Berhampur-16, Bhanjanagar-16, Kotraguda-16, Khariar-15, Kosagumda-14, Baliguda-14, Mahendargarh-12, Sorada-12, Athagarh-11, Kakatpur-11, Hindol-10, Pottangi-10, Naraj-9, Parlakhemundi-9, Komana-9, Nimapara-9, Pipili-9, Bhubaneshwar-9, Dhenkanal-8, Nayagarh-8, Alipingal-7, Udala-7, Titilagarh-7, **CHHATTISGARH:** Kanker-25, Keshkal-23, Nagari-20, Gariaband-19, Kondagaon-18, Devbhog-14, Patan-12, Jagdalpur-11, Antagarh-11, Baikunthpur-10, Dhamtari-10, Gurur-9, Narayanpur-8, Gunperdeh-7, Kurup-7

4 July, 2006 : ORISSA: Titilagarh-32, Junagarh-31, Kosagumda-31, Bhawanipatna-30, Tikabali-29, Nawarangpur-25, Lanjigarh-17, Kantamal-15,

Jeypore-11, Bolangir-11, Daringibadi-11, Phulbani-11, Kotraguda-10, Khairamal-9, Sonapur-9, Gudari-9, Rayagada-8, Binika-7 **CHHATTISGARH:** Antagarh-24, Manpur-23, Pakhanjur-22, Kanker-21, Bhanupratappur-21, Gariaband-19, Nagari-17, Churiya-17, Narharpur-17, Jagadalpur-15, Ambagarh-15, Mohala-14, Charama-13, Bijapur-12, Dhamtari-11, Gurur-9, Bopalpatna-8,

5 July, 2006 : GUJARAT REGION: Ahwa-39, Mahuva-37, Chikhli-36, Fatepur-31, Bansda-29, Jahajpur-29, Dharampur-27, Kamrej-27, Daman-26, Gandevi-25, Bardoli-23, Vyara-23, Palsana-22, Navsari-21, Pardi-19, Valod-18, Valsad-16, Songadh-16, Mandvi-15, Nanipalsan-14, Surat-14, Rajpipla-12, Sagbara-12, Kheda-11, Bodeli-11, Vagra-11, Mangrol-11, Balasinor-10, Nanad-9, Kapadvanj-9, Matar-9, Padra-9, Madhuban-9, Silvasa-9, Borsad-8, Tarapur-8, Tilakwada-8, Vapi-8, Vallabhavidyanagar-7, Dahegam-7, Umargaon-7, **SAURASHTRA, KUTCH & DIU:** Khambha-9, Kodinar-9, Lathi-8, Vallabhipur-8, Lilia-7.

6 JULY 2006 : GUJARAT REGION: Valsad-30, Vyara-25, Songadh-23, Umargaon-21, Gandevi-21, Detroj-19, Jalalpur-18, Navsari-17, Silvasa-17, Kamrej-17, Mahuva-17, Harij-16, Padra-16, Sankheda-16, Nandod-16, Chikhli-16, Anklav-15, Becharaji-15, Jambugoda-15, Dediapada-15, Vapi-15, Ahwa-15, Madhuban-15, Palsana-15, Valod-15, Patan-14, Sagbara-14, Dharampur-14, Pardi-14, Bansda-14, Bardoli-13, Olpad-13, Kathalal-12, Radhanpur-12, Idar-12, Kadi-12, Karjan-12, Nanipalsan-12, Broach-12, Mandvi-12, Mangrol-12, Dholka-11, Dhanera-11, Palanpur-11, Kheda-11, Sami-11, Kheralu-11, Tilakwada-11, Daman-11, Surat-11, Limkheda-10, Anand-10, Matar-10, Bayad-10, Visnagar-10, Baroda-10, Sinor-10, Hansot-10, Vagra-10, Ukai-10, Sanand-9, Borsad-9, Vallabhvidyanagar-9, Deesa-9, Wav-9, Sidhpur-9, Dhansura-9, Jhagadia-9, Dantewada-8, Kapadvanj-8, Meghraj-8, Mehsana-8, Vijapur-8, Rajpipla-8, Amod-8. **SAURASHTRA, KUTCH & DIU:** Sihor-16, Vallabhipur-15, Chotila-14, Palitana-14, Jasdan-14, Dhari-13, Lathi-12, Bhavnagar-12, Gariyadhar-12, Amreli-11, Bagsra-11, Lilia-11, Wadhwan-11, Babra-10, Dhrangdhra-10, Muli-10, Sayla-10, Talaja-10, Lodhika-10, Gogha-9, Morvi-9, Rajkot-9, Botad-8, Umarala-8. **MADHYA MAHARASHTRA:** Mahabaleshwar-19, Igatpuri-13, Peint-13, Surgana-9, Trimbak-9, Velhe-8, Gaganbavda-7, Radhanagri-7.

DAMAGES: As per the media following damages were reported

Orissa:

Total persons died	:	36
Fishermen missing	:	17
Cattle died	:	13
People affected due to flood	:	1, 72,839
Villages affected due to flood	:	834
Districts affected due to flood	:	16
Crop area affected due to flood	:	42,678 hectares

Vidarbha

Total persons died	:	41
Cattle died	:	5

Table 2.2.3

**Best track positions and other parameters for Bay of Bengal Deep Depression
July 02-05, 2006**

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	
02-07-2006	0000	20.0/89.5	1.5	990	25	-	D	
	0300	20.5/89.0	2.0	988	30	5	DD	
	0600	20.5/89.0	2.0	988	30	5	DD	
	0900	20.5/88.5	2.0	988	30	5	DD	
	1200	20.5/88.0	2.0	988	30	5	DD	
	The system crossed the Orissa coast between Paradip and Chandbali around 1500 UTC.							
	1500	20.5/87.0	2.0	982	30	5	DD	
	1800	20.5/86.0	--	982	30	5	DD	
	2100	20.5/86.0	--	982	30	5	DD	
	03-07-2006	0000	20.5/85.5	--	982	30	5	DD
0300		20.5/85.5	--	982	30	5	DD	
0600		20.5/85.5	--	982	30	5	DD	
0900		21.0/84.5	--	982	30	5	DD	
1200		21.0/84.0	--	982	30	5	DD	
1500		21.0/83.5	--	982	30	5	DD	
1800		21.0/83.0	--	982	30	5	DD	
2100		21.0/82.5	--	982	30	5	DD	
04-07-2006	0000	21.0/82.0	--	982	30	5	DD	
	0300	21.5/81.5	--	984	30	5	DD	
	0600	21.5/81.0	--	986	30	5	DD	
	0900	21.5/80.0	--	988	25	-	D	
	1200	21.5/79.5	--	990	25	-	D	
	1500	21.5/79.0	--	990	25	-	D	
	1800	21.5/78.5	--	990	25	-	D	
	2100	21.5/78.0	--	990	25	-	D	
05-07-2006	0000	21.5/78.0	--	990	25	-	D	
	0300	22.0/77.5	--	990	25	-	D	
	0600	22.0/77.5	--	990	25	-		

The system weakened into a well-marked low pressure area over west Madhya Pradesh and adjoining southeast Rajasthan around 0900 UTC of 5 July 2006.

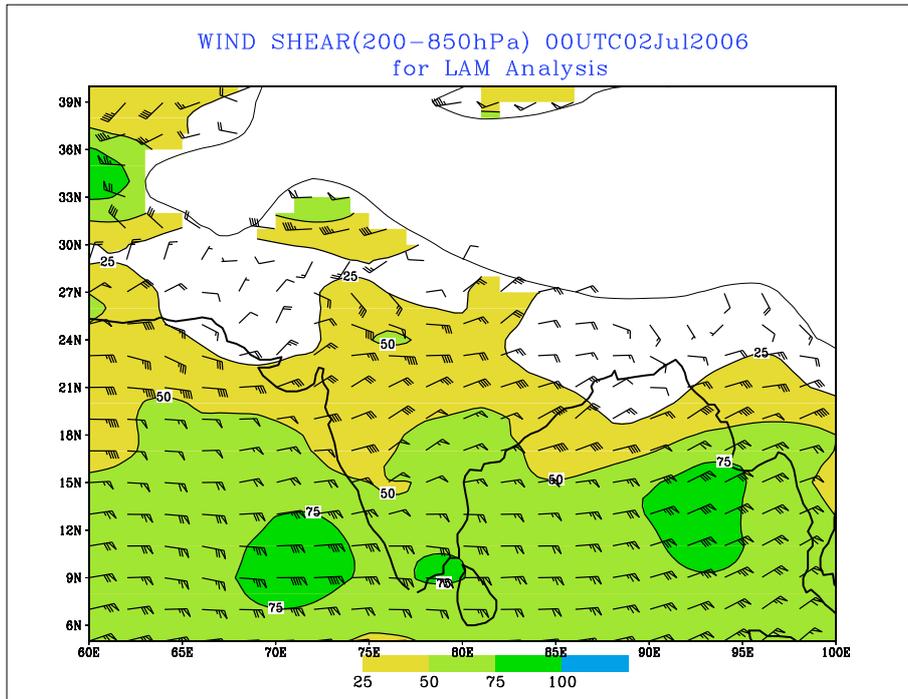


Fig 2.3.1: Wind shear on 2 July 2006 over RSMC, New Delhi region

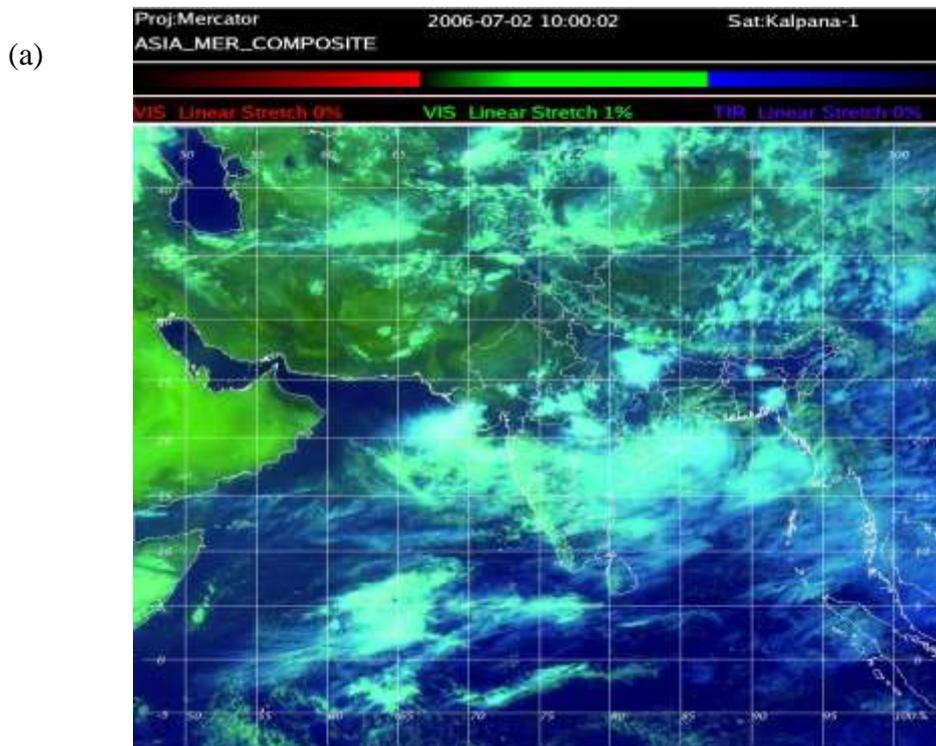
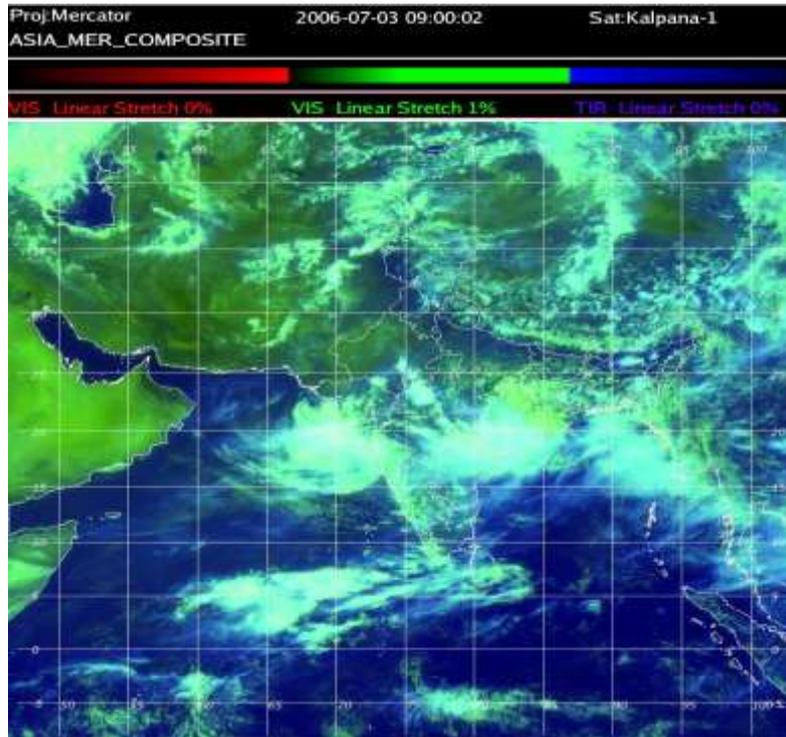


Fig 2.3.2 (a) Satellite KALPANA-I imagery at 1000 UTC of 2 July 2006 shows cloud over northwest Bay of Bengal in association with the depression.

(b)



(c)

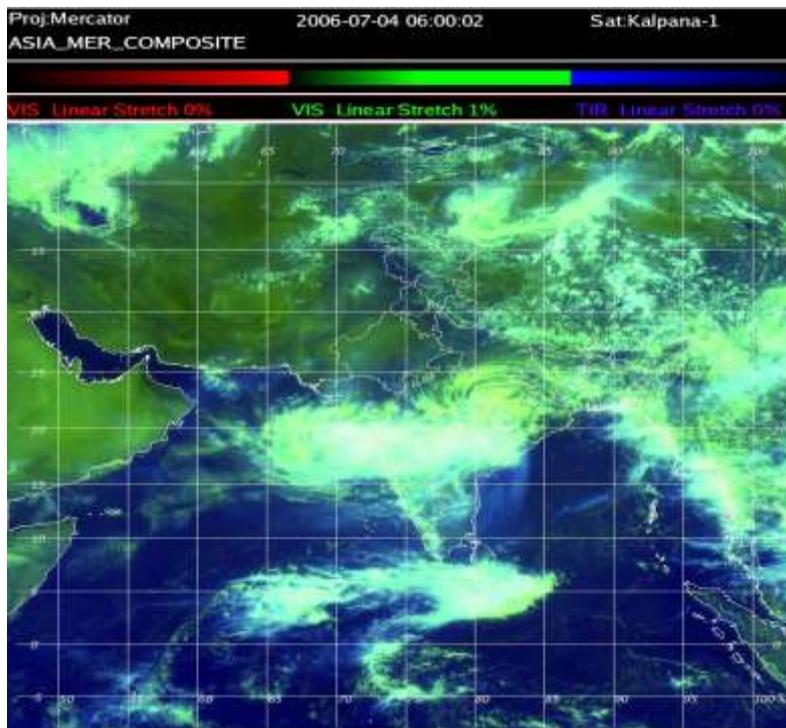


Fig 2.3.2 (b) Satellite KALPANA-I imagery at 0900 UTC of 3 July shows dense cloud mass over Orissa and over Gujarat coast with east west trough
(c) Imagery at 0600 UTC of July 4 shows dense cloud mass across central India to Gujarat-Maharashtra coast

(d)

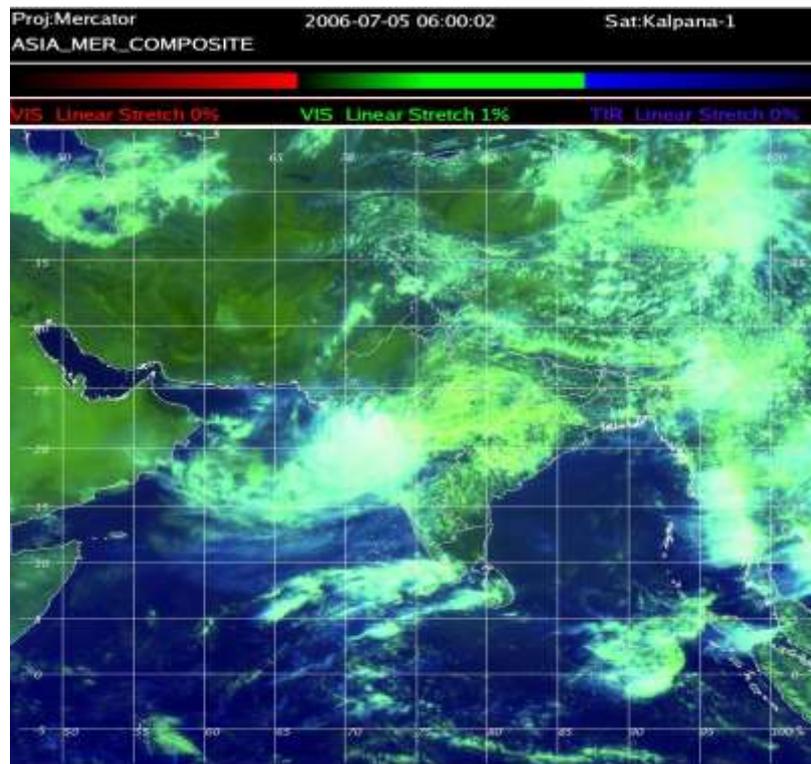


Fig 2.3.2 (d) Satellite KALPANA-I imagery at 0500 UTC of 5 July 2006 shows cloud mass associated with the system confined over south Rajasthan, Gujarat and adjoining sea areas of northeast Arabian sea.

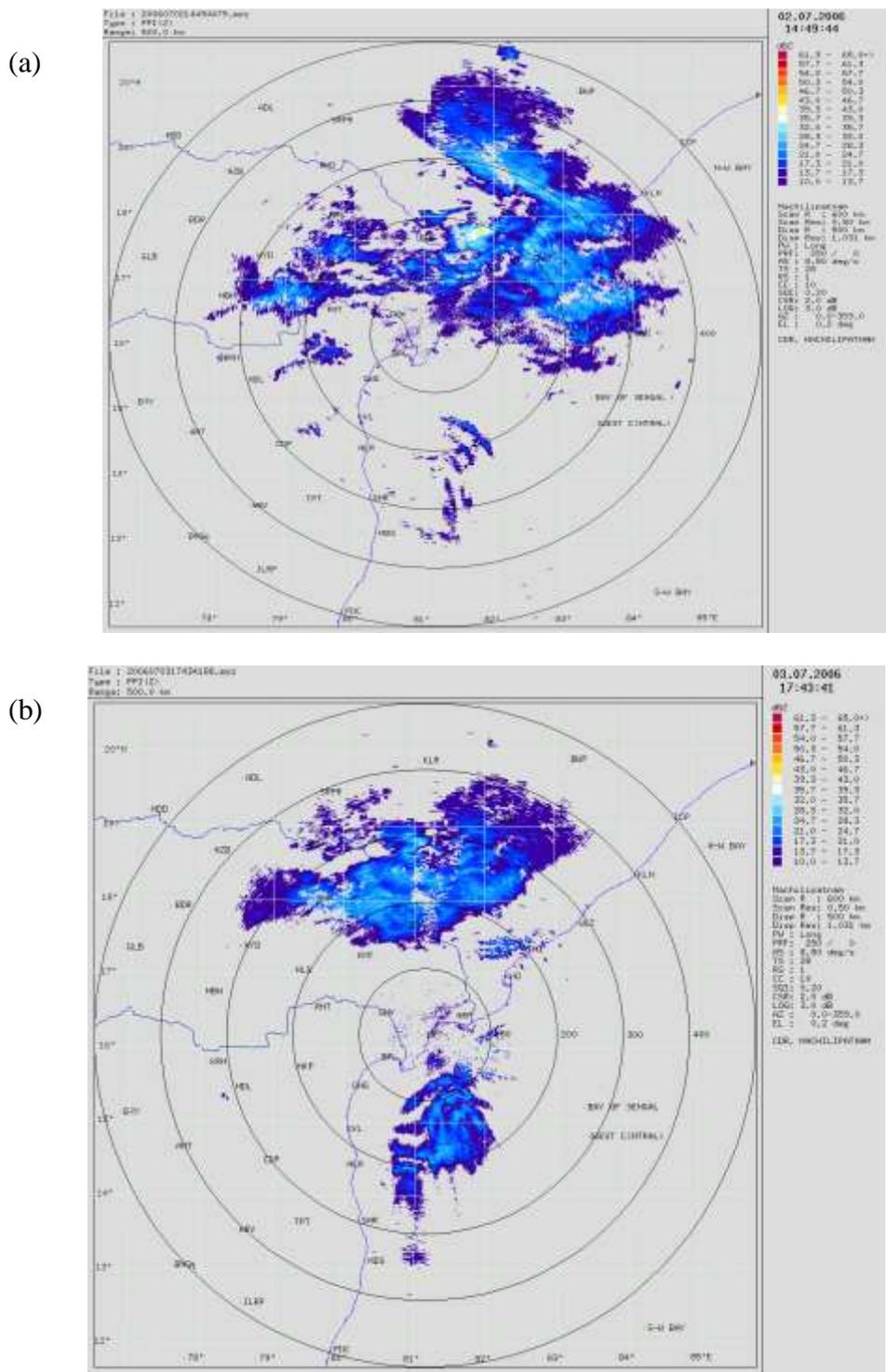


Fig 2.3.3 (a) Machilipatnam DWR at 14: 09:44 UTC observed reflectivity of the system mostly confined northeastern sector of the system and (b) at 17:43:45 UTC on 3 July 2006 reflectivity over Orissa.

2.4 Deep Depression August 02-05, 2006

A low pressure area formed over northwest Bay of Bengal off West Bengal and Orissa coasts in the evening of August 01. It intensified into a depression at 0300 UTC on August 02 and lay centred near Lat. 20.5°N/ Long. 87.5°E. The system initially moved in southwesterly direction and further intensified into a deep depression and lay centred near Lat. 20.0°N/ Long. 87.0°E at 0900 UTC of same day. Moving almost in the same direction it crossed south Orissa coast between Puri (43053) and Gopalpur (43049) in the morning of August 03. The system took westerly component and move in a westerly direction and continued moving westward upto 0000 UTC of August 03 and lay centred near Lat. 19.5°N/ Long. 85.0°E. At this time system came under the influence of upper air southeasterly, which yielded its northwestwards movement. While moving northwestwards it weakened into a depression at 0900 UTC and lay centred near Lat. 20.5°N/ Long. 82.0°E. From 1200 UTC of August 04 system moved westwards and then in a west-northwesterly direction and weakened into a low pressure area over Vidarbha (Maharashtra) and neighbourhood in the evening of August 05.

The track of the system is given in Fig. 2.1. The best track and other parameters are given in Table 2.4.1. Wind shear over RSMC, New Delhi region is shown in Fig 2.4.1. A few Kalpana-1 cloud imageries of the system are shown in Fig. 2.4.2(a-c) and The Doppler Weather Radar pictures of the system taken by DWR Visakhapatnam and Machilipatnam are shown in Fig.2.4.3 (a-b).

REALISED WEATHER: Heavy to very heavy rainfall occurred over south Orissa, north Andhra Pradesh, south Chhattisgarh and Vidarbha during the life span of the system. The significant amounts of rainfall are given below:

1 August, 2006: ORISSA: Akhuapada-14, Keonjhar-12, Swampatna-11, Anandpur-10, Pattamundai-9, Thakurmunda-9, Jajpur-8, Kendrapada-8, R Udaigiri-8, Paradip-7.

2 August, 2006: ORISSA: Baliguda-25, Kotagarh-16, Hindol-15, Madanpur Rampur-15, Pattamundai-13, Daringibadi-13, Kantamal-11, Tikabali-11, Kakatpur-10, Bissam Cuttack-10, Kotraguda-10, Athagarh-9, Bhawanipatna-9, Kendrapada-9, Puri-9, Lanjigarh-9, Jeypore-9, Koraput-9, Paradeep-8, Dhenkanal-8, Khairamal-8, Chandbali-8, Mundali-8, Sonapur-8, Gudari-8, Alipingal-7, Jenapur-7, Kamakhya Nagar-7, Naraj-7, Rajkanika-7, Kamakhya Nagar-7, Khairamal-7, R. Udaigiri-7, Nimapara-7, Phulbani-7.

3 August, 2006: ORISSA: Jeypore-23, Koraput-23, Komna-20, Pottangi-20, R. Udaigiri-16, Nawarangpur-15, Malkangiri-14, Gunpur-13, Kashinagar-12, Umerkote-12, Jaipatna-11, Kosagumda-9, Rayagada-9, Paikmal-8, Mahendragarh-7, Mohana-7, Chhatrapur-7, Baliguda-7, Kotagarh-7, Gudari-7, Kotraguda-7, **CHHATTISGARH:** Bhanupratappur-20, Gariaband-10, Narayanpur-9, Dantewada-9, Jagdalpur-8, Kondagaon-8, Sukma-7, **COASTAL ANDHRA PRADESH:** Ranasthalam-20, Kalingapatnam-19, Palakonda-15, Parvathipuram-13, Veeraghattam-

11, Tekkali-10, Bobbili-10, Komarada-10, Visakhapatnam-9, Salur-9, Terlam-9, Visakhapatnam (AP)-8, Palasa-7, Patapatnam-7.

4 August, 2006: ORISSA: Pottangi-32, Jeypore-22, Koraput-21, R. Udaigiri-12, Tikabali-11, Gunpur-9, Nawarangpur-7, **NORTH COASTAL ANDHRA PRADESH:** Ranasthalam-26, Cheepurupali-25, Veeraghattam-22, Visakhapatnam (AP)-21, Polavaram-21, Koyyalagudem-20, Parvthipuram-19, Vizianagaram-19, Bobbili-18, Anakapalli-17, Palakonda-16, Tuni-15, Chintapalli-15, Komarada-15, Prathipadu-15, Rajahmundry-15, Tiruvuru-15, Visakhapatnam-14, Chodavaram-14, Elamanchili-14, Paderu-14, Kakinada-12, Kalingapatnam-12, Bheemunipatnam-12, Dowlaiswaram-12, Chintalapudi-11, Gajapathinagaram-11, Peddapuram-11, Salur-10, Srungavbarapukota-10, Tekkali-8, Amalapuram-7, Nuzvid-7, Patapatnam-7.

5 August, 2006: MARATHAWADA: Hingoli-20, Basmat-18, Kallamunuri-17, Parbhani-16, Udgir-13, Latur-11, Ahmedpur-11, Chakur-10, Nelanga-7, Renapur-7, **VIDARBHA:** Chandrapur-10, Deoli-9, Manora-9, Washim-8, Karanja (Akola)-8, Akola-7, Mangrulpir-7,

6 August, 2006: RAJASTHAN: Ahore-12, Revdor-11, Mount Abu-9, Pindwara-9, Jaisalmer-13, Jalore-8, Jaswantpura-7, Siwana-7, Sirohi-6, Sajangarh-6, **GUJARAT REGION:** Satlasana-9, Kadana-9, Jamsugoda-8, Santrampur-8, Danta-8, Nanipalsan-8, Palanpur-7, Vadgam-7, Meghraj-7, Chhotaudepur-7, **VIDARBHA:** Washim-25, Akola -15, Yeotmal-12.

DAMAGES : As per the media following damages were reported

North Coastal Andhra Pradesh

Loss of life – 62
Loss of crops – 50,000 acres
Villages submerged – 900
Damage to houses (fully) – 2000
Damage to houses (partly) – 2000

Orissa

Loss of life – 45
No. of houses damaged – 1.05 lakhs
Damage to Crops – 6.68 lakhs hectares
No. of districts affected – 27 out of 30 districts

Vidarbha

Loss of life – 13

Madhya Pradesh

Loss of life – 55
Road and rail traffic affected.

Marathawada

Loss of life – 76

Table 2.4.1

Best track positions and other parameters for Bay of Bengal deep depression August 02-05, 2006

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
02-08-006	0300	20.5/87.5	1.5	990	25	-	D
	0600	20.5/87.5	1.5	990	25	-	D
	0900	20.0/87.0	2.0	988	30	5	DD
	1200	20.0/86.5	2.0	986	30	5	DD
	1500	20.0/86.5	2.0	986	30	5	DD
	1800	20.0/86.0	2.0	986	30	5	DD
	2100	20.0/85.5	2.0	986	30	5	DD
03-08-006	0000	Near Puri	2.0	986	30	5	DD
	The system crossed the south Orissa coast between Puri and Gopalpur around 0300 UTC						
	0300	19.5/85.0	--	986	30	5	DD
	0600	19.5/85.0	--	986	30	5	DD
	0900	19.5/84.5	--	986	30	5	DD
	1200	19.5/84.0	--	986	30	5	DD
	1500	19.5/84.0	--	986	30	5	DD
	1800	19.5/83.5	--	986	30	5	DD
	2100	19.5/83.0	--	986	30	5	DD
04-08-006	0000	19.5/83.0	--	986	30	5	DD
	0300	20.0/82.5	--	986	30	5	DD
	0600	20.0/82.5	--	986	30	5	DD
	0900	20.5/82.0	--	990	25	-	D
	1200	21.0/81.0	--	990	25	-	D
	1500	21.0/81.0	--	990	25	-	D
	1800	21.0/81.0	--	990	25	-	D
05-08-006	0000	21.0/80.5	--	990	25	-	D
	0300	21.0/80.0	--	990	25	-	D
	0600	21.0/79.5	--	990	25	-	D
	0900	21.0/79.5	--	990	25	-	D

The system weakened into a well-marked low pressure area over Vidarbha and adjoining southeast Madhya Pradesh at around 1200 UTC of 5 August 2006.

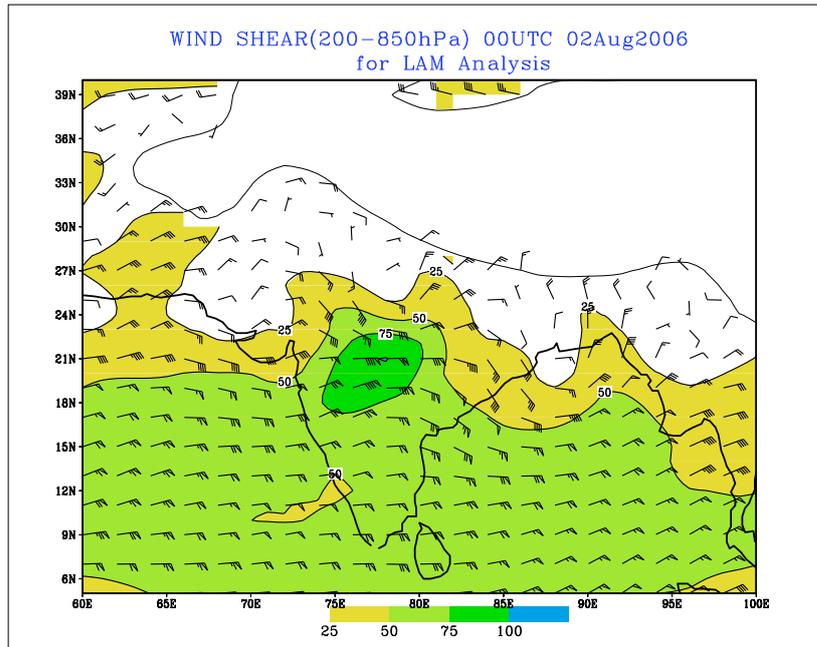


Fig. 2.4.1 Wind shear over RSMC, New Delhi region on 2 August 2006

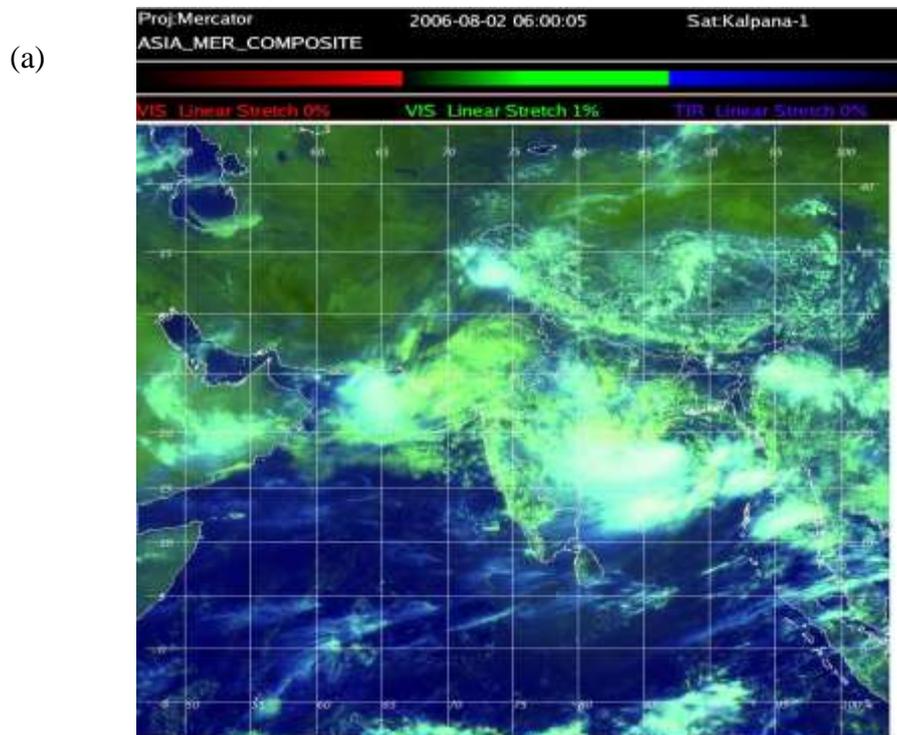
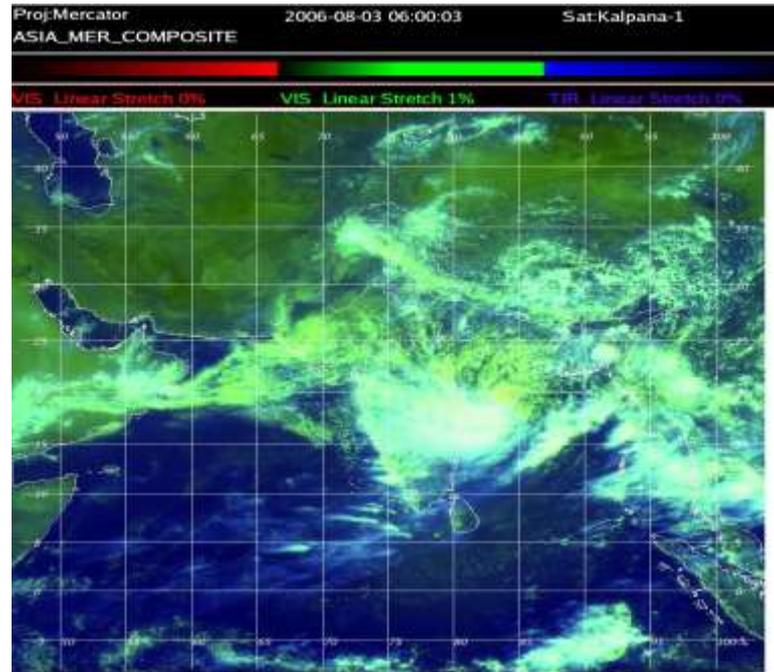


Fig. 2.4.3. (a) Satellite KALPANA –I imagery at 0600 UTC of 2 August 2006 shows dense cloud mass over westcentral Bay of Bengal in association with the depression.

(b)



(c)

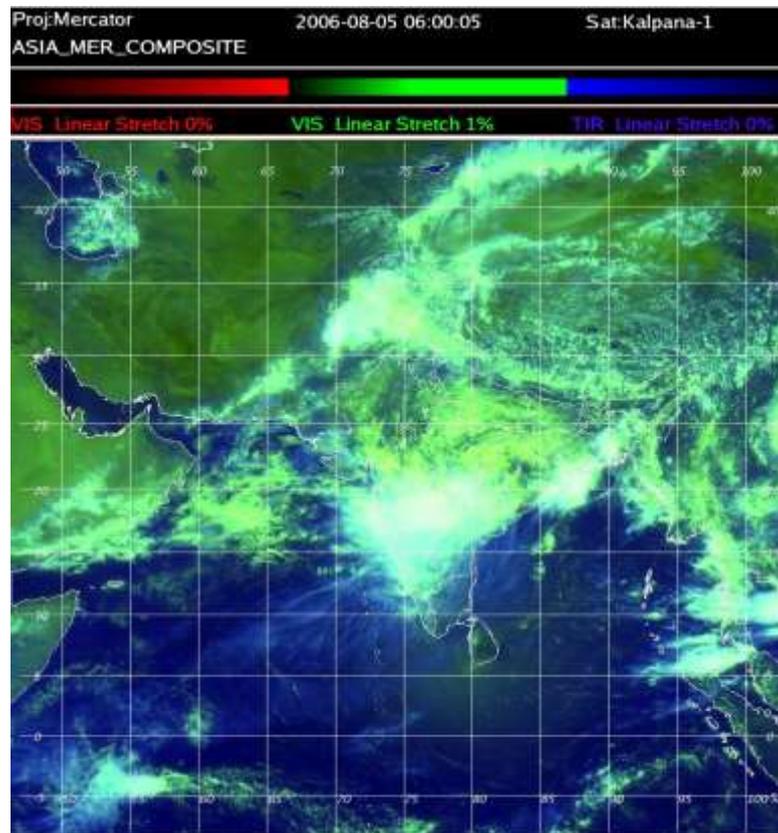


Fig. 2.4.3. (b) Satellite KALPANA –I imagery at 0600 UTC of 3 August shows dense cloud mass over Maharashtra in association with deep depression (c) the dense cloud mass seen in Imagery at 0600 UTC of 5 August 2006.

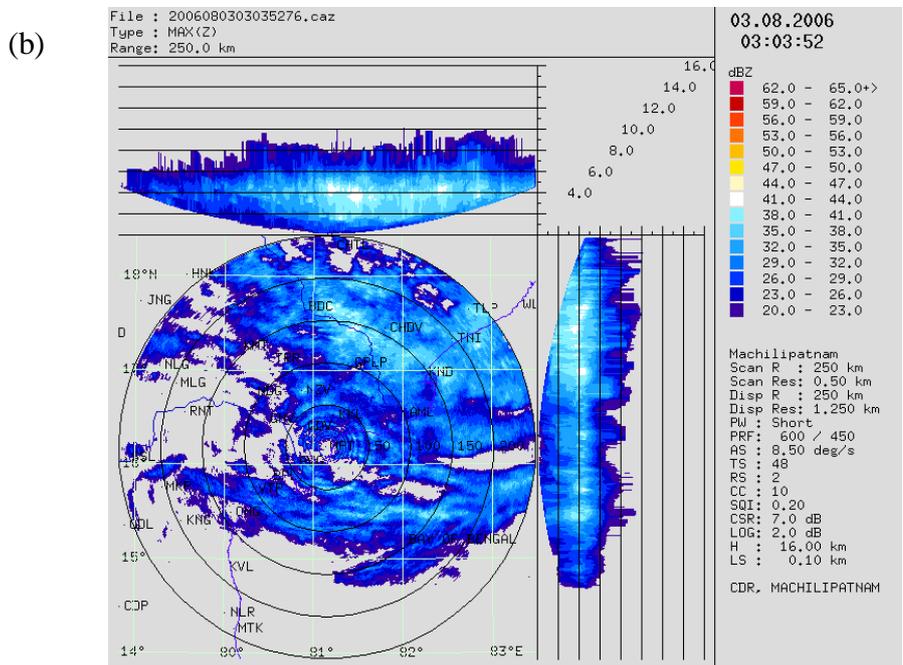
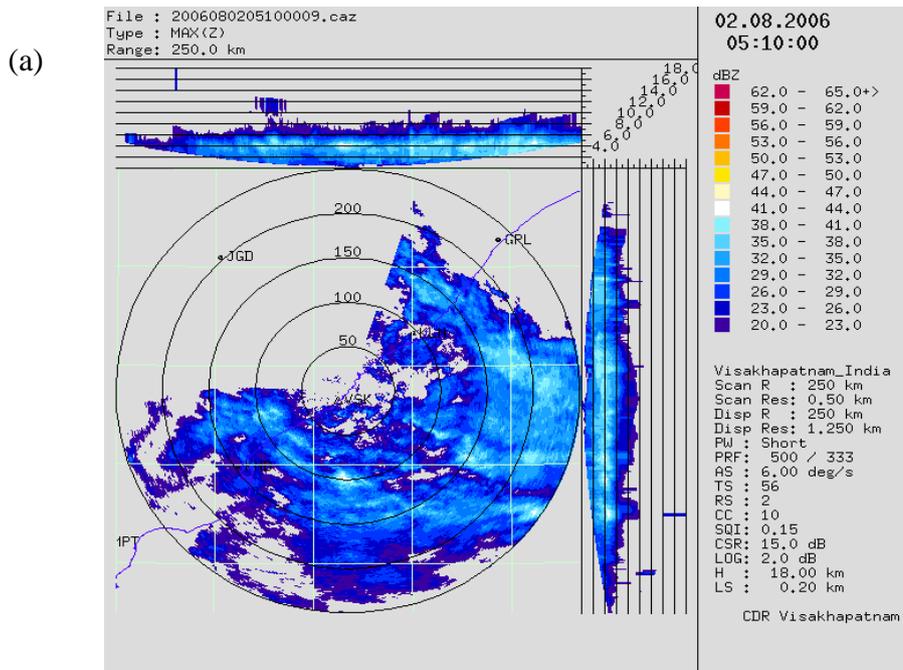


Fig. 2.4.3 (a) Visakhapatnam DWR observed reflectivity at 05:10:00 UTC of 2 August 2006 and (b) Machilipatnam DWR observed reflectivity at 03:03:52 UTC of 2 August 2006.

2.5 Depression over Bay of Bengal August 12-13, 2006

A low pressure area formed over northwest Bay of Bengal in the evening of August 11, 2006. It intensified into a depression over the same area in the morning of August 12 and lay centred at 0300 UTC near Lat. 21.0° N/ Long. 88.0° E. Moving initially in a westerly and west-northwesterly direction, it crossed Orissa coast close to Balasore (42895) around noon of August 12. Depression continued to move in a west-northwesterly direction and lay centred near Lat. 21.0°N/ Long. 87.5°E at 1200 UTC on same day. System afterwards moved in a westerly direction and lay centred at 0000 UTC on August 13 near lat. 22.0°N/long. 82.5°E. Moving in the same direction system weakened into a well-marked low pressure area in the morning of August 13 over Chhattisgarh & neighborhood.

The track of the system is given in Fig. 2.1. The best track and other parameters are given in Table 2.5.1. Fig.2.5.1 wind shear of 12 August 2006 for RSMC New Delhi region. A few Kalpana-1 cloud imageries of the system are shown in Fig. 2.5.2 (a-b). The Doppler Weather Radar (DWR) pictures of the system taken by DWR Machilipatnam are shown in Fig. 2.5.3 (a-b).

REALISED WEATHER: Heavy to very heavy rainfall occurred over Orissa, Chhattisgarh and west Madhya Pradesh during 12-14 August. Light rainfall with isolated heavy falls also occurred over west Madhya Pradesh and south Rajasthan during 15-18 August, 2006. The significant amounts of rainfall are given below:

11 August 2006: ORISSA: Panposh-9, Ghatagaon-7, Hemgiri-6.

12 August 2006: ORISSA: Nimapara-25, Gope-23, Puri-21, Kakatpur-17, Bijepur-16, Bargarh-14, Krishnaprasad-14, Paradeep-12, Rairakhol-12, Athagarh-11, Cuttack-11, Bhubaneswar-10, Pipili-9, Mundali-8, Naraj-8, Alipingal-7, Jenapur-7, Rengali-7, Ambabhona-7, Sohela-7, Thakurmunda-7, Barmul-7,

13 August 2006: ORISSA: Bijepur-32, Khairamal-19, Bargarh-19, Boudhgarh-19, Ambabhona-17, Dunguripalli-15, Kantamal-12, Phulbani-12, Angul-11, Sohela-11, Baliguda-11, Sambalpur-9, Nimapara-9, Pipili-9, Padampur-8, Naktideul-7, Chhendipada-7, Bhubaneswar-7, Bolangir-7, **CHHATTISGARH:** Durg-26, Mana-17, Raipur-16, Raigarh-5,

14 August 2006: ORISSA: Mundali-11, Cuttack-7, Naraj-7, Akhuapada-6, **MADHYA PRADESH:** Hosangabad-38, Amarwara-34, Budhni-33, Pachmari-23, Sehore-23, Lanjhi-23, Bhopal-29, Raisen-21, Waraseoni-18, Seoni-18, Katangi-16, Narsullaganj-14, Sironj-13, Bareli-12, Udaipura-12, Vidisha-11, Harda-8, Ashta-7, Sujalpur-7, Keolari-14, Balaghat-12, Narsingpur-12, Chhindwara-10, Tendukheda-7. **CHHATTISGARH:** Dongargaon-13, Ambagarh Chowki-11, Dongargarh-10, Rajnandgaon-7, Mungeli-6.

DAMAGES: As per the media following damages were reported

Orissa

Loss of lives - 13
 Crops damage - 1.25 lakh hectare
 Total people affected -11 Lakh
 Total districts affected - 11

Madhya Pradesh

Total death - 59
 Road, Rail & Air traffic disrupted, houses damaged, about 7 lakh people were evacuated.

Chhattisgarh

Loss of lives - 6

**Table 2.2.5
 Best track positions and other parameters for Bay of Bengal Depression
 August 12-13, 2006**

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
12-08-2006	0300	21.0/88.0	1.5	992	25	-	D
	0600	21.0/88.0	1.5	992	25	-	D
	0900	21.0/87.5	1.5	992	25	-	D
	1200	21.0/87.5	1.5	992	25	-	D
	The system crossed the Orissa coast near Balasore around 1500 UTC.						
	1500	22.0/86.5	--	992	25	-	D
	1800	22.0/85.0	--	992	25	-	D
	2100	22.0/83.5	--	992	25	-	D
13-08-2006	0000	22.0/82.5	--	992	25	-	D

The system weakened into a low pressure area over Chhattisgarh and neighbourhood around 0300 UTC of 13 August 2006.

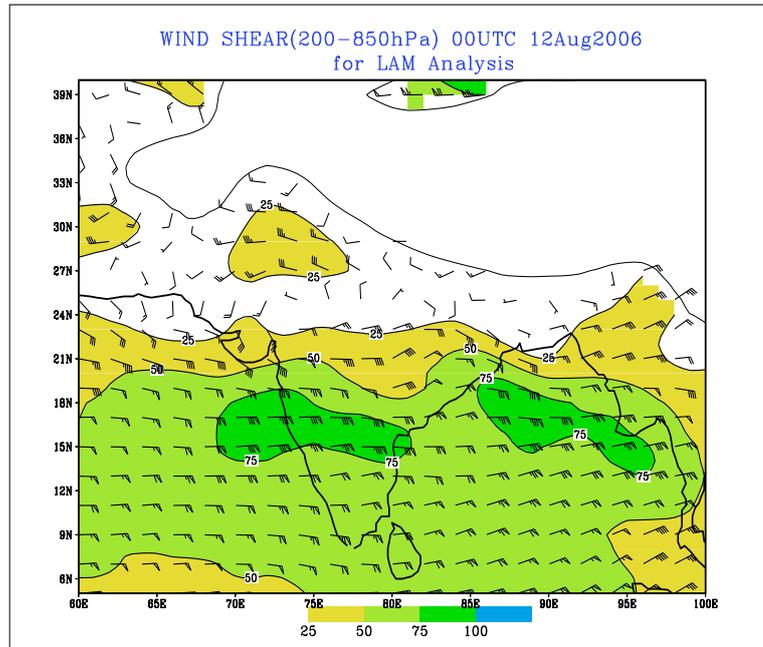


Fig. 2.5.1 Wind shear over RSMC, New Delhi region on 2 August 2006

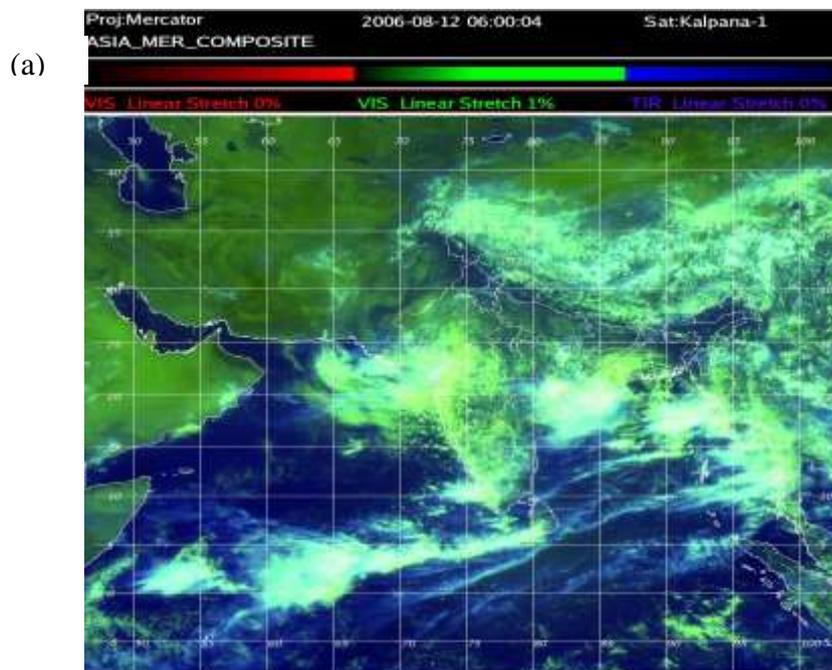


Fig. 2.5.1 (a) Satellite KALPANA-I imagery at 0600 UTC of August 12, 2006 shows dense convective cloud over Orissa in association with the depression

(b)

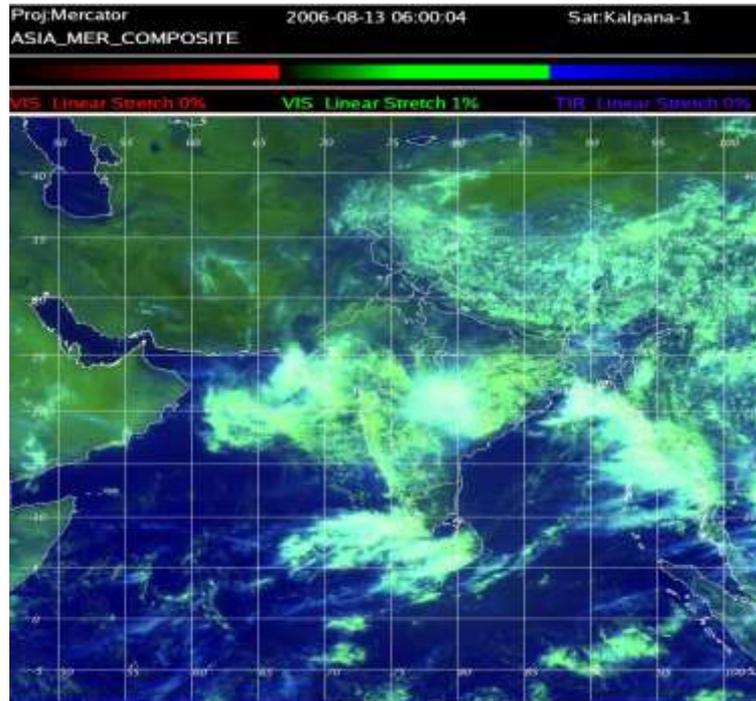


Fig. 2.5.1 (b) Satellite KALPANA-I imagery at 0600 UTC on 13 August imagery shows the system over east Madhya Pradesh and neighbourhood and started to weaken.

(a)

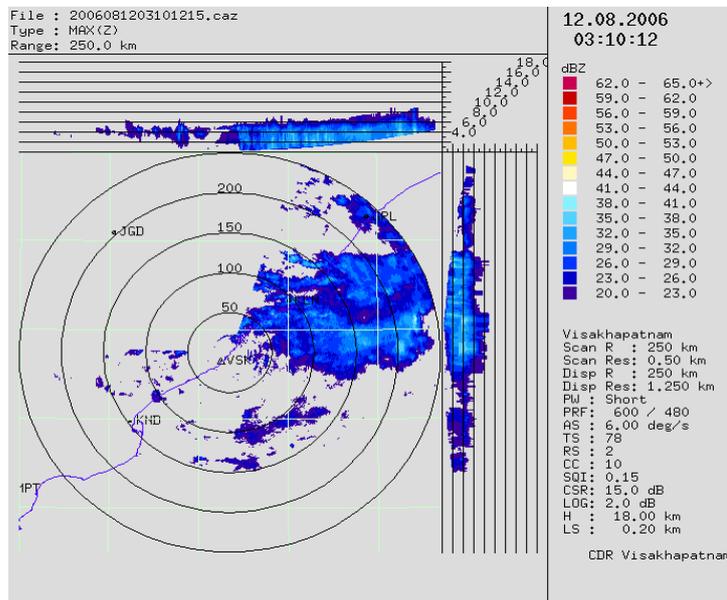


Fig. 2.5.3 (a) DWR Visakhapatnam shows good reflectivity over northwest Bay of Bengal at 03:10:12 UTC on 12 August 2006.

(b)

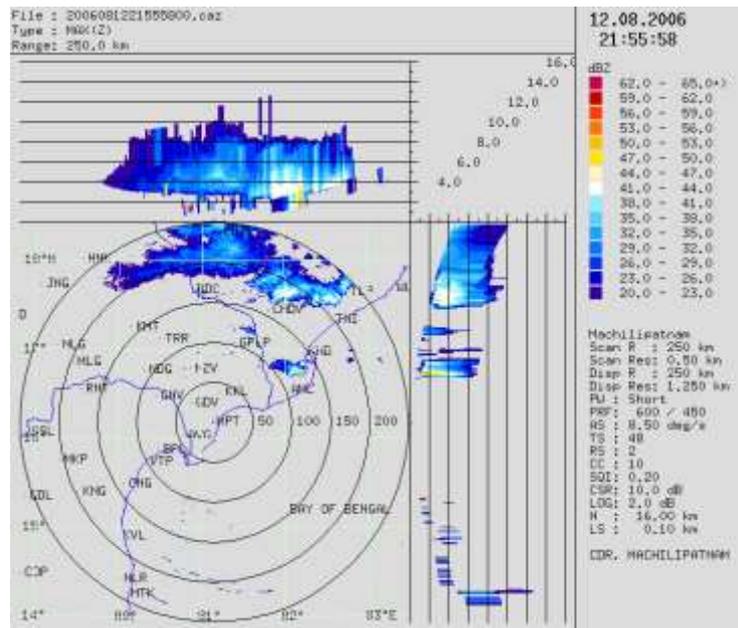


Fig. 2.5.3 (b) DWR Machilipatnam shows poor reflectivity over Chhattisgarh and neighbourhood areas at 21:55:58 UTC of 12th August, 2006.

2.6 Depression over Bay of Bengal August 16-18, 2006

A low pressure area formed over northwest Bay of Bengal in the evening of August 15, 2006. It concentrated into a depression in the morning of August 16, and lay centred near lat. 20.5° N/ long. 88.0° E. The system initially moved in a westerly direction and crossed Orissa coast close to Chandbali (42973) around 0900 UTC of August 16, 2006. The system took northerly course and continued to move northwestward along the monsoon trough and lay centred near lat. 22.0° N/ long. 83.5° E at 0300 UTC on April 17. Due to fast movement the system could not intensify further. The system remained south of upper level ridge, which supported its west-northwestward movement. Afterwards system took westerly component and moved in a west-northwesterly direction and lay centred near lat. 22.5° N/ long. 81.0° E at 1200 UTC on same day. Moving in the same direction it lay centred near lat. 23.0° N/ long. 78.0° E at 0300 UTC on April 18 and weakened into a well-marked low pressure area over northwest Madhya Pradesh and neighbourhood in the evening of August 18, 2006.

The track of the system is given in Fig. 2.1. The best track and other parameters are given in Table 2.6.1. Wind shear over the RSMC, New Delhi region is given in Fig 2.6.1. A few Kalpana-1 cloud imageries of the system are shown in Fig. 2.6.2(a-c). The Doppler Weather Radar (DWR) pictures of the system taken by DWR Machilipatnam are shown in Fig.2.6.3 (a-b).

REALISED WEATHER: Heavy to very heavy rainfall occurred over Gangetic west Bengal, Orissa, Chhattisgarh and Madhya Pradesh during the system period. Significant amounts of rainfall are given below:

15 AUGUST 2006: GANGETIC WEST BENGAL: Mohanpur-13, Midnapore-7, Digha-7, Gheropara-5, Bankura (CWC)-5, Purihansa-5, **ORISSA:** Baripada-14, NH-5-10, Jeypore-8, Jaleswar-7, Altuma-7, Balasore-6, Rajghat-6, Balimundali-6, Chandanpur-6.

16 AUGUST 2006: ORISSA: Nimapara-10, Keonjhar-9, Thakurmunda-9, Kakatpur-9, Athagarh-8, Ranpur-8, Ghatagaon-7, Purusottampur-7, Gop-7, Krishnaprasad-7, Dashpalla-7, Tikabali-7, **WEST MADHYA PRADESH:** Neemuch-8, Jawad-6.

17 AUGUST 2006: ORISSA: Athagarh-16, Jeypore-13, Umerkote-12, Bhawanipatna-9, Soro-8, NH-5-8, Dhenkanal-8, Jamsolaghat-8, Kotraguda-8, Bhogari-7, Jaleswar-7, Jajpur-7, Keonjhar-7, Pallahara-7, Tikarpada-7, Jaipatna-7, Khariar-7, Nawapara-7, Harabhanga-7, Bangiriposhi-7, Baripada-7, Khandapada-7, **JHARKHAND:** Jamshedpur-8, Ranchi-6.

18 AUGUST 2006: WEST MADHYA PRADESH: Hosangabad-18, Pachmarhi-12, Bhopal-11, Shahjapur-5, **MADHYA MAHARASHTRA:** Gaganbavda-10, Mahabaleshwar-8, Radhanagari-5.

19 AUGUST 2006: WEST MADHYA PRADESH: Ratlam-24, Mahidpur-21, Sailana-20, Agar-19, Shahjapur-19, Khachrod-18, Garoth-17, Mandsour-17, Ujjain-15, Depalpur-14, Jawad-14, Susner-14, Tarana-14, Jaora-13, Sujalpur-12, Badnagar-11, Ashta-10, Bhanpura-10, Budhni-10, Gautampur-10, Neewmach-10, Subasera-10, Hoshangabad-9, Indore-8, Kanno-8, Tonkmuro-8, Dewas-7, **EAST RAJASTHAN:** Banswara-23, Danpur-21, Arnod-19, Pratapgarh-16, Udaipur (Dabok)-14, Arthuna-

14, Pindwara-14, Dungla-13, Garhi-13, Ghatol-13, Kushangarh-12, Loharia-12, Mount abu-12, Sallumber-12, Vallabhnagar-12, Mavli-11, Rajsamand-10, Sarada-10, Amet-9, Begu-9, Barisadrai-9, Chhotisadri-9, Nathdwara-9, Shivganj-8, Rawat Bhata-7, Beawar-7, Dug-7, Jawaja-7, Kherwara-7.

DAMAGES: As per the media reports following damages were reported.

Orissa

Total death : 38
 Crop area affected : 1.60 lakh hectares
 Total people affected : 25 lakh
 Total districts affected : 27

Madhya Pradesh

Total death : 11
 Many villages were flooded, Traffic disrupted in Madhya Pradesh and Rajasthan.

Table 2.6.1
Best track positions and other parameters for Bay of Bengal Depression
August 16-18, 2006

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
16-08-2006	0300	20.5/88.0	1.5	990	25	-	D
	0600	20.5/87.5	1.5	990	25	-	D
	0900	20.5/87.5	1.5	990	25	-	D
	1200	20.5/87.0	1.5	990	25	-	D
	The system crossed the north Orissa coast near Chandbali around 1400 UTC						
	1500	20.5/86.5	--	988	25	-	D
	1800	20.5/86.0	--	988	25	-	D
	2100	21.0/85.0	--	988	25	-	D
17-08-2006	0000	21.5/84.5	--	988	25	-	D
	0300	22.0/83.5	--	988	25	-	D
	0600	22.0/83.5	--	988	25	-	D
	0900	22.5/83.0	--	988	25	-	D
	1200	22.5/81.0	--	988	25	-	D
	1500	22.5/81.0	--	988	25	-	D
	1800	22.5/80.5	--	988	25	-	D
	2100	22.5/80.0	--	988	25	-	D
18-08-2006	0000	22.5/79.0	--	990	25	-	D
	0300	23.0/78.0	--	992	25	-	D
	0600	23.0/77.5	--	994	25	-	D
	0900	23.5/77.0	--	994	25	-	D

The system weakened into a low pressure area over northwest Madhya Pradesh and adjoining east Rajasthan around 1200 UTC of 18 August 2006.

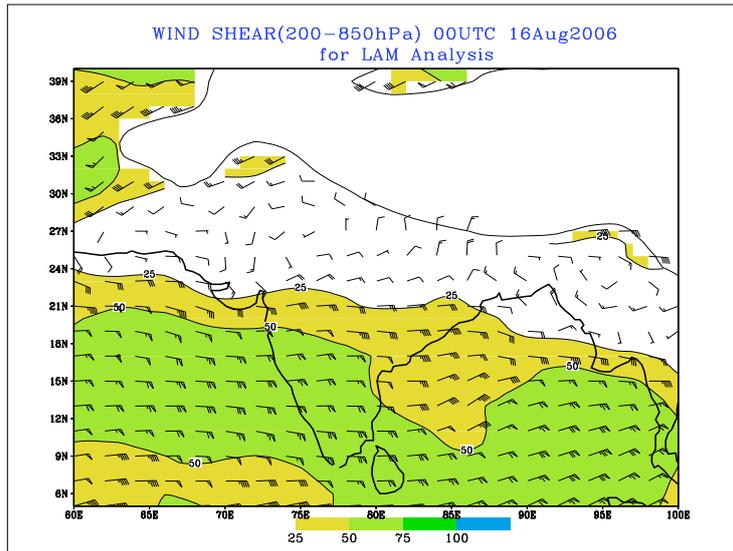


Fig 2.6.1: Wind shear over RSMC, New Delhi region on 16 August 2006.

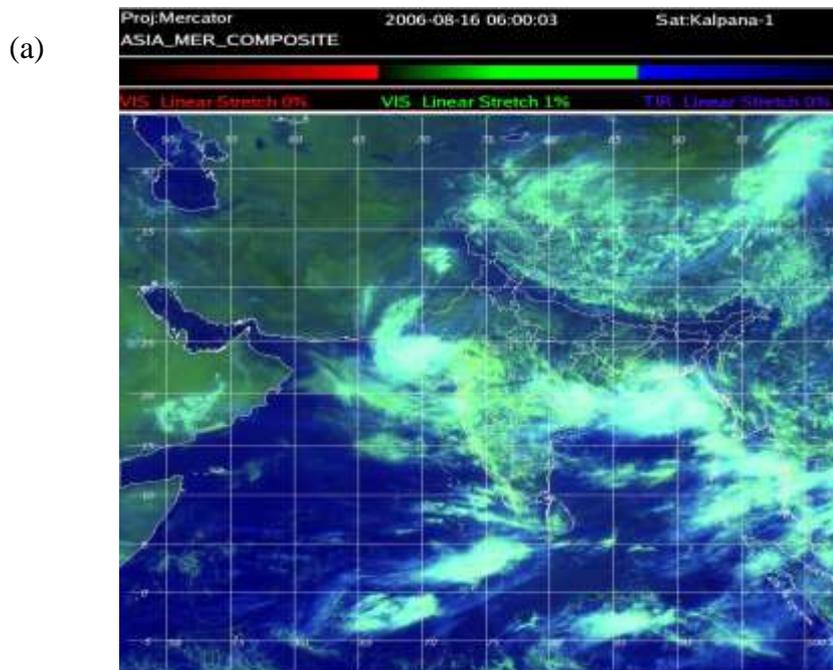


Fig 2.6.2 (a) Satellite KALPANA-I imagery at 0600 UTC on 16 August 2006 shows dense cloud mass over north Bay of Bengal in association with the system.

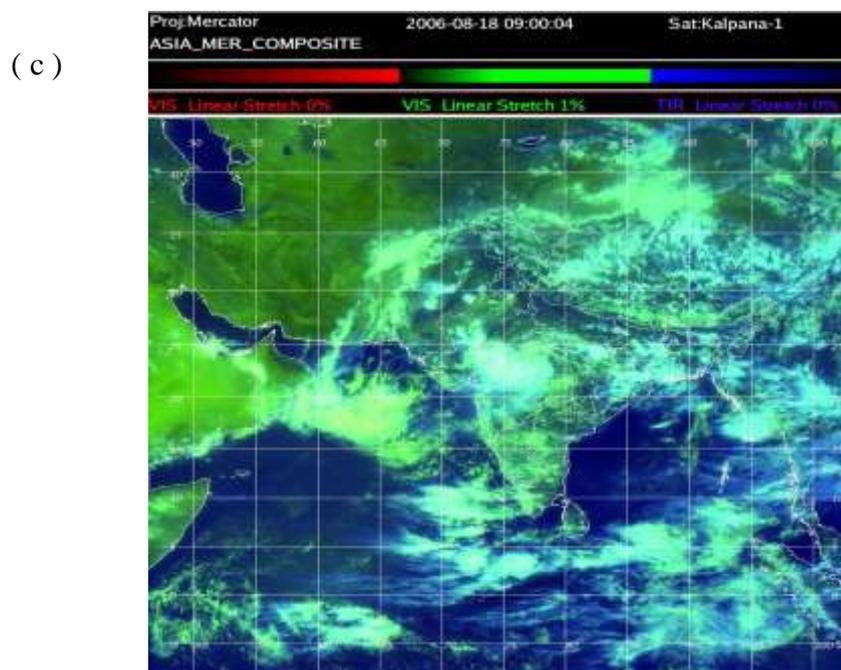
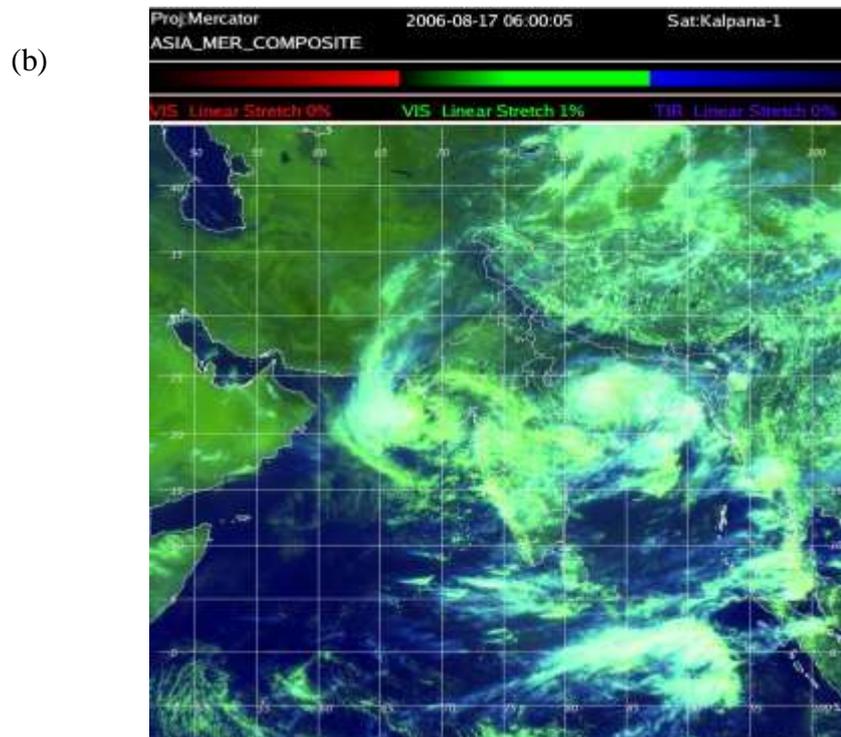
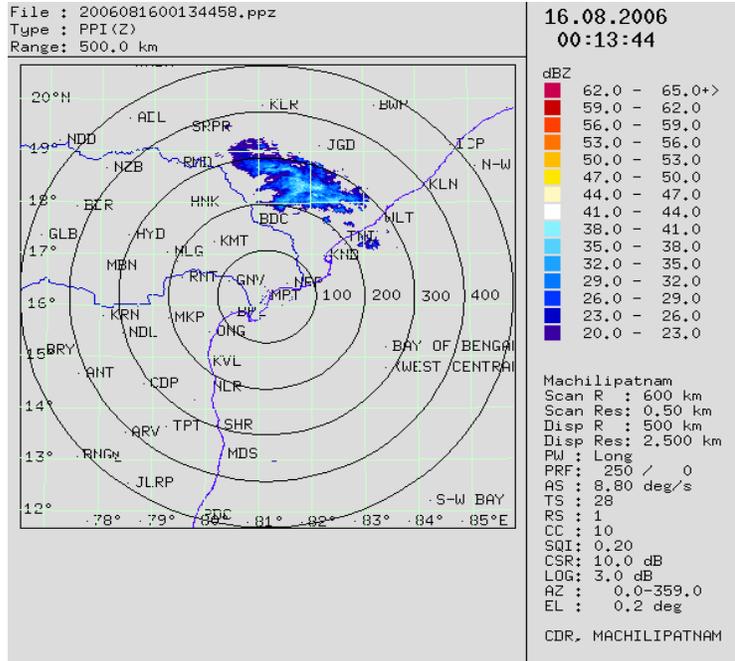


Fig 2.6.2 (b) Satellite KALPANA-I imagery shows well organized system seen over east Madhya Pradesh and neighbourhood at 0600 UTC on 17 August and (c) depression start weakening over east Rajasthan and adjoining west Madhya Pradesh at 0900 UTC on 18 August.

(a)



(b)

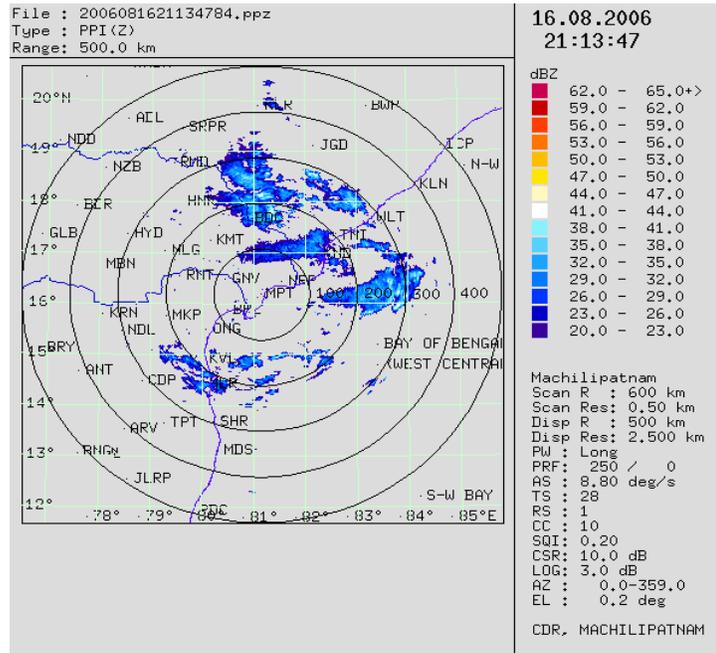


Fig 2.6.3 (a) DWR Machilipatnam observed reflectivity over Jharkhand and neighbourhood at 00:13:14 UTC on 16 August 2006 and (b) reflectivity at 21:13:47 UTC on same day shows scattered type of convection.

2.7 Depression over Bay of Bengal 29 August- 01 September 2006

During the month of August northwest Bay of Bengal witnessed the formation of four depressions. The fourth depression formed as a low pressure area over northwest Bay of Bengal on August 27, 2006. Persisting for about two days it concentrated into a depression and lay centred at 0300 UTC of August 29 near lat. 20.5° N/ long. 87.5° E close to Orissa coast. Initially it moved in a westerly direction and crossed Orissa coast near Paradip (42976) around noon of same day. Moving west-northwestwards, it lay centred at 1200 UTC of August 29 near lat. 21.0° N/ long. 84.5° E. It continued to move in same the direction and lay centred at 0300 UTC on August 30 near lat. 22.0° N/ long. 83.0° E. Thereafter, the depression moved northwestwards and lay centred at 0300 UTC of August 31 near lat. 23.5° N/ long. 79.0° E. Again, it moved in a west-northwesterly direction and lay centred at 0600 UTC of September 1, 2006 near lat. 26.0° N/ long. 76.5° E. After 1200 UTC on September 01 it took northwest movement and continued to move in the same direction and weakened into a low pressure area over west Madhya Pradesh and east Rajasthan and neighbourhood in the evening of September 1, 2006.

The track of the system is given in Fig. 2.1. The best track and other parameters are given in Table 2.7.1. Wind shear over the RSMC region on 29 August 2006 is shown in Fig. 2.7.1. A few Kalpana-1 cloud imageries of the system are shown in Fig. 2.7.2(a-d). The Doppler Weather Radar (DWR) pictures of the system taken by DWR Machilipatnam are shown in Fig. 2.7.3(a-c).

REALISED WEATHER: Heavy to very heavy rainfall with extremely heavy falls occurred at one or two places over Gangetic West Bengal, Orissa, Chhattisgarh, Madhya Pradesh and northwest Rajasthan during the depression period August 29 to September 2, 2006. The significant amounts of rainfall are given below:

28 August, 2006: GANGETIC WEST BENGAL: Kolkata (Dum Dum)-11, Durgachak-7, Haldia-7, Burdwan-6.

29 August, 2006: ORISSA: Baliguda-21, Tikabali-17, Nimapara-16, Phulbani-14, Alipingal-13, Pipili-13, Bhubaneswar-12, Boudhgarh-11, Puri-11, Paradeep-10, Khairamal-9, Lahunipara-9, Madanpur Rampur-9, Kantamal-9, Gop-9, Krishnaprasad-9, Chandbali-8, Deogarh-8, Aska-8, Banpur-8, Sonapur-8, Daringibadi-8, Jamankira-7, Cuttack-7, Kendrapada-7, Rajkanika-7, Athamalik-7, Bhanjanagar-7, Madhabarida-7, Lanjigarh-7, Bhangiriposhi-7, Khandapada-7, Titilagarh-7.

30 August, 2006: ORISSA: Bijepur-32, Tikabali-32, Baliguda-30, Sohela-29, Dunguripalli-23, Phulbani-20, Belgaon-18, Binika-17, Paikmal-15, Umerkote-15, Titilagarh-15, Alipingal-13, Athamalik-13, Ambabhona-13, Padampur-13, Bargarh-12, Krishnaprasad-11, Nimapara-11, Bhanjanagar-10, Barmul-10, Narsinghpur-9, Tirng-9, Pipili-9, Bhubaneswar-9, Hindol-8, Rairakhol-8, Jamsolaghat-8, Kakatpur-8, Kotraguda-8, Khairamal-7,

Cuttack-7, Mundali-7, Khandapada-7, Sonepur-7, Bissam Cuttack-7, **CHHATTISGARH:** Raigarh-6, Champa-5.

31 August 2006: MADHYA PRADESH: Betul-15, Bhasdehi-13, Chincholi-13, Pachmari-11, Multai-9, Begamganj-9, Ashoknagar-8, Shajapur-8, Susner-8, Ganjbasoda-8, Chaderi-7, Sehore-7, Karera-7, Malajkhanda-16, Lanjhi-16, Narsingpur-13, Tendukheda-12, Seoni-12, Deori-11, Balaghat-10, Katangi-10, Amarwara-10, Waraseoni-9, Khurai-9, Chhindwara-8, Sagar-7, Ghansore-7.

01 SEPTEMBER 2006: EAST RAJASTHAN: Mandal-32, Asnawar-17, Banswara-17, Bakani-16, Arnod-15, Aklera-13, Begu-11, Dug-11, Kesarpura-11, Ladpura-11, Pirawa-11, Anta-10, Bundi-10, Chittorgarh-10, Kota-10, Talera-10, Danpur-9, Khanpur-9, Mandana-9, Manohar Thana-9, Nimbhera-9, Bhainsroadgarh-8, Bijolia-8, Chhoti Sadri-8, Degod-8, Jhalarpatan-8, Pipalkhunt-8, Sangod-8, Sawai Madhopur (Tehsil)-8, Gangdhar-7, Jhalawar-7, Pachpahar-7, Phuliakalan-7, **WEST MADHYA PRADESH:** Narsinghgarh-25, Khilchipur-24, Rajgarh-23, Bhopal-21, Raisen-21, Biora-21, Ganjbasoda-20, Ujjain-18, Khachrod-17, Begamganj-15, Sironj-15, Tonkhurd-14, Vidisha-13, Chachora-12, Guna-12, Subasera-12, Tarana-12, Bareilly-11, Dewas-10, Neemuch-10, Kurwai-10, Bhanpura-9, Jawad-9, Sarangpur-9, Ashoknagar-8, Chanderi-8, Hosangabad-8, Gautampura-7, Bandnagar-7,

02 SEPTEMBER 2006: RAJASTHAN: Bhinmal-7, Sindseri-7, Marwar Junction-6, Bilara-5, Ramsar-5, Bhainsroadgarh-14, Jhalawar-12, Kachola-11, Mandana-11, Ramganjmandi-11, Chabra-10, Asnawar-9, Anta-8, Jhalarpatan-8, Atru-7, Bakani-7, Bijoliya-7, Jahajpur-7, Shahbad-7, **WEST MADHYA PRADESH:** Bhanpura-8, Guna-7, Narsinghgarh-7, Shivpuri-7, Kurwahi-6, Mungaoli-6, Rajgarh-6, Javra-5, Karera-5, Kolaras-5.

DAMAGES: As per the media the following damages were reported.

Orissa and Madhya Pradesh reeled under flood situation. Houses were damaged. Traffic disrupted. Floods in Madhya Pradesh took a toll of 9 lives. No damage was reported from Andhra Pradesh.

Table 2.2.7
Best track positions and other parameters for Bay of Bengal depression
August 29- September 01, 2006

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
29-08-2006	0300	20.5/87.5	1.5	992	25	-	D
	0600	20.5/86.5	1.5	992	25	-	D
	The system crossed the north Orissa coast near Paradip around noon.						
	0900	21.0/85.0	1.5	990	25	-	D
	1200	21.0/84.5	--	990	25	-	D
	1500	21.0/84.5	--	990	25	-	D
	1800	21.0/84.0	--	990	25	-	D
	2100	21.0/83.5	--	990	25	-	D
30-08-2006	0000	21.0/83.0	--	992	25	-	D
	0300	22.0/83.0	--	992	25	-	D
	0600	22.5/82.5	--	992	25	-	D
	0900	22.5/81.5	--	992	25	-	D
	1200	22.5/81.0	--	992	25	-	D
	1500	22.5/81.0	--	992	25	-	D
	1800	22.5/81.0	--	992	25	-	D
	2100	22.5/80.5	--	992	25	-	D
31-08-2006	0000	23.0/80.0	--	994	25	-	D
	0300	23.5/79.0	--	994	25	-	D
	0600	24.0/78.0	--	994	25	-	D
	0900	24.0/78.0	--	994	25	-	D
	1200	24.0/78.0	--	994	25	-	D
	1500	24.0/78.0	--	994	25	-	D
	1800	24.5/77.5	--	994	25	-	D
	2100	25.0/77.0		994	25	-	D
01-09-2006	0000	25.5/77.0		994	25	-	D
	0300	26.0/76.5		994	25	-	D
	0600	26.0/76.5		994	25	-	D

The system weakened into a low pressure area over west Madhya Pradesh and adjoining east Rajasthan around 1200 UTC on 1 September 2006.

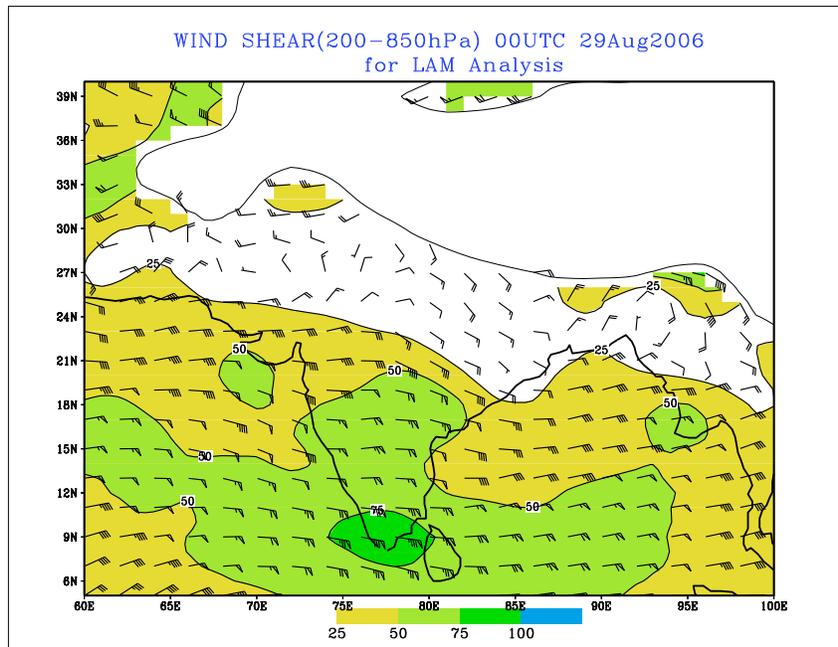


Fig. 2.7.1 Wind shear over RSMC, New Delhi region on 29 August 2006

(a)

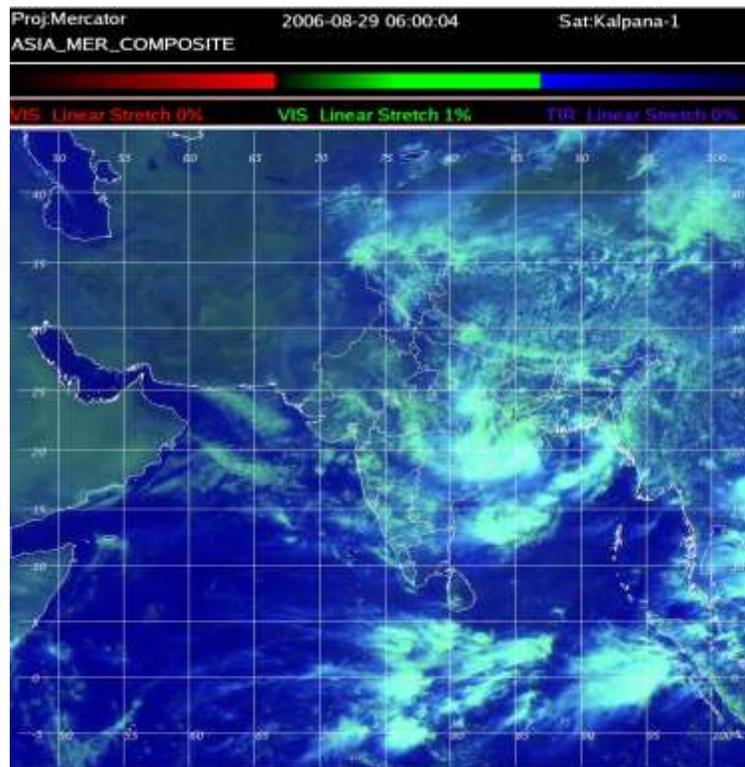
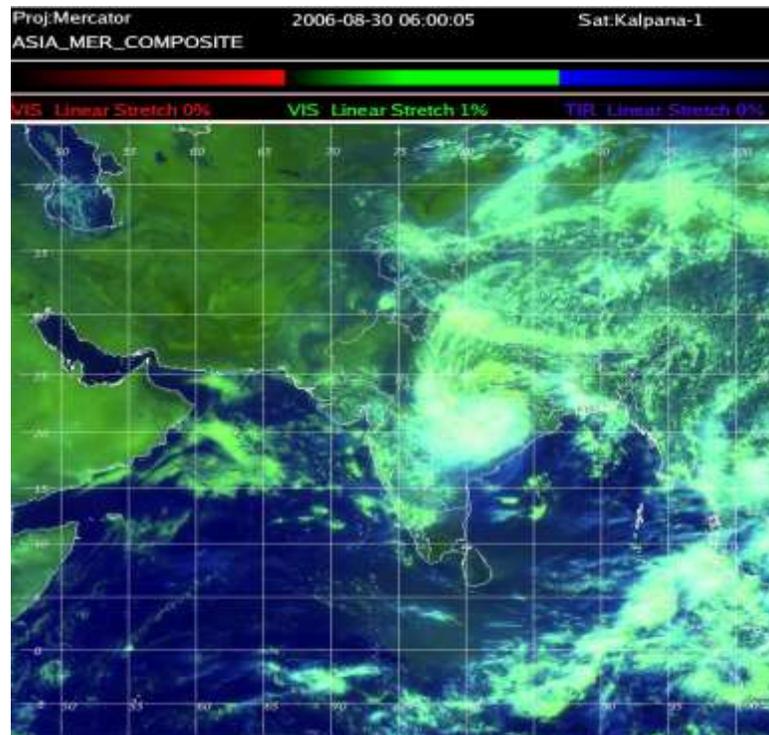


Fig. 2.7.2(a) Satellite KALPANA-I imagery at 0600 UTC on 29 August 2006 shows the dense cloud mass in association with depression at the time of crossing the depression.

(b)



(c)

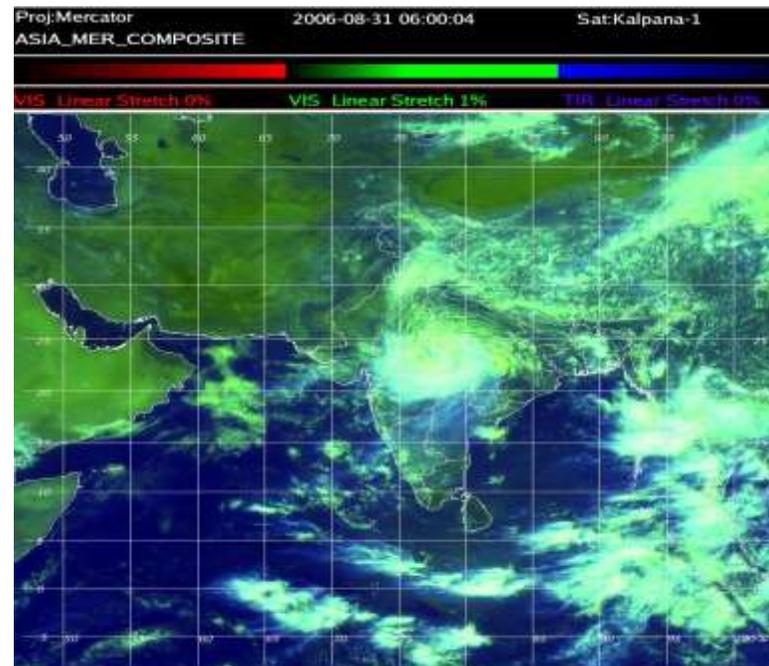


Fig. 2.7.2 (b) Satellite KALPANA-I imagery at 0600 UTC on 30 August imagery shows cloud mass over Chhattisgarh and its forward sector (c) Cloud imagery at 0600 UTC on 31 August indicate the system over northwest Madhya Pradesh and adjoining areas.

(d)

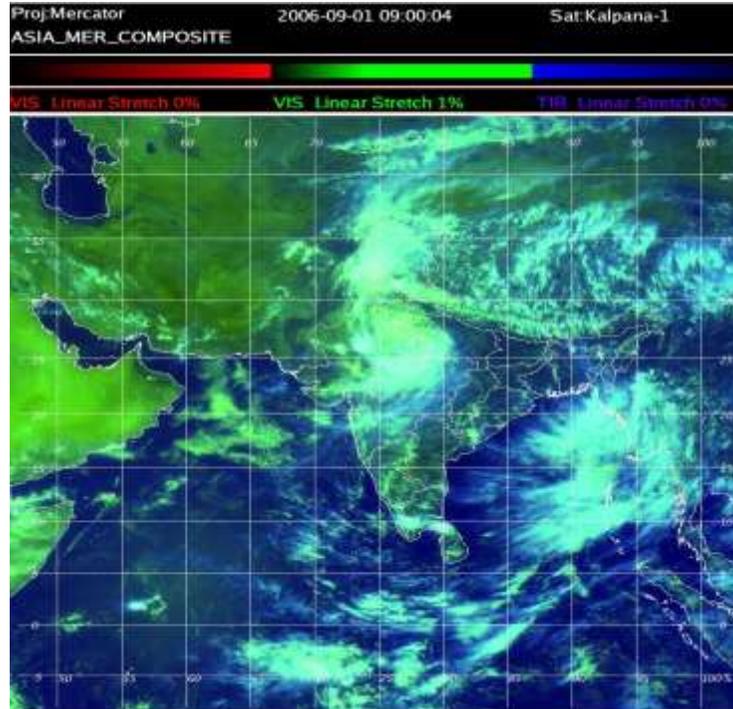


Fig. 2.7.2 (d) Satellite KALPANA-I imagery at 0900 UTC on 1 September 2006 indicate that the system is weakened over south Rajasthan and neighbourhood.

(a)

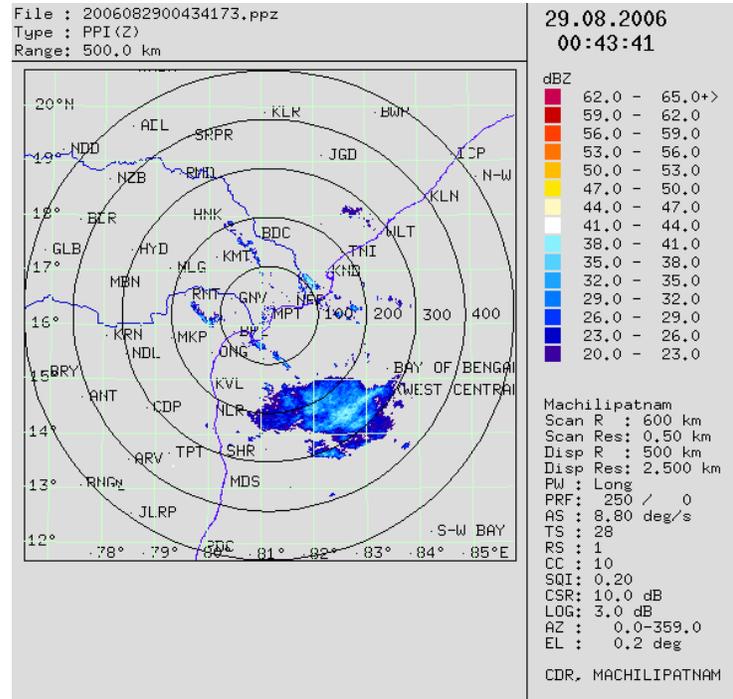
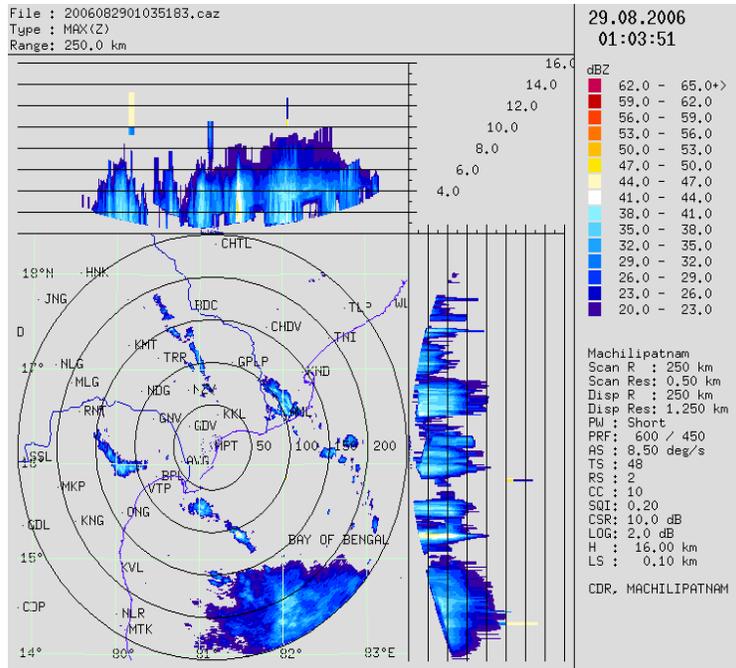


Fig 2.7.2 (a) DWR Machilipatnam observed reflectivity at 00:43:41 UTC on 29 August 2006 southeast of the Radar.

(b)



(c)

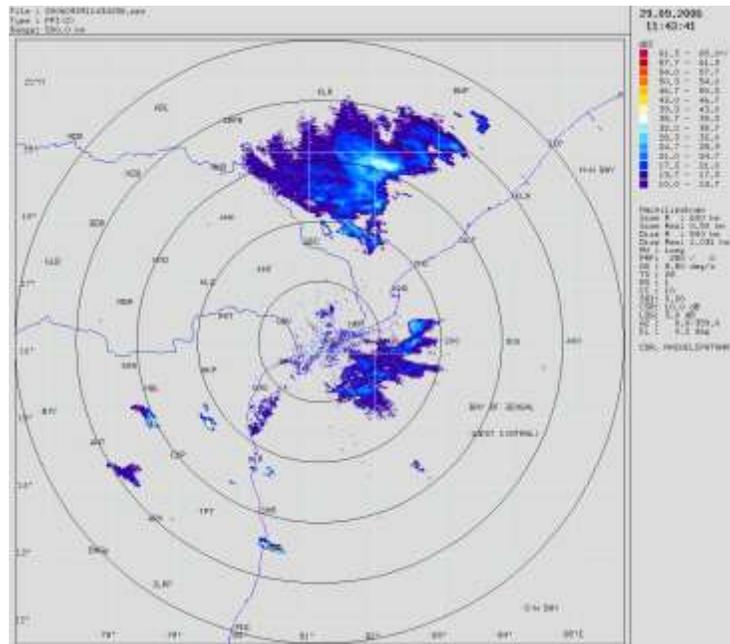


Fig 2.7.2 (b) DWR Machilipatnam observed reflectivity at 01:03:51 UTC on 29 August 2006 southeast of the Radar and (c) when the system over Orissa at 11:43:41 UTC on same day.

2.8 Depression over Bay of Bengal September 03-04, 2006

A low pressure area formed over northwest Bay of Bengal on September 2, 2006. It concentrated into a depression at 1200 UTC of September 3 and lay centred near lat. 20.5° N/ long. 88.5° E. Moving west-northwestward it crossed north Orissa coast near Chandbali (42973) in the early morning of September 4, it was centred at 0300 UTC near lat. 21.0° N/ long. 86.5° E on September 04, 2006. Thereafter, system took northerly component and started to move in a northwesterly direction lay centred near lat. 22.5° N/ long. 84.5° E at 2100 UTC of September 4. Moving in a west-northwesterly direction it weakened into a well marked at 0000 UTC September 5 and further weakened into a low pressure area over Chhattisgarh and adjoining east Madhya Pradesh in the morning of September 6, 2006.

The track of the system is given in Fig. 2.1. The best track and other parameters are given in Table 2.8.1. Wind shear is shown on Fig 2.8.1 over RSMC region on 3 September 2006. A few Kalpana-1 cloud imageries of the system are shown in Fig. 2.8.2(a-c). The Doppler Weather Radar (DWR) pictures of the system taken by DWR Machilipatnam are shown in Fig. 2.8.3(a-b).

REALISED WEATHER: Under the influence of depression heavy to very heavy rainfall occurred over Gangetic West Bengal Orissa, Chhattisgarh and Jharkhand during September 3-6, 2006. The significant amounts of rainfall are given below:

03 SEPTEMBER 2006: GANGETIC WEST BENGAL: Diamond Harbour-10, Kolkata (Alipore)-9, Canning-8, Digha-5, Durgchak-5, **ORISSA:** Jaleswar-9, Rajghat-6.

04 SEPTEMBER 2006: ORISSA: NH-5 Govindpur-15, Jaipur-14, Rajkanika-13, Udala-12, Kendrapada-10, Nilgiri-10, Paradeep-10, Akhuapada-8, Chandbali-8, Pattamundai-7, Sukinda-7, Ghatagaon-7, Balasore-7, Jajpur-7, Balimundali-7, Baripada-7, **JHARKHAND:** Konner-9, Sikadia-8, Jamshedpur-5, Khusiary-5, Tenughat-5, Ramgarh-5.

05 SEPTEMBER 2006: ORISSA: Pallahara-13, Nawarangpur-12, Bhubaneswar-12, Sukinda-11, Ghatagaon-11, Kamakhya Nagar-10, Naraj-10, Kendrapada-10, Mundali-9, Ambabhona-9, Baripada-9, Balasore-8, Jaipur-8, Jaleswar-8, Akhuapada-8, Athagarh-8, Cuttack-8, Bangiriposh-8, Thakurmunda-8, Madanpur Rampur-7, Balimundali-7, **CHHATTISGARH:** Raipur-9, Mana-9, Durg-9, Champa-7, Jagdalpur-5.

DAMAGES: Nil

Table 2.8.1
Best track positions and other parameters for Bay of Bengal depression
September 03-04, 2006

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
03-09-2006	1200	20.5/88.5	1.5	992	25	-	D
	1500	20.5/88.0	1.5	992	25	-	D
	1800	20.5/87.5	1.5	992	25	-	D
	2100	20.5/87.5	1.5	992	25	-	D
04-09-2006	0000	21.0/87.0	1.5	992	25	-	D
	The depression crossed the north Orissa coast near Chandbali around 0100 UTC						
	0300	21.0/86.5	--	992	25	-	D
	0600	21.5/85.5	--	992	25	-	D
	0900	21.5/85.0	--	992	25	-	D
	1200	22.0/84.5	--	992	25	-	D
	1500	22.0/84.5	--	992	25	-	D
	1800	22.0/84.5	--	992	25	-	D
	2100	22.0/84.5	--	994	25	-	D

The system weakened into a low pressure area over Chhattisgarh and adjoining east Madhya Pradesh at around 0000 UTC of 5 September, but as a low pressure area it move upto southwest Rajasthan and dissipated over west Rajasthan and adjoining areas on 9 September 2006.

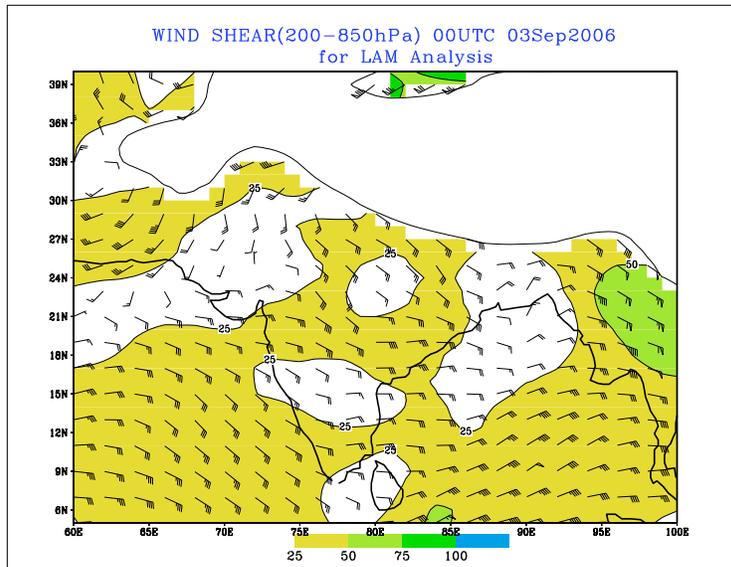


Fig. 2.8.1 Wind shear over RSMC, New Delhi region on 3 September 2006

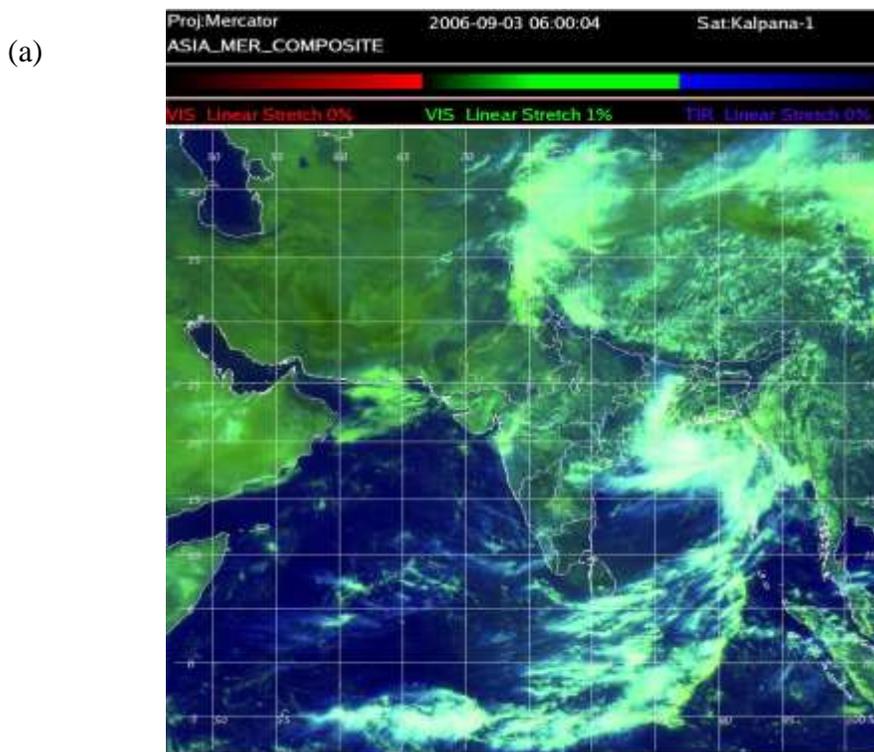
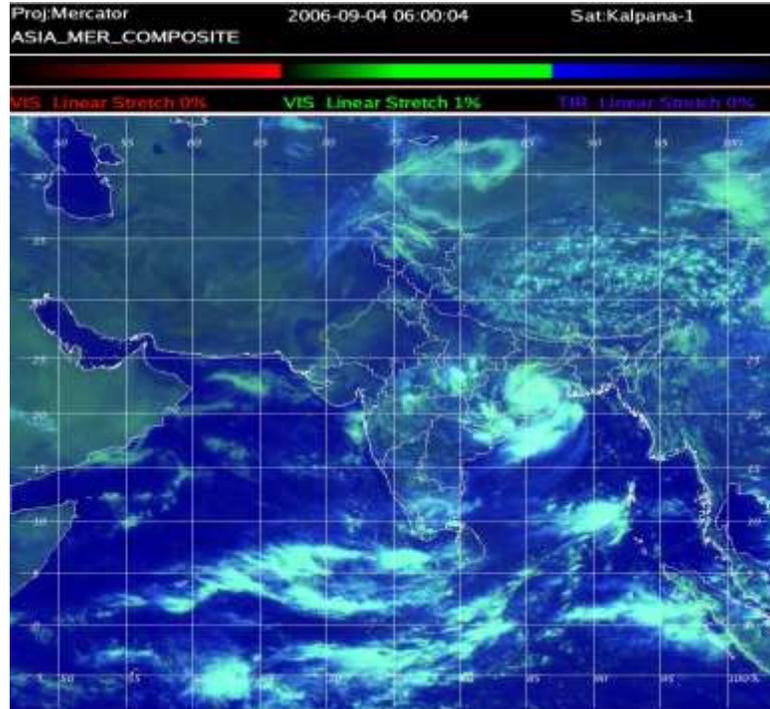


Fig. 2.8.2 (a) Satellite KALPANA-I imagery at 0600 UTC on 3 September shows cumulus lines around the system over Orissa coast.

(b)



(c)

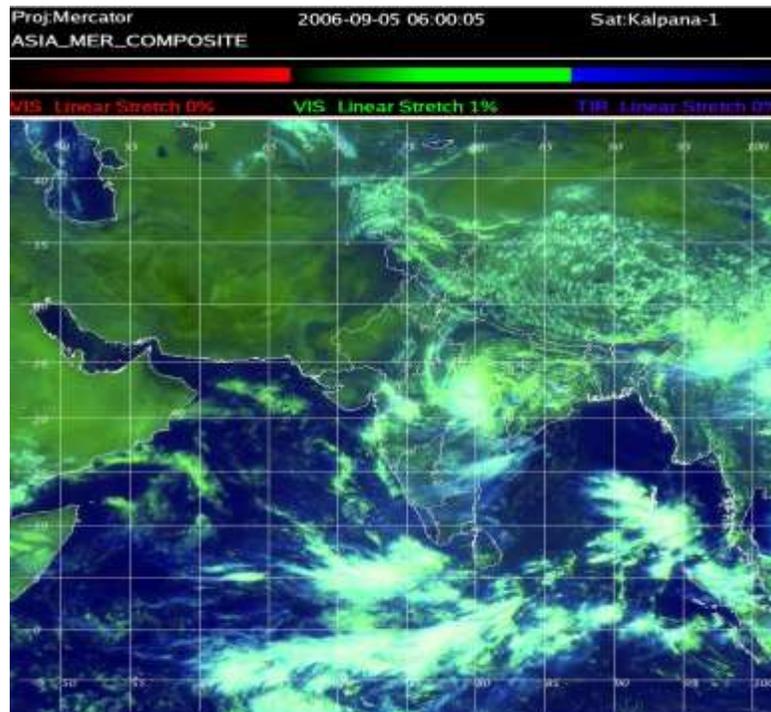
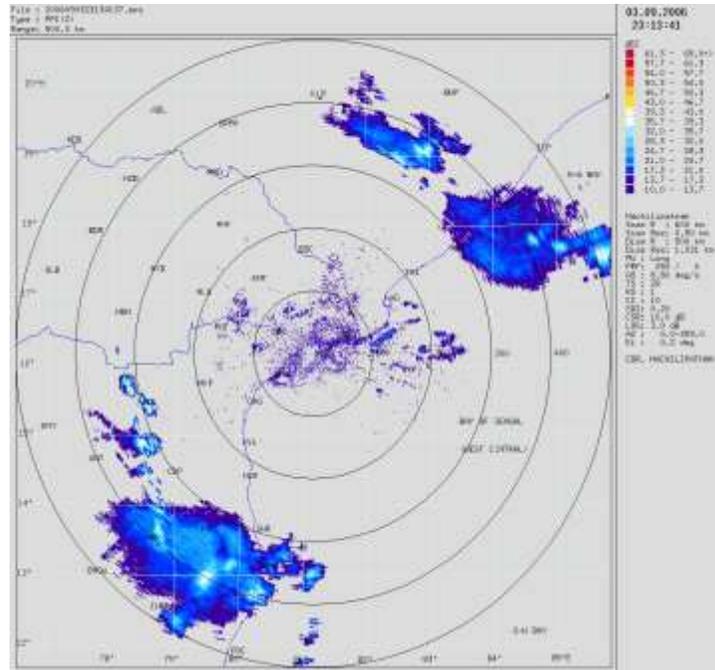


Fig. 2.8.2 (b) Satellite KALPANA-I imagery at 0600 UTC On 4 September shows well organized cloud in association with the depression and (c) at 0600 UTC on 5 September seen over east Madhya Pradesh and it started to weaken.

(a)



(b)

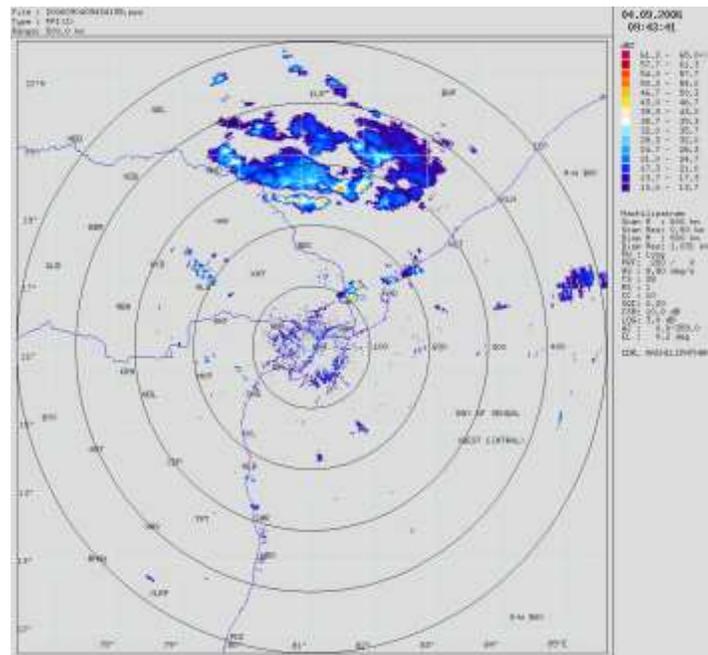


Fig.2.8.3 Radar picture taken by DWR Machilipatnam (a) observed reflectivity at 29:13.33 UTC on 3 September when system over Orissa coast and (b) reflectivity at 09:43: 41 UTC on 4 September 2006, when depression over Interior Orissa.

2.9 Land Depression over Jharkhand during September 21-24, 2006

A low pressure area formed over northwest Bay of Bengal and adjoining Gangetic West Bengal on 20 September 2006. It moved in a northwesterly direction and concentrated into a depression over Jharkhand near lat. 23.0°N/ long. 86.5°E, close to Jamshedpur in the morning (around 0300 UTC) of 21 September 2006. It further moved northwestward and lay centred near lat. 23.5°N/ long. 86.0°E at 0300 UTC east of Ranchi (42701) in the morning of 22 September 2006. The system moved slowly northwards and lay centred at 0300 UTC of 23 September near lat. 23.5°N/ long. 85.5°E close to Dhanbad (42703). At this time system came under the influence of lower level easterlies and took westerly component and it started to move in a westerly direction. Moving in the same direction it weakened into a low pressure area over Bihar and neighbourhood in the morning of September 24, 2006.

The track of the system is given in Fig. 2.1. The best track and other parameters are given in Table 2.9.1. A few Kalpana-1 cloud imageries of the system are shown in Fig. 2.9.1. The Doppler Weather Radar (DWR) picture of the system taken by DWR Kolkata and Machilipatnam are shown in Fig. 2.9.2.

REALISED WEATHER: under the influence of depression widespread rainfall with heavy to very heavy fall occurred over Gangetic West Bengal & Sub-Himalayan West Bengal & Sikkim, Orissa, Jharkhand, Bihar and east Uttar Pradesh during the depression period. The significant amounts of rainfall are given below:

21 SEPTEMBER 2006: GANGETIC WEST BENGAL: Durgachak-21, Canning-14, Berhampore-13, Krishnanagar-12, Diamond Harbour-12, Dengarparaghat-12, Rampurhat-11, Basirhat-10, Uluberia-9, Kolkata-9, Barrackpur-9, Bagati-9, Narayanpur-8, Kharagpur-8, Purihansa-7, Kolkata-7, Kalaikunda-7, **ORISSA:** Khairamal-12, Umerkote-12, Athamalik-9, Sonapur-9, Jeypore-8, Pottangi-8, Malkangiri-7, Kantamal-6, Banpur-6, Jaleswar-5, Telkoi-5, Jamsolaghat-5, Rairangpur-5, **JHARKHAND:** Jamshedpur-13, Maharo-8, Sikadia-7, Messanjore-7, Nandadih-5.

22 SEPTEMBER 2006: GANGETIC WEST BENGAL: Tantloi-21, Kolkata-21, Suri-15, Tilpara Barrage-14, Barrackpur-13, Gheropara-11, Sriniketan-10, Asansol-10, Durgapur-10, Canning-10, Diamond Harbour-10, Digha-10, Panagarh-9, Durgachak-9, Rampurhat-8, Kangsabati Dam-8, Narayanpur-7, Purihansa-7, Dengarparaghat-7, **ORISSA:** Bhogari-12, Anandpur-10, Jenapur-9, Sukinda-8, Swarnapatna-7, Jamankira-7, Baripada-7, Balasore-6, Soro-6, Keonjhar-6, Akhuapada-6, **JHARKHAND:** Jamshedpur-14, Ranchi-5, **BIHAR:** Bhagalpur-5, Gaya-5.

23 SEPTEMBER 2006: GANGETIC WEST BENGAL: Tantloi-17, Suri-13, Bankura-12, Tilpara Barrage-11, Asansol-11, Tusuma-10, Canning-10, Durgachak-9, Sriniketan-6, **JHARKHAND:** Tilaiya-17, Messanjore-17, Nandadih-16, Barkisurya-15, Sikadia-15, Ramgarh-14, Maharo-14, Ranchi-13, Hindigir-13, Khusiari-10, Tenughat-9, Mython-8, Konner-8, **BIHAR:**

Palmerganj-8, Gaya-7, Darauli-7, Indrapuri-7, Manihari-6, Buxor-5, Lalbegiaghat-5, Rewaghat-5, **EAST UTTAR PRADESH:** Ballia-9, Ghazipur-8.

24 SEPTEMBER 2006: SUB-HIMALAYAN WEST BENGAL & SIKKIM: Sevoke-11, Singlabazar-8, Alipurduar-7, Chepan-7, Gajoldoba-7, Bagdogra-6, Champasarai-6, Barobhisa-5, Coochbehar-5, Hasimara-5, Khanitar-5, Murti-5, NH-31-5, Neora-5, **JHARKHAND:** Ramgarh-8, Khesiary-7, Hindigir-7, Tilaya-6, Barkisuraya-6, Maharo-5, Koner-5, Messanjore-5, **BIHAR:** Bhagalpur-18, Colgaon-11, Baltara-10, Khagaria-7, Gaya-6, Motihari-6, Messanjore-5, Munger-5, Rewaghat-5, Sikandarpur-5, Galgalia-5, **EAST UTTAR PRADESH:** Mukhlisipur-8, Varanasi-5, Birdghat-5.

25 SEPTEMBER 2006: SUB-HIMALAYAN WEST BENGAL & SIKKIM: Darjeeling-10, Sevoke-6, Singlabazar-5, **GANGETIC WEST BENGAL:** Tantloi-11, Suri-5, Tilpara Barrage-5, **ORISSA:** Cuttack-8, Naraj-5, **JHARKHAND:** Khusiary-24, Maharo-19, Tenughat-7, Tilaiya-5, **BIHAR:** Benibad-31, Motihari-30, Muzaffarpur-27, Kursela-24, Lalbegiaghat-21, Sikandarpur-21, Sonbarsa-21, Colgaon-20, Saulighat-19, Basua-18, Khagaria-13, Rosera-13, Ahirwalia-12, Jainagar-12, Baltara-10, Chorgharia-10, Lalganj-10, Araria-9, Rewaghat-8, Patna-7, Jhawa-6, Munger-6, Sripalpur-6, Galgalia-5, Taibpur-5.

DAMAGES: As per the media, following damages were reported.

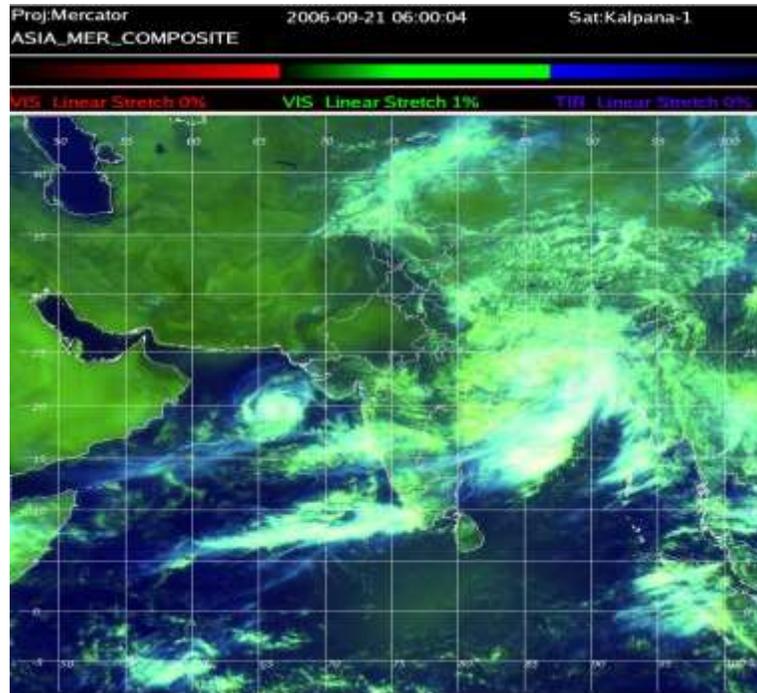
In West Bengal, 61 people died, lakhs of people rendered homeless and crops damaged. In Bihar, heavy to very heavy rain took a toll of 37 lives. In Jharkhand, many houses were damaged and transport disrupted.

Table 2.9.1
Best track positions and other parameters for land Depression over
Jharkhand and neighbourhood during September 21-24, 2006

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
21-09-2006	0300	23.0/86.5	--	996	25	-	D
	0600	23.0/86.5	--	996	25	-	D
	0900	23.0/86.5	--	996	25	-	D
	1200	23.0/86.5	--	996	25	-	D
	1500	23.0/86.5	--	996	25	-	D
	1800	23.0/86.5	--	996	25	-	D
	2100	23.0/86.5	--	996	25	-	D
22-09-2006	0000	23.5/86.0	--	996	25	-	D
	0300	23.5/86.0	--	996	25	-	D
	0600	23.5/86.0	--	996	25	-	D
	0900	23.5/86.0	--	996	25	-	D
	1200	23.5/86.0	--	996	25	-	D
	1500	23.5/86.0	--	996	25	-	D
	1800	23.5/86.0	--	996	25	-	D
23-09-2006	0000	23.5/86.0	--	996	25	-	D
	0300	23.5/85.5	--	996	25	-	D
	0600	23.5/85.5	--	996	25	-	D
	0900	23.5/85.5	--	996	25	-	D
	1200	23.5/85.5	--	996	25	-	D
	1500	23.5/85.5	--	996	25	-	D
	1800	23.5/85.5	--	996	25	-	D
24-09-2006	0000	23.5/85.5	--	996	25	-	D

The depression weakened into a low pressure area over Jharkhand around 0300 UTC of September 24, 2006.

(a)



(b)

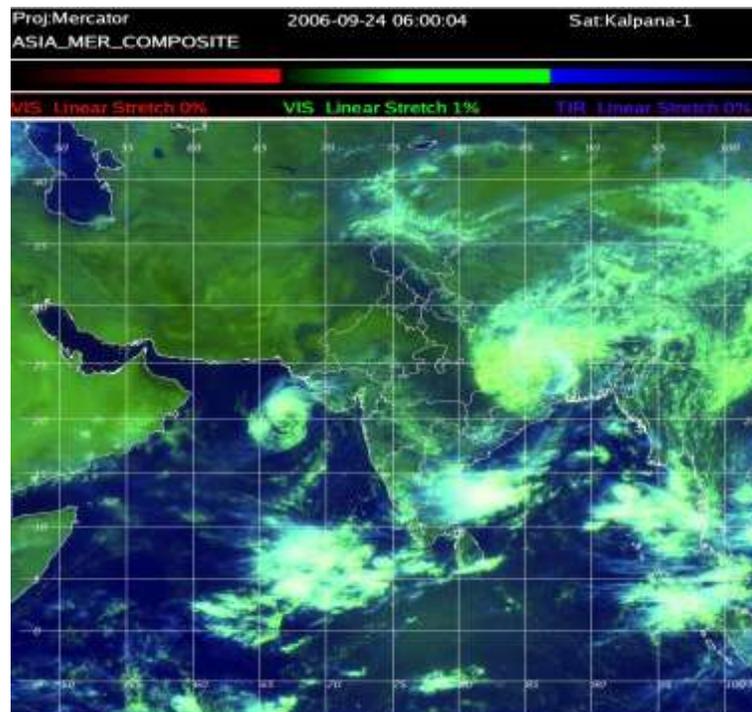


Fig. 2.9.1. (a) Satellite KALPANA-I imagery at 0600 UTC on 21 September 2006 shows well organized cloud over northeast Orissa and adjoining sea areas as system intensity was depression at this time and (b) at 0600 UTC on 24 September when the system located over Bihar and adjoining areas.

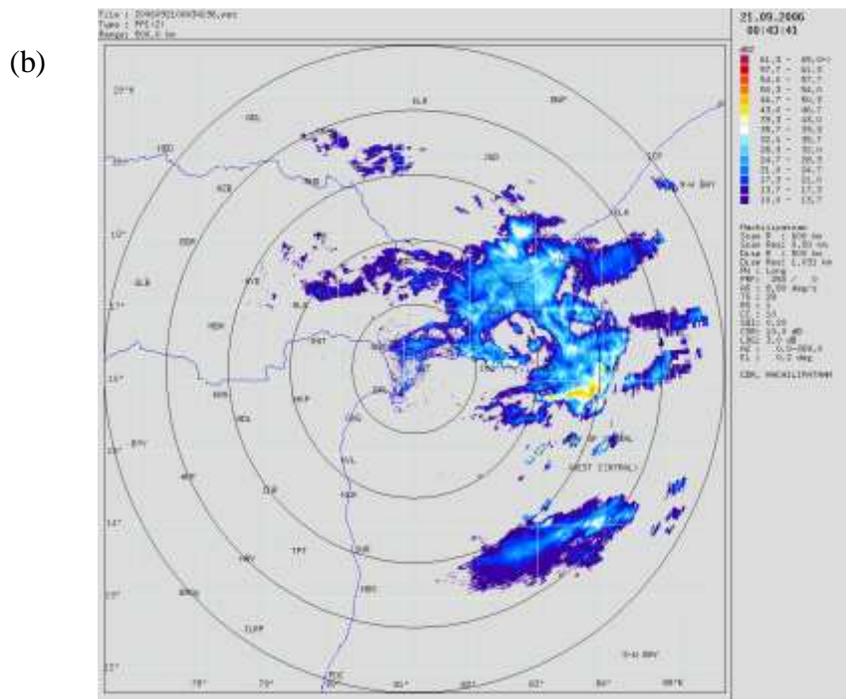
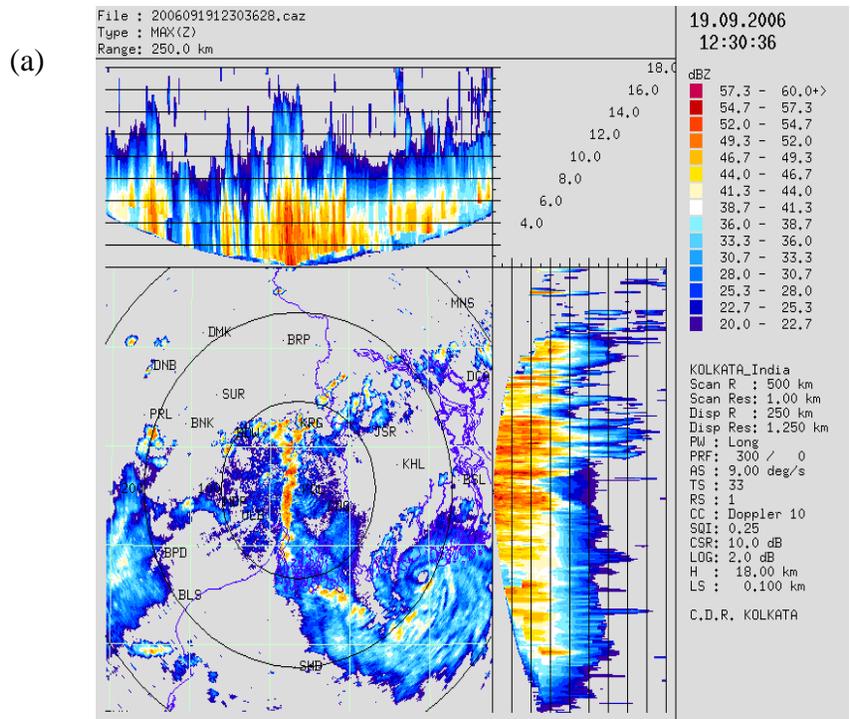
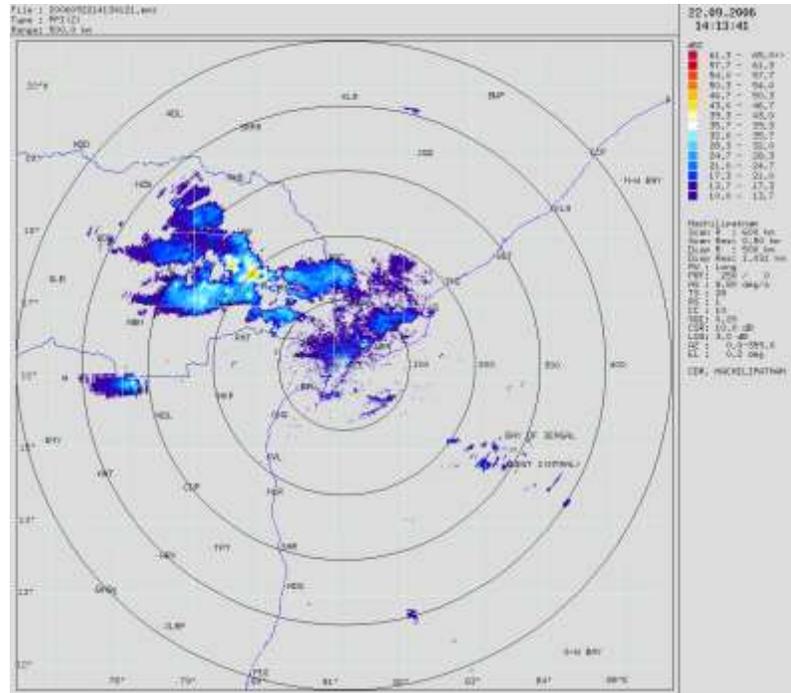


Fig. 2.9.2. DWR Kolkata observed reflectivity (a) at 12:30:36 on 19 September 2006 when the system shows curved features at this time the system was in sea (b) DWR Machilipatnam shows the system in crossing process at 06:43:41 UTC on 21 September.

(c)



(d)

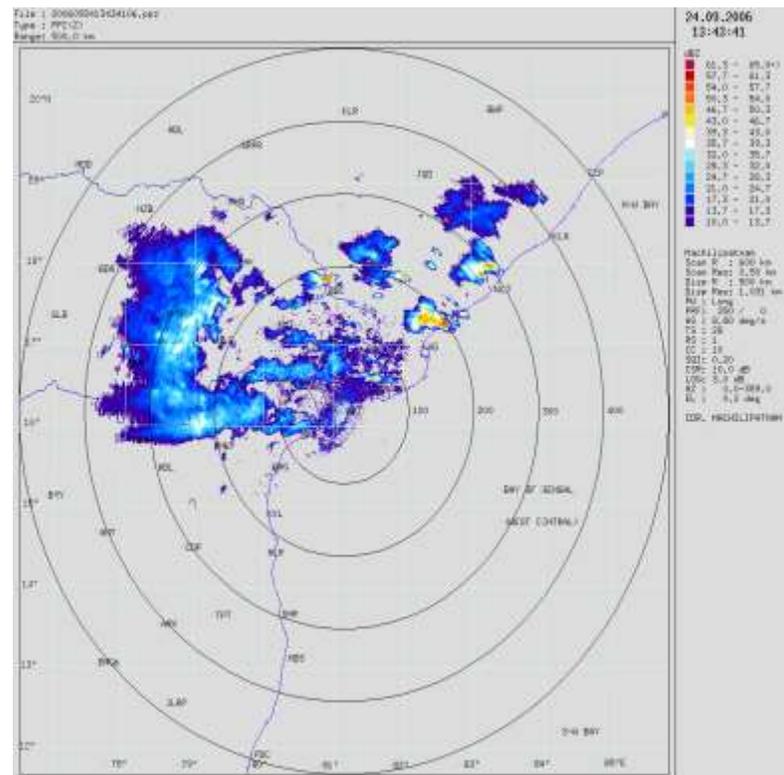


Fig 2.9.2. (c) DWR Machilpatnam observed reflectivity shows the system elongated northwest to southwestwards over Orissa at 14 : 13:42 on 22 September and (d) System seen over Orissa and adjoining Jharkhand and Chhattisgarh at 13:41:43 on 24 September 2006.

2.10 Severe Cyclonic Storm “MUKDA” over Arabian Sea September 21- 24, 2006

A low pressure area formed over eastcentral Arabian Sea on September 20, which intensified into a depression and lay centered at 0300 UTC of 21 September 2006 near lat. 19.5 N/long. 66.0 E about 450 Kms southwest of Porbandar (42830). It intensified very rapidly into a deep depression at 0600 UTC of the same day. The system remained practically stationary and further intensified into a Cyclonic Storm “MUKDA” and lay over east central Arabian Sea at 0000 UTC on 22 September near lat. 20.0°N / long. 66.0°E. It continued to remain practically stationary upto 0900 UTC of the same day and intensified further into a severe cyclonic storm and lay centred near lat 20.5°N/long.66.5°E at 1200 UTC of September 22. Afterwards, it started to move slowly in north-northeasterly direction toward Gujarat Coast. It lay centred at 2100 UTC of 22 near Lat. 20.5° N/Long. 66.5° E, about 350 kms southwest of Porbandar. It moved northeastward and lay centred at 0000 UTC of September 23 near Lat. 21.0° N/Long. 67.0°E. Thereafter, it remained stationary and weakened into a deep depression and lay centred at 0600 UTC of 23. It further weakened into a depression in the mid night of September 24, 2006 over the same area and then into a low pressure area.

The track of the system is given in Fig. 2.1. The best track and other parameters are given in Table 2.10.1. Wind shear over RSMC New Delhi region is given in Fig. 2.10.1. A few Kalpana-1 cloud imageries of the system are shown in Fig. 2.10.2.

REALISED WEATHER: Heavy rainfall occurred at isolated places in Saurashtra & Kutch, are given below:

21 September, 2006	Upleta 7
22 September, 2006	Lodhika 7
24 September, 2006	Jodia 8
25 September, 2006	Upleta 10

DAMAGES: As the system was away from the coast, no damage was caused.

Table 2.10.1

Best track positions and other parameters for Arabian Sea Severe Cyclonic Storm "MUKDA" September 21-24, 2006

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
21-09-2006	0300	19.5/66.0	1.5	1004	25	4	D
	0600	19.5/66.0	2.0	1002	30	5	DD
	0900	19.5/66.0	2.0	1000	30	5	DD
	1200	19.5/66.0	2.0	1000	30	5	DD
	1500	19.5/66.0	2.0	1000	30	5	DD
	1800	19.5/66.0	2.0	1000	30	5	DD
	2100	19.5/66.0	2.0	998	30	5	DD
22-09-2006	0000	20.0/66.0	2.5	996	40	6	CS
	0300	20.0/66.0	3.0	994	45	6	CS
	0600	20.0/66.0	3.0	994	45	6	CS
	0900	20.0/66.0	3.0	994	45	8	CS
	1200	20.5/66.5	3.0	994	45	10	SCS
	1500	20.5/66.5	3.0	992	45	10	SCS
	1800	20.5/66.5	3.0	990	45	10	SCS
	2100	20.5/66.5	3.0	988	45	10	SCS
23-09-2006	0000	21.0/67.0	3.0	988	45	10	SCS
	0300	21.0/67.0	3.0	988	45	10	SCS
	0600	21.0/67.0	3.0	988	45	10	SCS
	0900	21.0/67.0	3.0	988	45	10	SCS
	1200	21.0/67.0	3.0	988	50	10	SCS
	1500	21.0/67.0	3.5	990	55	15	SCS
	1800	21.0/67.0	3.5	992	50	15	SCS
	2100	21.0/67.0	3.0	994	45	10	CS
24-09-2006	0000	21.0/67.0	3.0	994	40	10	CS
	0300	21.0/67.0	2.0	996	35	8	CS
	0600	21.0/67.0	2.0	1000	30	5	DD
	0900	21.0/67.0	2.0	1002	30	5	DD
	1200	21.0/67.0	1.5	1004	25	4	D

The system weakened into a low pressure area over the same area around mid-night of September 24, 2006.

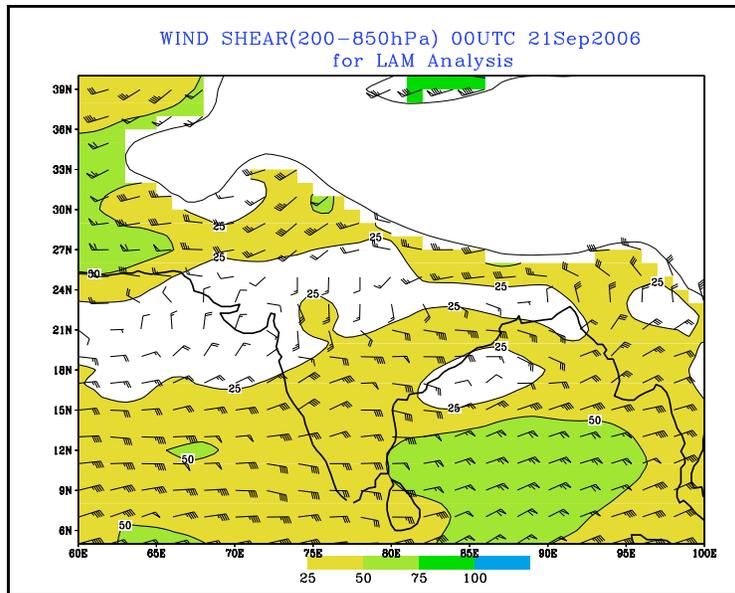


Fig 2.10.1 Wind shear on 21 September 2006 over RSMC, New Delhi region.

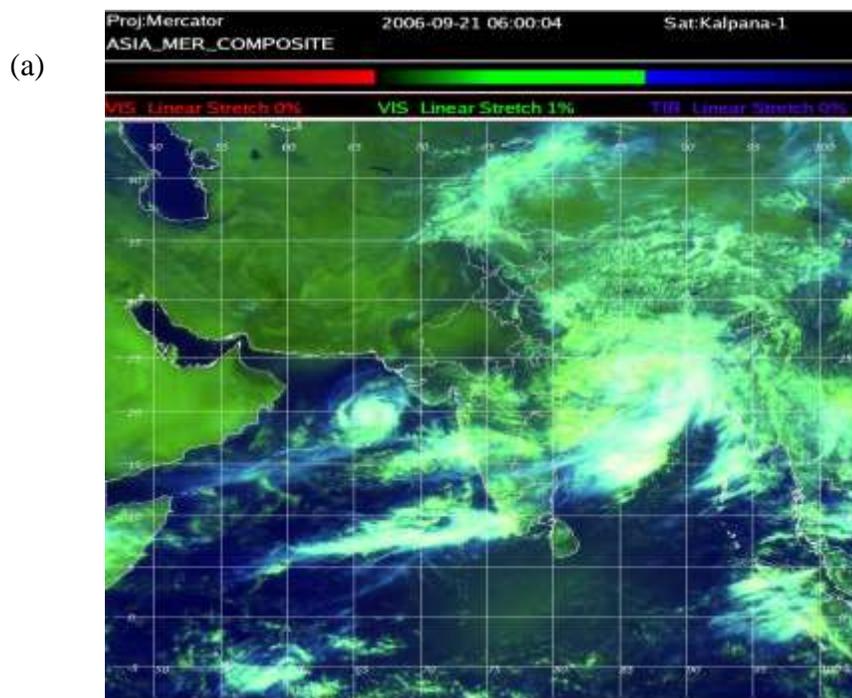
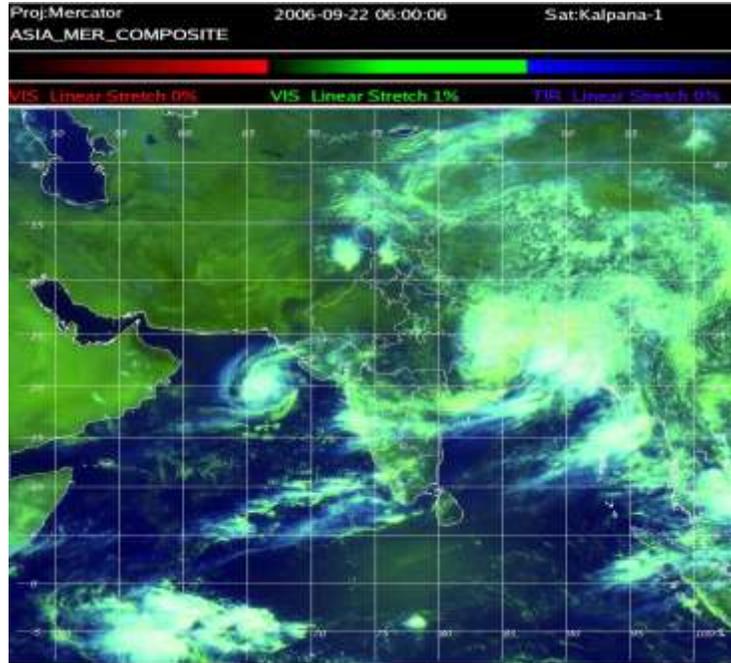


Fig. 2.10.2 (a) Satellite KALPANA-I imagery at 0600 UTC on 21 September shows well organized with circular shape cloud in association with the system.

(b)



(c)

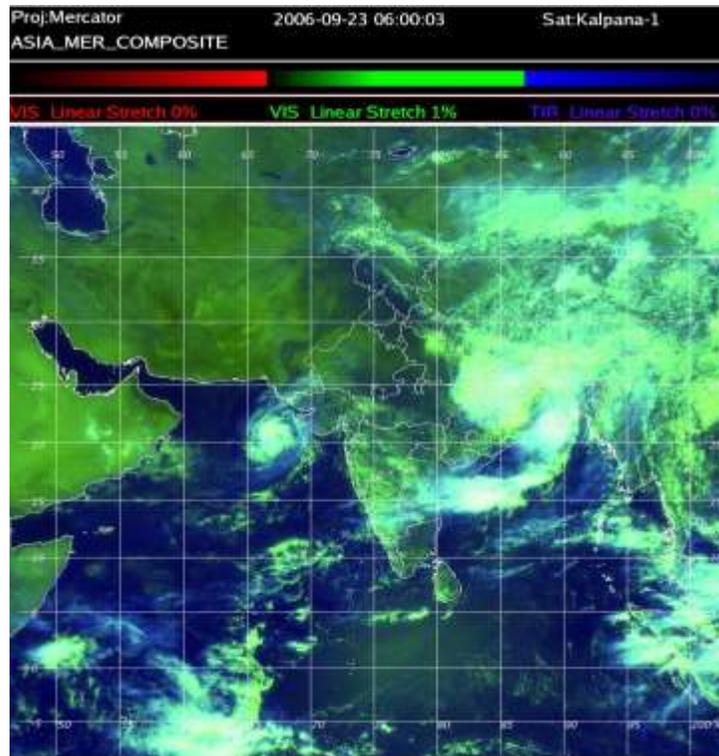


Fig. 2.10.2 (b) Satellite KALPANA-I imagery shows at 0600 UTC on 22 September band features shown in the imagery (c) at 0600 UTC CDO type pattern shows in the imagery and system upgraded as severe cyclonic storm at this time.

(d)

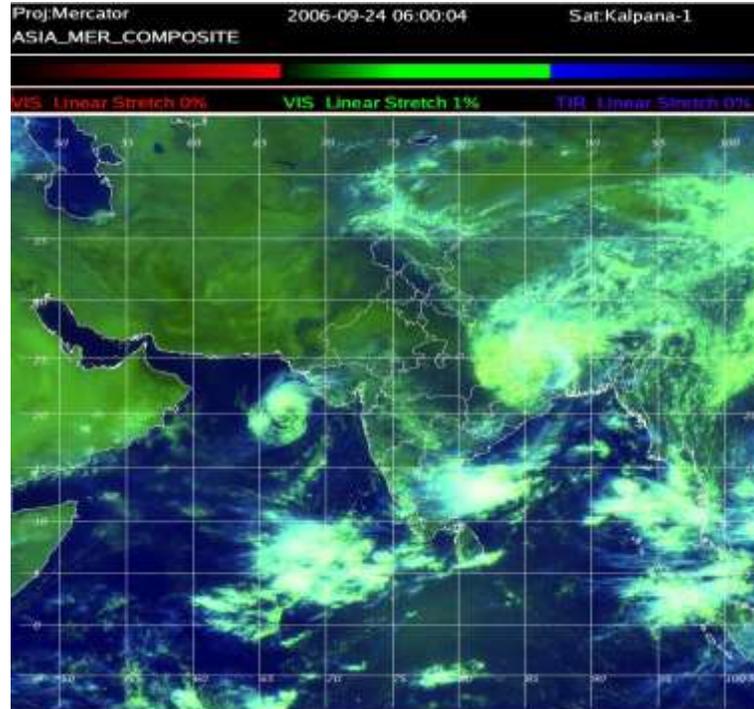


Fig. 2.10.2 (d) Satellite KALPANA-I imagery at 0600 UTC on 24 September shows that the system elongated towards northeast and showing sinning weakening.

2.11 Depression over the Bay of Bengal September 28-30, 2006

A well marked low pressure area formed over northeast and adjoining eastcentral Bay of Bengal at 0300 UTC of 28. It intensified into a depression on the same day at 0900 UTC and lay centred at 0900 UTC near Lat. 18.0° N/Long. 89.0° E, it was about 300 km southeast of Paradip (42976) on September 28. System initially moved in a northwesterly direction and lay centered at 1200 UTC near Lat.18.5°N/Long. 88.5°E on the same day. After 1200 UTC it started to move in west-northwesterly direction. It lay centred at 0000 UTC near Lat. 19.0° N/Long. 86.5° E about 125 km east-southeast of Gopalpur (43049) on September 29. System continued to move in westerly direction and crossed Orissa coast close to Gopalpur (43049) around 1200 UTC on September 29. After 1200 UTC system again moved slowly in a northwesterly direction and weakened into a low pressure area over Chhattisgarh and neighbourhood in the morning of September 30, 2006.

The track of the system is given in Fig. 2.1. The best track and other parameters are given in Table 2.11.1. Wind shear over RSMC New Delhi region is given in Fig. 2.11.1. A few Kalpana-1 cloud imageries of the system are shown in Fig. 2.11.2 (a-b). The Doppler Weather Radar (DWR) picture of the system taken by DWR Machilipatnam is shown in Fig.2.1.3 (a-b).

REALISED WEATHER: Heavy to very heavy rainfall occurred due this system over south Orissa, north Andhra Pradesh, Chhattisgarh and Orissa during 29 September to 1 October 2006. The significant amounts of rainfall are given below:

29 SEPTEMBER 2006: ORISSA: Puri-12, Krishnaprasad-10, Banpur-8, Pipili-8, Tangi-8, Aska-7, Gopalpur-7, Akhuapada-6, Alipingal-6, Berhampur-6, Chhatrapur-6, Govindpur-6, Nimapara-6, Purusottampur-6, **ANDHRA PRADESH:** Vishakhapatnam-12, Vizianagaram-6.

30 SEPTEMBER 2006: ORISSA: Mahendragarh-17, R. Udaigiri-15, Jeypore-13, Mohana-11, Sorada-11, Gunpur-10, Kotraguda-9, Bangiriposhi-7, Udala-7, Barmul-6, Bhanjnagar-6, Jenapur-6, **CHHATTISGARH:** Bhanupratappur-20, Kondagaon-12, Narayanpur-10, Jagdalpur-7, Kanker-7, Devbhog-6, **ANDHRA PRADESH:** Sompeta-9, Komarada-6, Mandasa-6, Kalasa-6, Ichapuram-5, Tekkali-5.

01 OCTOBER 2006: VIDARBHA: Yeotmal-11, Akola-5, **ANDHRA PRADESH:** Adilabad-6, Metpalli-5.

Table 2.11.1
Best track positions and other parameters for the Bay of Bengal
Depression September 28-30, 2006

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	
28-09-2006	0900	18.0/89.0	1.5	1002	25	-	D	
	1200	18.5/88.5	1.5	1002	25	-	D	
	1500	18.5/88.0	1.5	1002	25	-	D	
	1800	18.5/87.5	1.5	1002	25	-	D	
	2100	19.0/87.0	1.5	1002	25	-	D	
29-09-2006	0000	19.0/86.5	1.5	1002	25	-	D	
	0300	19.0/86.0	1.5	1002	25	-	D	
	0600	19.0/85.5	1.5	1002	25	-	D	
	0900	19.0/85.0	1.5	1002	25	-	D	
	The depression crossed the coast close to Gopalpur around 1200 UTC							
	1200	19.0/84.5	--	1002	25	-	D	
	1500	19.0/84.5	--	1002	25	-	D	
	1800	19.0/84.5	--	1002	25	-	D	
	2100	19.0/84.0	--	1002	25	-	D	
	30-09-2006	0000	19.5/83.5	--	1002	25	-	D

The system weakened as a low pressure area over south Chhattisgarh and neighbourhood in the morning of September 30, 2006.

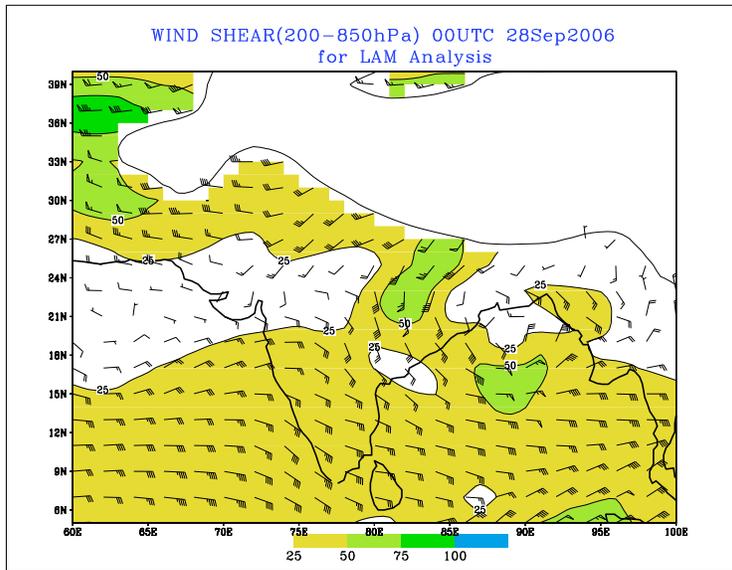


Fig. 2.11.1. Wind shear over RSMC, New Delhi region on 28 September 2006.

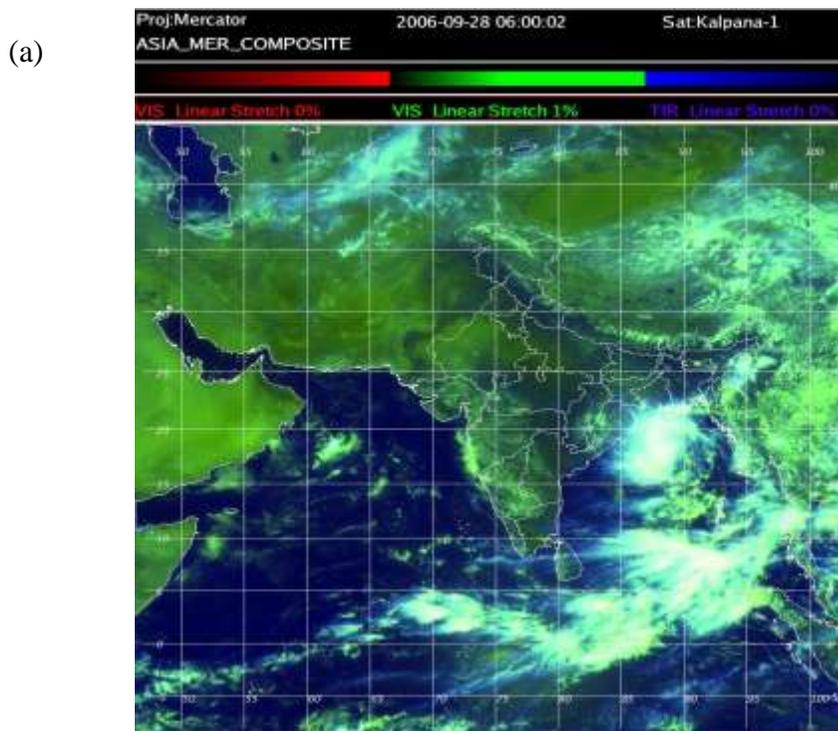
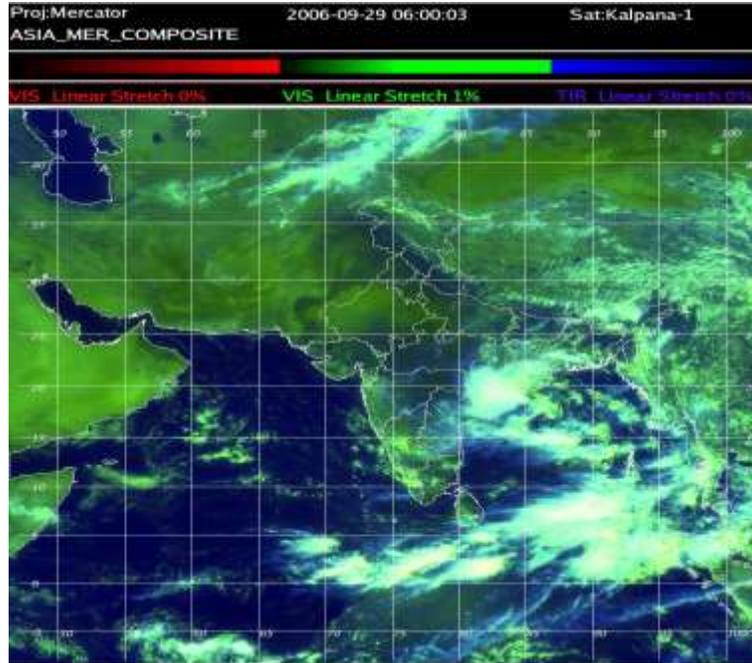


Fig. 2.11.2 (a) Satellite KALPANA-I imagery at 0600 UTC on 28 September shows dense cloud with spiral features over Orissa and north Andhra coasts.

(b)



(c)

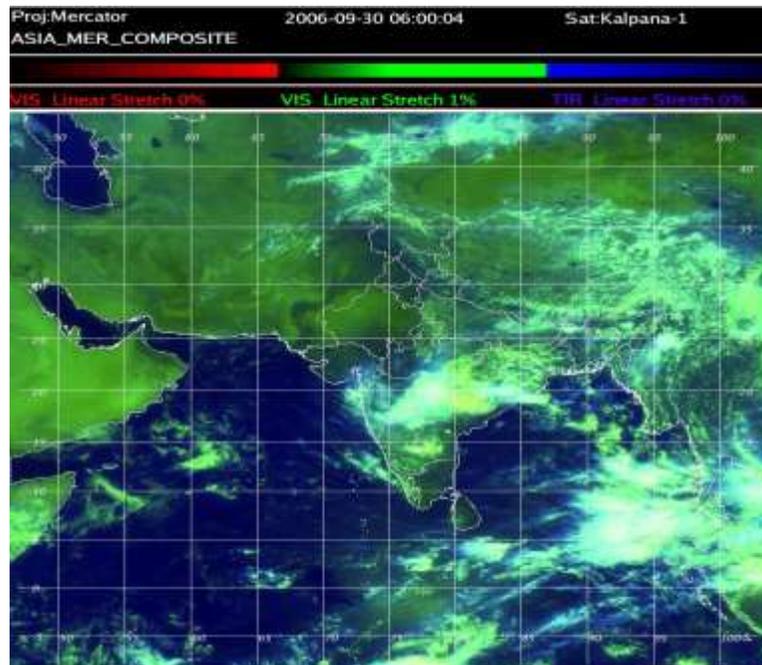
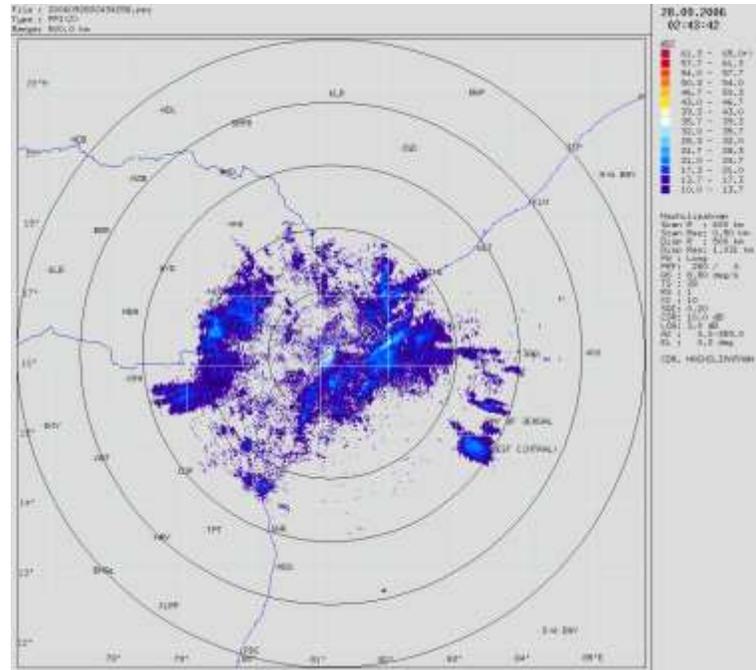


Fig. 2.11.2 (b) Satellite KALPANA-1 imagery at 0600 UTC on 29 September dense cloud seen over Orissa in association with depression and (c) Satellite imagery at 0600 UTC on 30 September is shown weakening feature of the system.

(a)



(b)

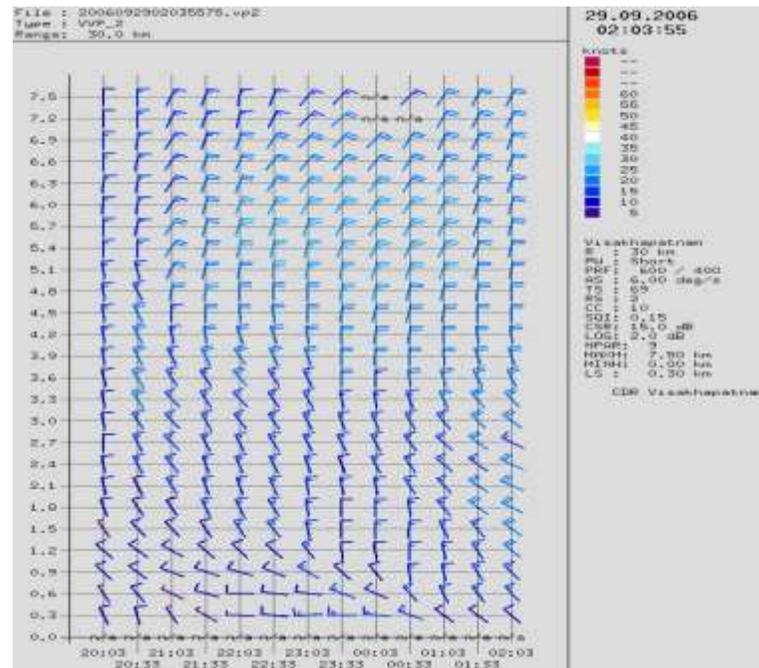


Fig.2.1.3 Radar picture taken by DWR Machilipatnam (a) reflectivity at 02:43:42 UTC at 29 September and (b) vertical wind profile at 02: 05:55 UTC on same day.

2.12 Cyclonic storm “OGNI” over the Bay of Bengal October 29-30, 2006

A low pressure area formed over west-central Bay of Bengal off Andhra Pradesh coast in the evening of 28 October 2006. It intensified into a depression and lay centred near lat. 14.0° N/ Long. 80.5° E in the morning of 29. While moving slowly in a northerly direction it intensified into a deep depression and lay centred near lat. 15.0° N/ 80.5° E in the afternoon of the same day about 50 km east of Kavali (43243). The system further intensified into a cyclonic storm in the evening of 29th. The system moved slightly northward and till the morning of 30th the movement of the system was very slow. It lay centred near lat. 19.5° N/ long. 83.5° E at 0000 UTC of September 30, 2006 about 30 km east of Kavali (43243). Doppler weather radar at Machilipatnam showed band features with small core. The Doppler weather radars of Chennai and Machilipatnam constantly monitored the system. The satellite imageries on hourly basis helped to track the system. Besides this, hourly synoptic observations were also taken from the coastal observatories, which were of immense use in the determination of landfall point and time. The cyclonic storm moved northwestward and crossed “the coast near Bapatla as deep depression around noon of October 30, 2006. After crossing the coast, the system weakened into a depression in the afternoon of same day. The depression further weakened into “a low pressure area over north Andhra Pradesh and adjoining areas in the evening of October 30, 2006.

NOTE: This system was a small core (meso-cyclone type). Its diameter was about 100 km and it sustained the cyclone intensity for a few hours only. As it was located very close to the coast it did not get enough sea travel to attain higher intensity.

The track of the system is given in Fig. 2.1. The best track and other parameters are given in Table 2.12.1. A few Kalpana-1 cloud imageries of the system are shown in Fig. 2.12.1(a-b). The Doppler Weather Radar (DWR) picture of the system taken by DWR Machilipatnam is shown in Fig.2.12.2(a-d).

REALISED WEATHER: Heavy to very heavy rainfall with extremely heavy falls at one or two places occurred over north Andhra Pradesh and south Orissa coast during September 29 to October 01, 2006. The significant amounts of rainfall (cm) are given below:

29 OCTOBER 2006: NORTH ANDHRA PRADESH: Ongole-19, Kakinada-13, Amalapuram-13, Kandukur-13, Avanigadda-10, Sullurpet-9, Kavali-8, Repalle-8, Nellore-7, Gudur-7.

30 OCTOBER 2006: NORTH ANDHRA PRADESH: Avanigadda-35, Repalle-28, Machilipattinam-27, Bapatla-20, Amalapuram-16, Narsapur-15, Kakinada-15, Bhimavaram-12, Gudivada-12, Tenali-12, Tanuku-11, Guntur-10, Kaikalur-10, Gannavaram-10, koderu-9, Mangalagiri-9, Ongole-8, Kandukur-8, Peddapuram-8, Visakhapatnam-7, Addanki-7, Eluru-7, Rajahmundry-7.

31 OCTOBER 2006: NORTH ANDHRA PRADESH: Gudivada-55, Machilipattinam-34, Avanigadda-32, Narsapur-22, Gannavaram-19, Kaikalur-16, Amalapuram-15, Eluru-15, Bhimavaram-14, Mangalagiri-13, Bapatla-12, Chintalapudi-11, Koderu-11, Tanuku-10, Prakasam Barrage-9, Bhimadole-8, Nuzvid-8, Tadepalligudem-7 Kakinada-7,

DAMAGES: As per media, following damages were reported.

Andhra Pradesh

Loss of life : 24
 Livestock : 3, 61,553
 Loss of crops : 1, 99,986 acres
 Villages submerged : 900
 Damage to houses (fully) : 26,853
 Damage to houses (partly) : 73,218
 Total loss : 21,601 lakhs

Table 2.12.1
Best track positions and other parameters for Bay of Bengal Cyclonic Storm “OGNI” (October 29-30, 2006)

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
29-10-2006	0000	14.0/80.5	1.5	1002	25	-	D
	0300	14.5/80.5	1.5	1002	25	-	D
	0600	14.5/80.5	1.5	1002	25	-	D
	0900	15.0/80.5	2.0	1000	30	5	DD
	1200	15.0/80.5	2.5	998	35	6	CS
	1500	15.0/80.5	2.5	998	35	6	CS
	1800	15.5/80.5	2.5	998	35	6	CS
	2100	15.5/80.5	2.5	998	35	5	CS
30-10-2006	0000	15.5/80.5	2.5	998	35	6	CS
	0300	15.6/80.3	2.5	1000	35	6	CS
	0600	15.7/80.3	2.0	1002	30	6	DD
	Crossed the coast between Bapatla and Ongole around 0700 UTC.						
	0900	15.8/80.3	--	1004	25	8	D

The system weakened into a low pressure area over south coastal Andhra Pradesh and neighbourhood around 1200 UTC of October 30, 2006.

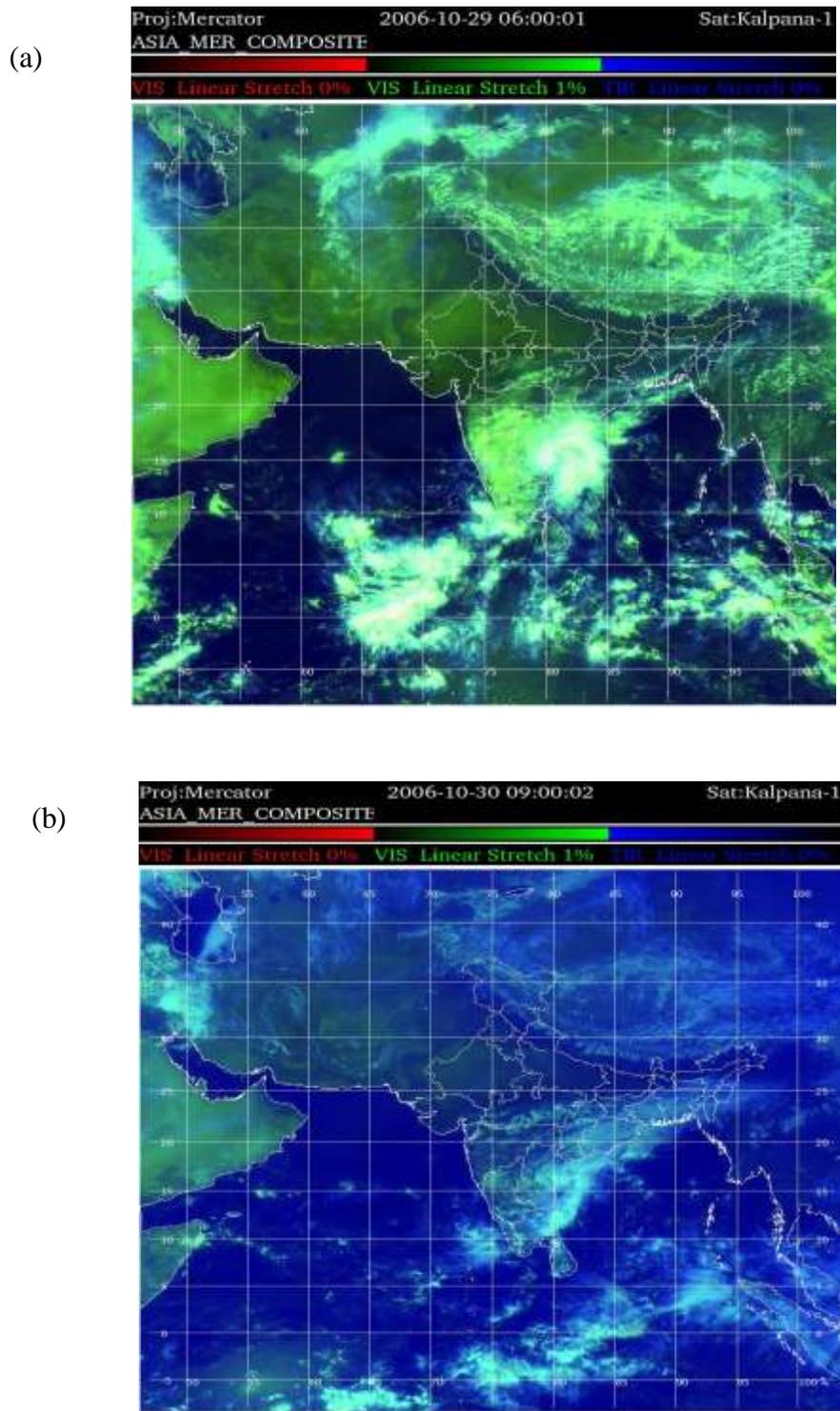
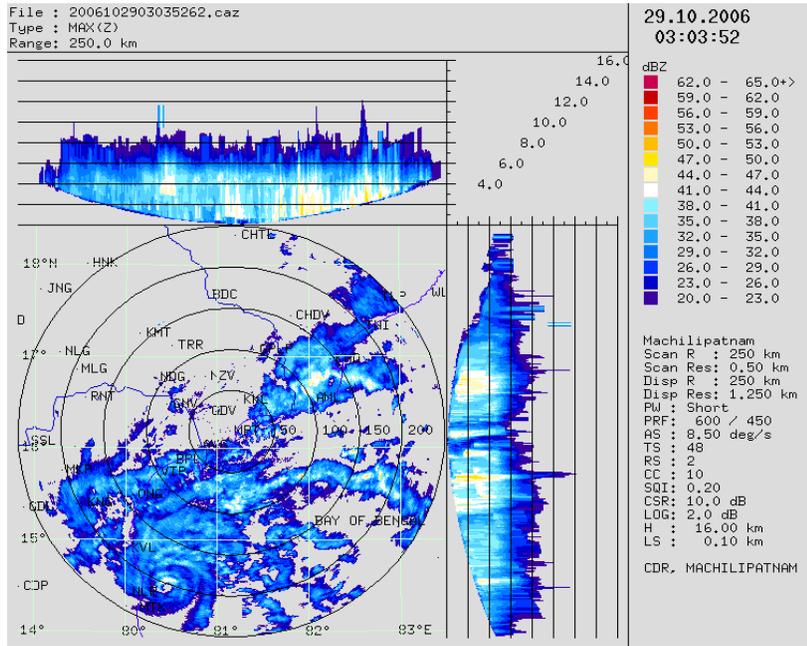


Fig. 2.12.1 Satellite KALPANA-1 imageries (a) at 0600 UTC on 29 October 2006 shows dense convective cloud over north Andhra Pradesh in association with the system and (b) at 0600 UTC on 30 October 2006 solid convective cloud are seen over north Andhra Pradesh in association with the cyclone.

(a)



(b)

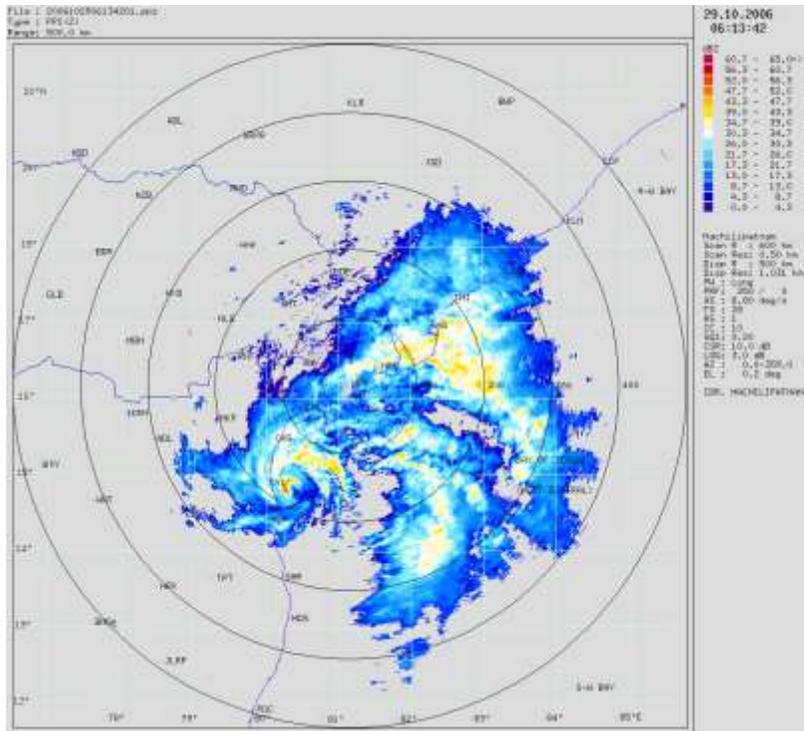


Fig.2.12.2 Radar picture taken by DWR Machilipatnam shows band feature (a) at 03:03:52 UTC and (b) at 06:13:42 UTC on 29 September 2006.

(c)



Track prediction by Numerical Models

Recent improvement in Quasi- Lagrangian Model

Quasi-Lagrangian model (QLM) for cyclone track prediction is the operational limited area model used in the India Meteorological Department for providing numerical guidance in cyclone forecasting operations. QLM is specially tailored for providing cyclone track forecasts using the methodology of a synthetic vortex superimposed on gridded fields to correct the location and intensity of the vortex in the initial fields. QLM has a horizontal resolution of 40 km and 16 sigma levels in the vertical. It is integrated in a domain of about 4400x4400 km² area that is centered on the initial position of the cyclone.

Recently, the QLM code have been modified in collaboration with SAARC Meteorological Research Centre (SMRC), Dhaka to receive inputs from a global analysis and forecast system in the grid point form and thus to delink the model from the spectral form of inputs, with which the original version of model was tied up. The modified model was used to test its success using some past historical cases of tropical cyclones, which hit the east coast of India and Bangladesh coast. A number of experiments have been conducted on northward moving and recurving storms, as they constitute a difficult forecast problem. In these experiments we used the idealized vortex without dipole winds. Track prediction experiments were performed with the basic data sets drawn from the ECMWF Re-analysis (ERA-40), NCEP GDAS & GFS. The use of GFS data is of particular significance in these experiments in view of its potential in the real time forecasting operations. The case of '**MALA**' in April 2006, the most recent cyclone in Bay of Bengal was experimented upon with real-time GFS data. Performance evaluation in terms of qualitative comparison of the model simulated and actual tracks on the one hand and quantitative comparisons with forecast error statistics in various forms indicated that while the forecast errors are reasonable, the direction of movement of the storms, largely northward and recurving northeastward in the cases under study, is well captured by the model. The mean error works out to be 153 km for 24 hour forecast, 226 km for 48h forecast and 344 km for 72h forecast. Two facts emerge from this statistics: (a) the mean errors in all the forecast ranges are negative except in the 72 hour range, which indicates a slow bias in the predicted speed of movement; and (ii) the RMSE Angular Deviations are small, being within 20 degrees for all forecast ranges except in the 12 hour range. An early indication about the most likely direction of movement and the most likely part of the coastline to be struck by the storm, 48 to 72 hours in advance, when the storm is located in the southern parts of Bay of Bengal and has the possibility of striking any part of the long coastline from the extreme south of India through Bangladesh to Myanmar, may be considered a good numerical guidance for the forecasters.

Severe Cyclonic Storm 'MALA' over Bay of Bengal (25-29 April 2006)

MODEL SIMULATED TRACKS

The mean sea level pressure (MSLP) analyses and model simulated storm tracks based on the initial conditions of 27, 28 and 29 April 2006, 00 UTC are shown in Figs. 3.1-3.3. The model forecast based on 27th (Fig. 1) produced a track, which had an orientation towards north-north-west, positioned to the left of the actual track and crossed coast about two degrees away from the actual landfall. The forecast based on 28th gave a movement much closer to the observation and the landfall was within about 50 km. The 12-hour forecast based on 29th placed the landfall coinciding with the actual.

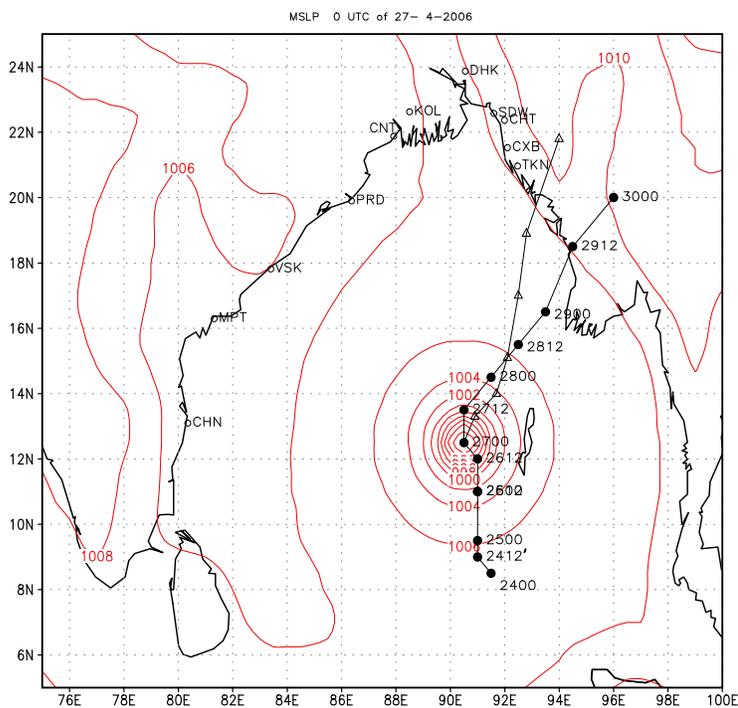


Fig. 3.1 Mean sea level pressure (hPa) analysis valid for 00 UTC of 27 April 2006 and track forecast based on 27 April/ 00 UTC initial conditions with idealized vortex (●- analysed; ▲ - predicted)

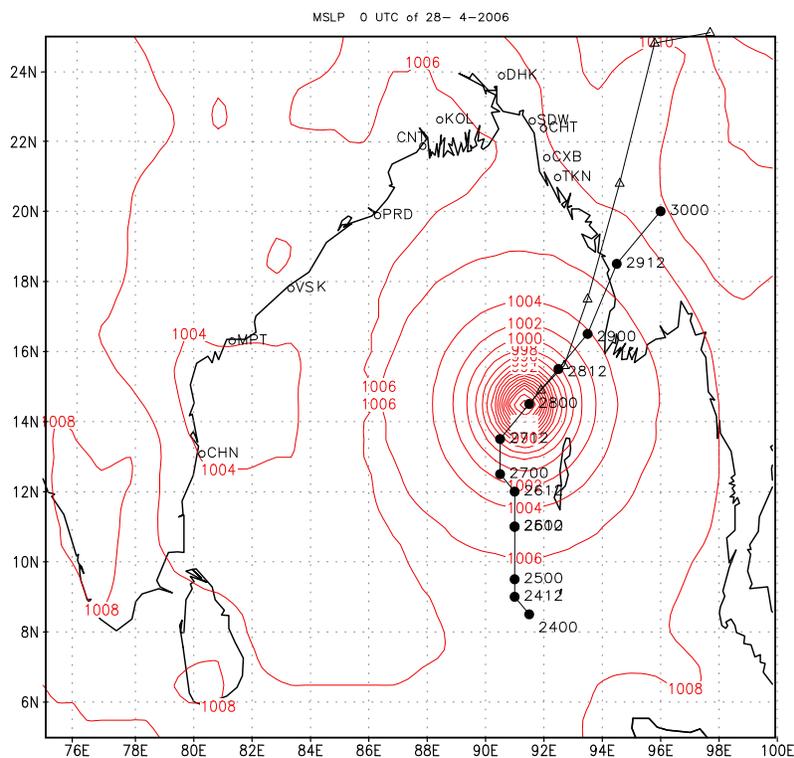


Fig. 3.2 Mean sea level pressure (hPa) analysis valid for 00 UTC of 28 April 2006 and track forecast based on 28 April/00 UTC initial conditions with idealized vortex (● analysed; ▲ predicted)

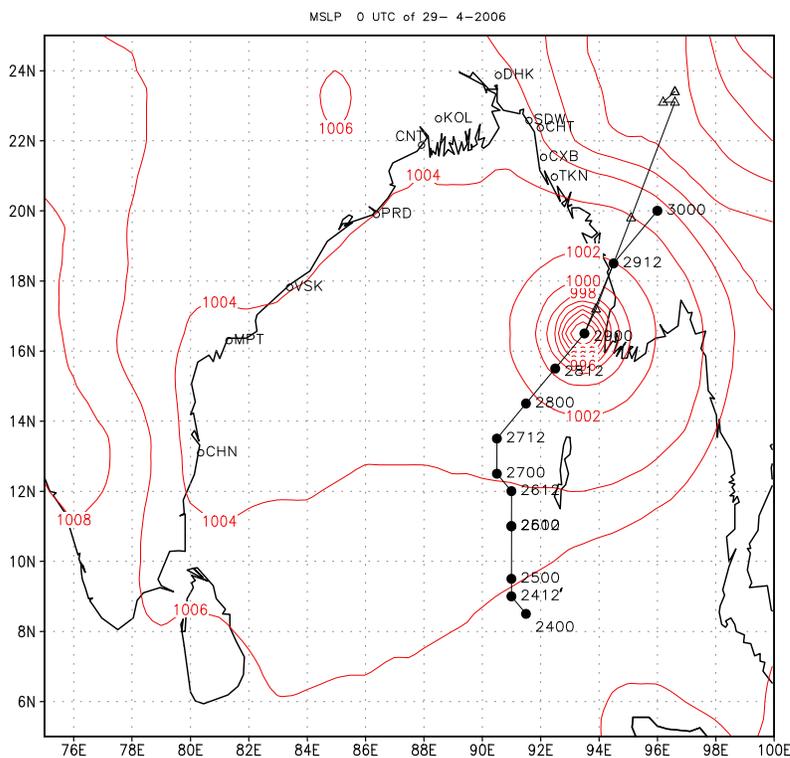


Fig. 3.3 Mean sea level pressure (hPa) analysis valid for 00 UTC of 29 April 2006 and track forecast based on 29 April/00 UTC initial conditions with idealized vortex (● analysed; ▲ predicted)

Performance evaluation

The performance evaluation in terms of a qualitative comparison of the observed and the model simulated tracks the model has captured the northward movement and recurvature of the cyclones to a fair degree of accuracy. Quantitative verification has been carried out by computing the 'Direct Position Error' (DPE) and Vector Difference (Km) Angular Deviation (Deg.) period ranging from 12 hour to 72 hour are given in Table 3.1, 3.2, for Very severe cyclonic storm "MALA" and Table 3.3 & 3.4 for severe cyclonic storm "MUKDA" .

Table 3.1

FORECAST VERIFICATION						
DIRECT POSITION ERRORS (KM)						
Initial date	Forecast hour					
	12	24	36	48	60	72
27-04-2006	49	60	62	120	184	288
28-04-2006	93	132	153	171	-	-
29-04-2006	158	97	-	-	-	-
Mean error	100	96	107	145	184	288

Legend: Direct Position Error' (DPE) is the geographical distance between the predicted location of the storm and the verifying position at valid hour.

Table 3.2

FORECAST VERIFICATION												
FORECAST ERRORS												
Initial date	Forecast hour											
	12		24		36		48		60		72	
	VD	AD	VD	AD	VD	AD	VD	AD	VD	AD	VD	AD
27-04-2006	-12	26	-36	12	-60	-2	-5	-13	-40	-14	79	-15
28-04-2006	-93	0	-131	3	-152	-3	-3	-13	-	-	-	-
29-04-2006	-158	3	-66	-9	-	-	-	-	-	-	-	-
Mean error	-87	10	-77	2	-110	-3	-4	-13	-40	-14	79	-15

Legend: VD - Vector Difference (Km), AD - Angular Deviation (Deg.)

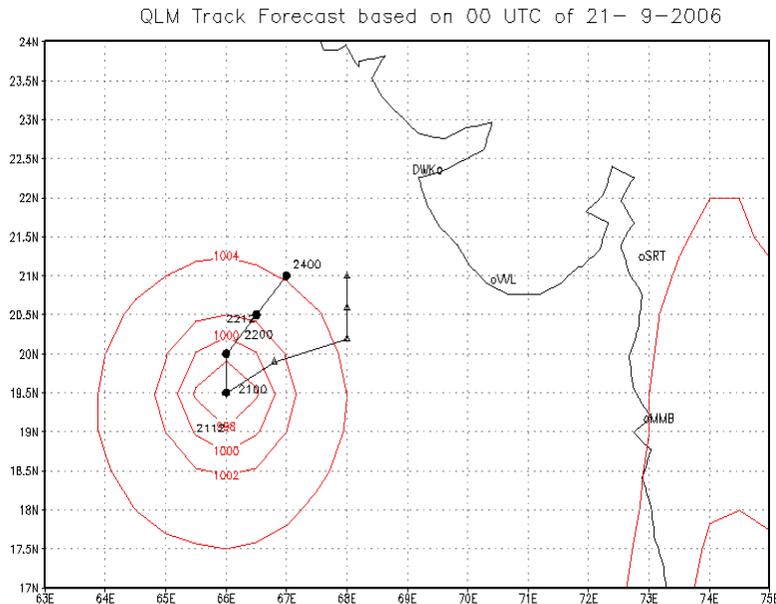


Fig. 3.4 Mean sea level pressure (hPa) analysis valid for 00 UTC of 21 September 2006 and track forecast based on 21 September/00 UTC initial conditions with idealized vortex (● analysed; ▲ predicted)

Table 3.3

FORECAST VERIFICATION						
DIRECT POSITION ERRORS (KM)						
Initial date	Forecast hour					
	12	24	36	48	60	72
21-09-2006	41.9	55.5	73.6	136.9	113.1	103.8
22-09-2006	63.8	199.0	167.7	1873	127.5	-
23-09-2006	60.8	41.5	60.8	-	-	-
Mean error	55.5	98.7	100.7	162.1	120.3	103.8

Legend: Direct Position Error' (DPE) is the geographical distance between the predicted location of the storm and the verifying position at valid hour.

Table 3.4

FORECAST VERIFICATION												
FORECAST ERRORS												
Initial date	Forecast hour											
	12		24		36		48		60		72	
	VD	AD	VD	AD	VD	AD	VD	AD	VD	AD	VD	A D
21-09-2006	41.9	-90.0	-55.5	0.0	-28.0	36.9	26.6	37.6	45.4	27.6	70.4	19 .3
22-09-2006	7.4	46.8	32.4	-108.3	20.9	-118.3	61.6	-121.2	14.9	46.8	-	-
23-09-2006	60.8	43.0	41.5	90.0	60.8	43.0	-	-	-	-	-	-
Mean error	36.7	-0.1	6.1	-6.1	17.9	-12.8	44.1	-41.8	30.2	37.2	70.4	19 .3

Legend: VD - Vector Difference (Km), AD - Angular Deviation (Deg.)

'Vector Difference' is the difference of the following two vectors:- (i) vector joining the initial position of the vortex and the observed position at relevant forecast hour; and (ii) vector joining the initial position of the vortex and the predicted position at relevant forecast hour; a negative value indicates predicted motion slower than actual and vice versa. 'Angular Deviation' is the angle between the above two vectors; negative value indicates predicted track to the left of the actual track and vice versa.