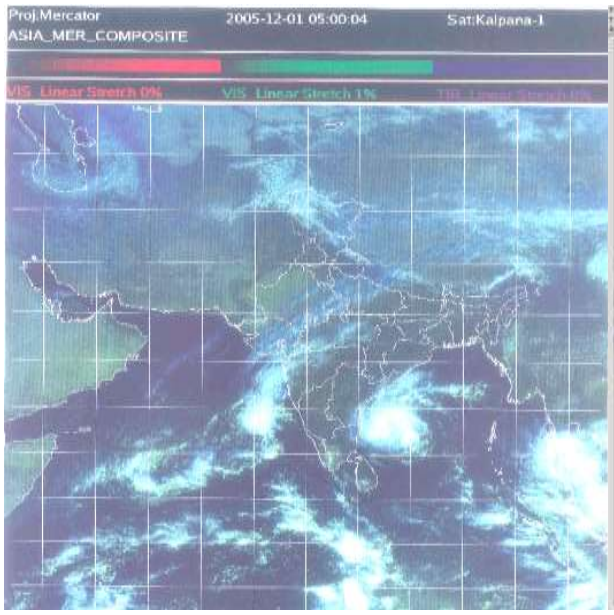
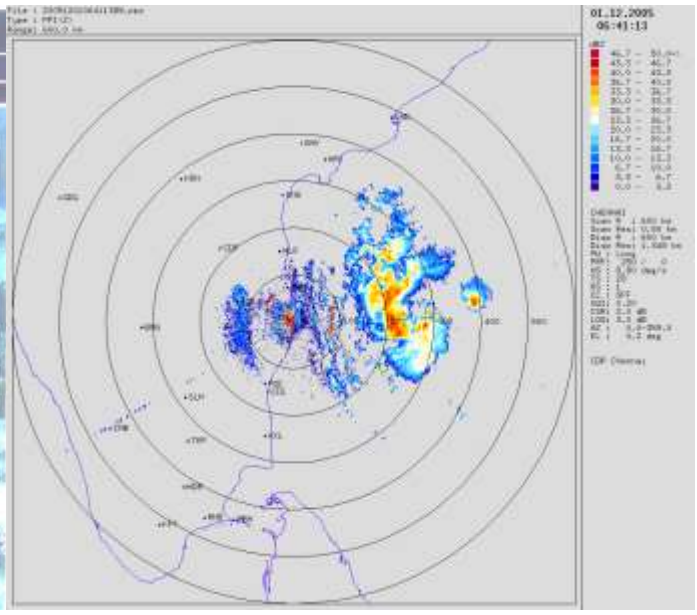
भारत मौसम विज्ञान विभाग

INDIA METEOROLOGICAL DEPARTMENT

REPORT ON CYCLONIC DISTURBANCES OVER NORTH INDIAN OCEAN DURING 2005



Kalpana-1 Imagery of cyclonic storm, 'BAAZ' at 0500 UTC of December 01, 2005



Doppler Weather Radar Chennai imagery of cyclonic storm, 'BAAZ' at 0641 UTC of December 01, 2005

RSMC-TROPICAL CYCLONES, NEW DELHI

JANUARY 2006

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INTRODUCTION

Regional Meteorological Centre (RMC) New Delhi was re-designated as Regional Specialized Meteorological Centre (RSMC) - Tropical Cyclones New Delhi with effect from July 1988 with 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 storms in the Bay of Bengal and the Arabian Sea.
- Running of numerical models for tropical cyclone track 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 at 6 - hourly intervals.
.
- Collection, processing and archival of all data pertaining to cyclonic storms 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 1

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 45^0 E and 100^0 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 and Cyclone Advisories on tropical cyclones (at three hourly interval) when they develop over the north Indian Ocean. RSMC New Delhi has commenced the practice of issuing Tropical Cyclone Advisories for Aviation as per requirements of International Civil Aviation Organisation (ICAO) from post monsoon season of 2003.

As per recommendation of WMO/ESCAP Panel, RSMC- New Delhi started naming of Tropical Cyclones formed over north Indian Ocean with effect from post monsoon season of 2004.

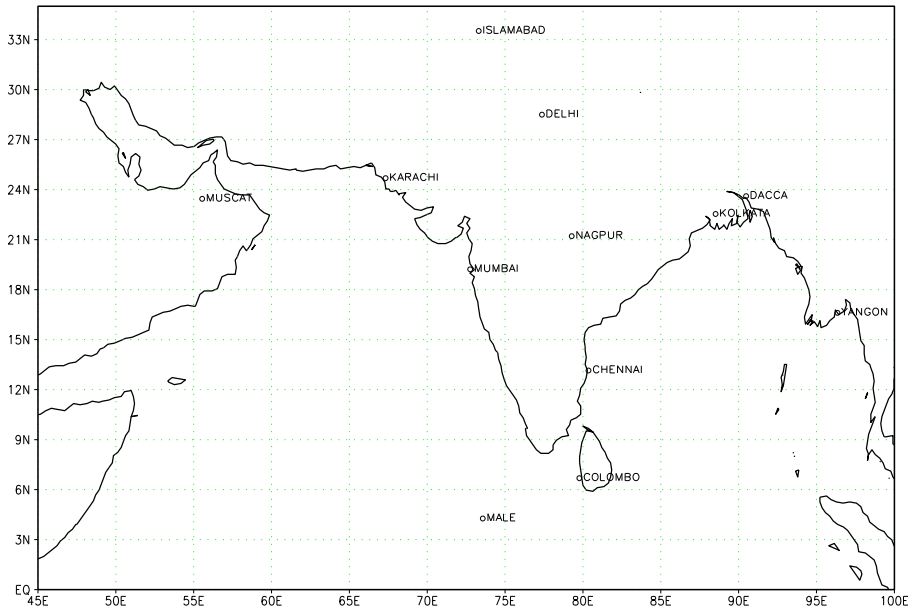


Figure 1.1 Area of responsibility of RSMC New Delhi

Analysis

Surface analysis of tropical disturbances is performed five times daily at 00, 03, 06, 12, and 18 UTC. During cyclone period, synoptic charts are prepared and analysed every three hour to monitor the tropical cyclonic storms that form over the north Indian Ocean.

Cloud images 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 a number of moored ocean buoys including meteorological buoy (MB) and shallow water (SW), deep sea (DS) and ocean thermal (OT) buoys deployed over the Indian Sea, under the National Data Buoy Programme of the Department of Ocean Development, Government of India. The existing Buoy network is given in fig 1.2.

The direction and speed of the movement of a tropical cyclone are determined primarily from the three hourly displacement vectors of the centre position and inputs from various numerical

models. When the system comes closer to the coastline, the system location and intensity are determined based on hourly observations from Radar stations as well as coastal observatories.

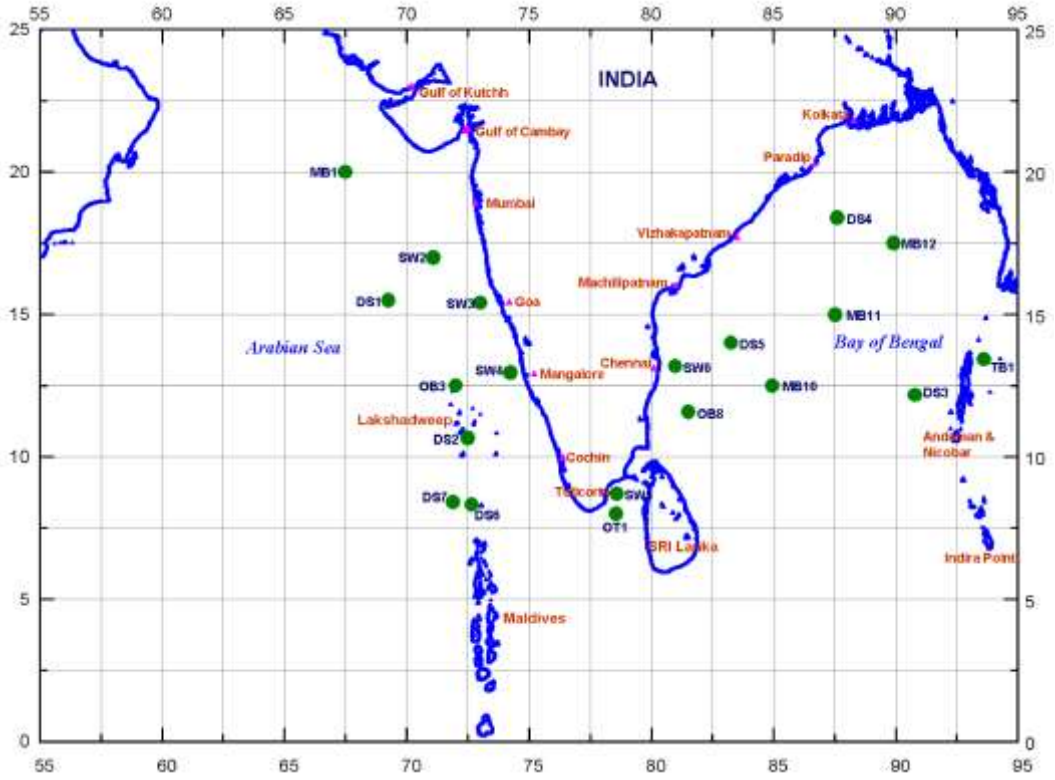


Fig.1.2. Existing buoys network over north Indian Ocean

Prediction system in operational use during the year 2005

(a) Quasi-Lagrangian Model (QLM)

The QLM, a multilevel fine-mesh primitive equation model with a horizontal resolution of 40 km and 16 sigma levels in the vertical, has been used for tropical cyclone track prediction. The integration domain consists of 111x111 grid points centred over the initial position of the cyclone. The model includes parameterization of basic physical and dynamical processes associated with the development and movement of a tropical cyclone. The two special attributes of the QLM are: (i) merging of an idealized vortex into the initial analysis to represent a storm in the QLM initial state; and (ii) imposition of a steering current over the vortex area with the use of a dipole. The initial fields and lateral 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 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^{o}x0.75^{o} 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, New Delhi. The forecast products are disseminated as a World Weather Watch activity of RSMC, New Delhi.

(c) Non-hydrostatic Mesoscale Model MM-5 (Version 3.6)

The non-hydrostatic model MM-5 has been 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^{o} S to 45^{o} N and long. 30^{o} E to 120^{o} 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 World Weather Watch activity of RSMC, New Delhi.

(d) Storm Surge Modelling

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 hydrodynamical 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^{o} N to 22.25^{o} N and long. 65^{o} E to 100^{o} 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 for use by the member Countries of WMO/ESCAP Panel. This contains description of synoptic systems over north Indian Ocean along with information on major 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

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 cyclone situation, 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, 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

The practice of issuing Tropical Cyclone Advisories for aviation was introduced from the post monsoon cyclone season of 2003. These bulletins 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. 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 74^0 E. Another Geostationary satellite under INSAT series (INSAT-3A) was launched in April, 2003 with the meteorological payloads identical to those of INSAT-2E and became operational since May , 2003. It is positioned over the equator at 93.5^0 E. Both these satellites provide imageries in visible, infrared (IR) and water vapour Channels. In addition INSAT-3A is also equipped with Charged Coupled Device (CCD) cameras capable of providing imageries in visible, Near IR (NIR and Shortwave 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 (MDD)

IMD transmits processed imagery, meteorological and fascimile 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 is uplinked 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 along with 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 under bilateral agreement. 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 (CWDS)

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 official and people in general 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 India Meteorological Department's Area Cyclone Warning Centres (ACWCs) at Chennai, Mumbai and Kolkata and Cyclone Warning Centre at Bhubaneswar, Visakhapatnam and Ahmedabad are responsible for originating and disseminating the cyclone warnings through CWDS. In this system, the cyclone warning bulletin is generated by concerned ACWC/ CWC for the areas affected or likely to be affected by the cyclone every hour. The cyclone warning bulletin is uplinked 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 in Andhra Pradesh. One hundred digital receiver stations with an uplink station at IMD, Chennai have been installed. These have shown good results.

CHAPTER 2

1. Cyclonic activities over north Indian Ocean during 2005

The year-2005, was a year of near normal cyclonic activity over north Indian Ocean. This basin witnessed the formation of twelve disturbances (Table 2.1) (against a normal of fifteen). Out of twelve disturbances, four (against a normal of five to six) intensified into cyclonic storms and three concentrated only upto deep depressions. There was one land depression during this year. Tracks of the systems are shown in fig. 2.

The Arabian Sea was less active and was devoid of any cyclonic storm. Only two depressions formed over that basin. On the other hand, the Bay of Bengal was more active with formation of four cyclonic storms, three deep depressions and two depressions during the year.

The first system, Cyclone **"HIBARU",** developed from a low pressure area which concentrated into a depression over southwest Bay of Bengal and adjoining Indian Ocean on the evening of 13th January, 2005. It remained practically stationary and intensified into a deep depression on the morning of 14th and into a cyclonic storm on the morning of 15th. Moving slowly in a westerly and then in a west-southwesterly direction it maintained its intensity till the morning of 17th, when it weakened into a deep depression and then into a depression on the same afternoon. On the same night, the system further weakened into a low pressure area over southwest Bay of Bengal and adjoining Indian Ocean.

The cyclone **"PYARR",** developed from a low pressure area over eastcentral Bay of Bengal on 16th September, 2005. Subsequently it intensified into a depression on 17th morning. The system initially moved in a west-northwesterly direction and then in a westerly direction and intensified into a deep depression in the morning of 18th. Subsequently the system moved in a southwesterly direction and intensified into a cyclonic storm in the same evening. Continuing to move in a southwesterly direction, the cyclone "PYARR" crossed north Andhra Pradesh coast close to Kalingapatnam in the morning of 19th. It remained as a cyclonic storm over north coastal Andhra Pradesh close to Kalingapatnam till the evening of 19th. It then moved west-northwestwards and weakened gradually into deep depression and then as a depression. On 22nd morning, it was seen as a well marked low pressure area over western parts of central India.

The third system formed from a well marked low pressure area which was seen over south Andaman sea and adjoining southeast Bay of Bengal on the morning of 27th November, 2005. It concentrated into a depression on the morning of 28th. Moving in a westerly direction, it intensified into a cyclonic storm **"BAAZ"** around midnight of 28th. Thereafter it moved swiftly in a northwesterly direction till the same evening. Then "BAAZ" became sluggish in its movement and hovered around the area till the morning of 01st December, 2005. Thereafter the system moving in a northwesterly direction, gradually weakened and dissipated over sea itself on the morning of 02nd December.

The cyclonic storm **"Fanoos",** developed from a low pressure area over south Andaman Sea. It intensified in to a depression and lay over southeast Bay of Bengal in the morning of 06th December,2005. Moving in a northwesterly direction, it further intensified into a deep depression in the same afternoon. Thereafter, it took a steady westerly direction and intensified into a cyclonic storm in the morning of 07th. It had southwestward movement till the morning of 08th. Thereafter it moved westwards till 10th morning. On 10th morning due to proximity to land, it weakened into a deep depression and crossed north Tamilnadu coast south of Nagapattinam (close to Vedaranyam) around 0530 UTC. After landfall, it rapidly weakened into a depression at 0600 UTC of the same day. Moving in a westerly direction, it weakened further into a low pressure area in the morning of 11th December.

Comprehensive information on Tropical Cyclone Activity over the north Indian Ocean for last five years is given in table 2.2. The frequency of cyclonic disturbances over the north Indian Ocean was highest after 1992.

Some of the characteristic features of these twelve 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.

Salient features :

- The formation of cyclonic storm in the month of January over low latitude is very rare, last such occurrence was in the year 1987 (30 Jan. – 4 Feb, over the Bay of Bengal). Though the system attained and remained as cyclonic storm for about two days, its movement was very sluggish (only about 50 km per day).

- No cyclone disturbance developed over north Indian Ocean during the pre-monsoon season (April – May).

- Monsoon season was quite active, compared to recent years in the past with the formation of one cyclonic storm and five depressions / deep depressions.

- During post monsoon season (October- December), systems formed over the southern latitude had their movement restricted only upto 15 degree north. Most of the systems during this period weakened before the landfall due to large vertical wind shear.

- No system intensified beyond the stage of cyclonic storm.

Table 2.1.

List of cyclonic disturbances during 2005

1.	Cyclonic Storm "HIBARU" over the Bay of Bengal, January 13-17
2.	Depression over the Arabian Sea, June 21-22
3.	Land depression June 27- July 05
4.	Deep Depression over the Bay of Bengal, July 29-31
5.	Depression over the Bay of Bengal, September 12-16
6.	Depression over the Arabian Sea, September 14-16
7.	Cyclonic Storm "PYARR" over the Bay of Bengal, September 17-21
8.	Deep Depression over the Bay of Bengal, October 26-29
9.	Depression over the Bay of Bengal, November 20-22
10.	Cyclonic storm " BAAZ" over the Bay of Bengal, November 28 – December 02
11	Cyclonic storm "FANOOS" over the Bay of Bengal, December 06-10
12	Deep Depression over the Bay Bengal, December, 15- 22

Table 2.2
The frequency of cyclonic disturbances over north Indian Ocean and adjoining region during 2000-2005

Year		D	DD	CS	SCS	VSCS	Total
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**

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 during 2005

Cyclonic Storm / Depression	Date, Time (UTC) & lat.^{0}N / long. ^{0}E of Genesis	Date, Time (UTC) place of landfall/ dissipation	Estimated lowest central pressure, Date &Time (UTC) & lat.^{o}N /long.^{o}E	Estimated Maximum wind speed (kt), Date & Time	Maximum T. No. attained
Cyclonic Storm "HIBARU" over Bay of Bengal, January 13-17	January 13, 1200 UTC near 5.5 / 87.0	Weakened over southwest Bay of Bengal in the night of January 17	1000 hPa at 0600 UTC on January 15 near 5.5/87.0	35 kt at 0300 UTC on January 15	T 2.5
Depression over Arabian Sea June 21-22	June 21, 0300 UTC near 21.5 / 68.5	Weakened over northeast Arabian Sea around morning of June 23	992 hPa at 0300 UTC on June 21 near Porbandar (42830)	25 kt at 0300 UTC on June 21	T 1.5
Land depression June 27 -July 05	June27, 1200 UTC near 21.5 / 88.0	Weakened over northwest Madhya Pradesh and adjoining west Uttar Pradesh in the morning of July 06	990 hPa at 1200 UTC on June 27 near 21.5/88.0	25 kt at 1200 UTC on June 27	
Deep Depression over Bay of Bengal July 29-31	July 29, 0300 UTC near 21.5 / 87.5	Crossed Orissa coast close to Balasore (42895) around noon of July 30	988 hPa at 1200 UTC on July 30 near 21.5/85.5	30 kt at 0300 UTC July 30	T 2.0
Depression over Bay of Bengal, September 12-16	September 12, 0300 UTC near 20.0 / 88.0	Crossed Orissa coast near Paradip (42976) around afternoon of September 12	992 hPa at 0300 UTC on September 12 Near 20.0/88.0	25 kt at 0300 UTC on September 12	T 1.5
Depression over Arabian Sea September 14-16	September 14, 0300 UTC near 20.0/ 68.5	Crossed north Saurashtra coast north of Porbandar (42830) around midnight of Sept. 16	996 hPa at 0300 UTC on September 14 near 20.0/68.5	25 kt at 0300 UTC on September 14	T 1.5
Cyclonic Storm "PYARR" over Bay of Bengal, September 17-21	September 17, 0300 UTC near 20.0 / 90.5	Crossed Andhra Pradesh coast near Kalingapatnam (43105) in the morning of Sept. 19	988 hPa at 2100 UTC on September 18 Near18.5/84.5	40 kt at 1800 UTC on September 18	T 2.5
Deep Depression over Bay of Bengal October 26-29	October 26, 0300 UTC near 12.0/ 84.5	Crossed south Andhra Pradesh coast near Ongole (43221) in the afternoon of October 28	998 hPa at 0600 UTC on Oct. 27 near 13.0/81.5	30 kts at 1800 UTC on October 26	T 2.0

Table 2.3 (contd)

Some Characteristic features of cyclonic disturbances during 2005

Cyclonic Storm / Depression	Date, Time (UTC) & lat.^{0}N / long. ^{0}E of Genesis	Date, Time (UTC) place of landfall/ dissipation	Estimated lowest central pressure, Date &Time (UTC) & lat. ^{o}N. / long. ^{o}E	Estimated Maximum wind speed (kt), Date & Time	Maximum T. No. attained
Depression over Bay of Bengal November 20-22	November 20, 0300 UTC near 8.0/ 84.5	Crossed Sri Lanka coast around 00 UTC of Nov. 22	1002 hPa at 0300 UTC on November 20	25 kt at 0300 UTC on Nov. 20	T 1.5
Cyclonic storm " BAAZ" over Bay of Bengal, November 28 – December 02	November 28, 0300 UTC near 10.5/ 90.5	Weakened over southwest and adjoining westcentral Bay of Bengal on December 02 around noon.	998 hPa at 0600 UTC on November 29 Near 11.0/86.0	45 kt at 0300 UTC on November 29	T3.0
Cyclonic storm "FANOOS" over Bay of Bengal December 06-10	December 06, 0300 UTC near 10.5^0 N/89.5^0 E	Crossed Tamilnadu coast Close to Vedaranyam (43349) south of Karaikal (43346) the forenoon of December 10	998 hPa at 0900 UTC on December 7 near11.0/86.5	45 kt at 0900 UTC on Dec. 7	T3.0
Deep Depression over Bay of Bengal December 15- 22	December 15, 1200 UTC near 8.0/ 87.0	Weakened over southwest and adjoining central Bay of Bengal on December 22 forenoon	1000 hPa at 0300 UTC on December 17 Near 8.0/84.0	30 kt at 0300 UTC on December 17	T 2.0

Table 2.4

Statistical data relating to cyclonic disturbances over the north Indian Ocean during 2005

a) Monthly frequencies and total lifetime of cyclonic disturbances (CI ≥ 1.5)

S.No	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Life Time in (Days)
1.	D						↔ ↔			↔ ↔		↔		**22**
2.	DD							↔			↔		↔	**15**
3.	CS	↔								↔		↔	↔	**20**
4.	SCS													
5.	VSCS													
6.	SuCS													

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**	**7**	**4**	**2**	**-**	**-**	**-**	**-**

c) Basin-wise distribution of cyclonic disturbances

Bay of Bengal	**9**
Arabian Sea	**2**
Land depression	**1**

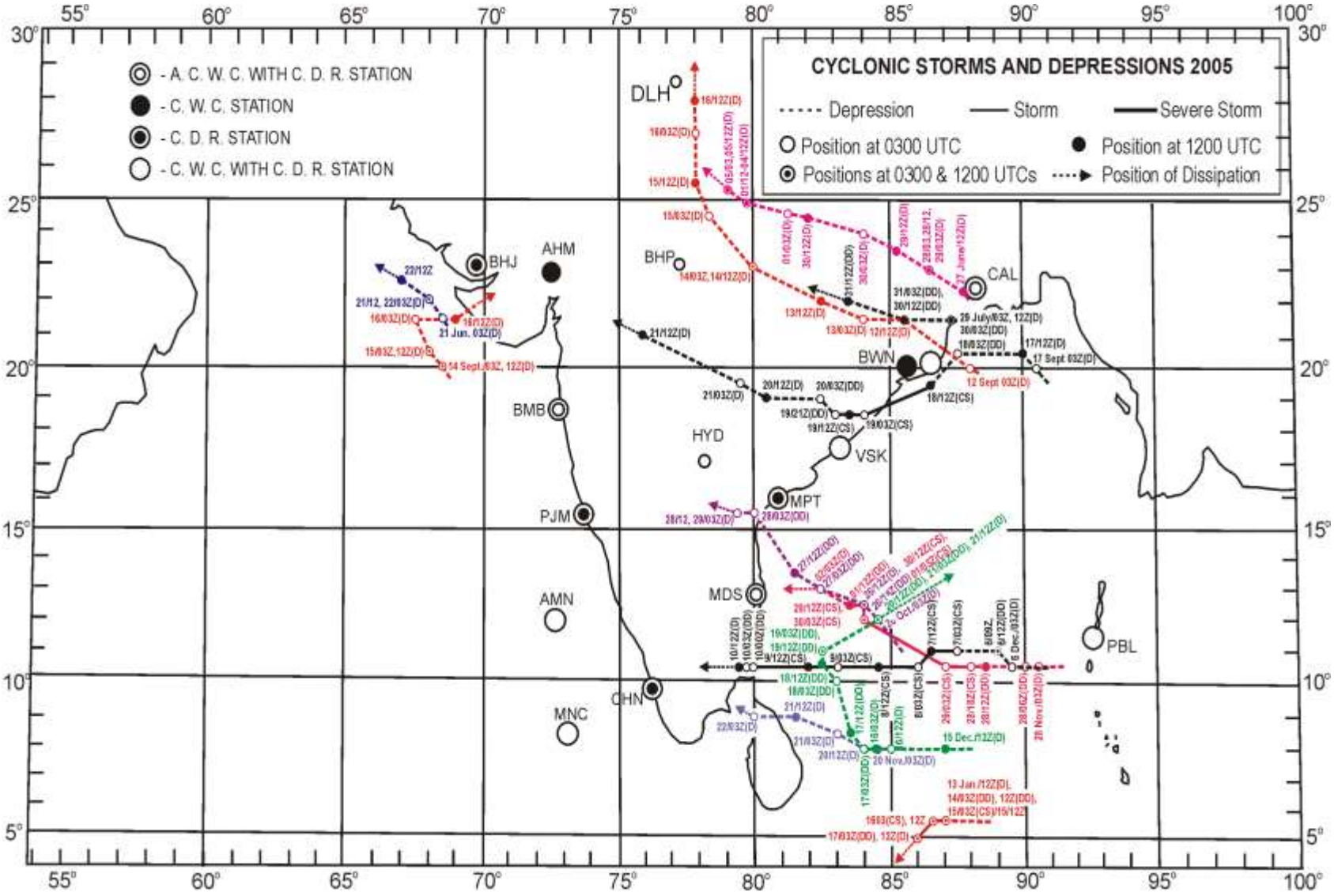


Fig.2. Tracks of cyclonic storms and depressions during 2005

- **Brief Description of the Systems**

2.1 Cyclonic Storm "HIBARU" over Bay of Bengal January 13-17, 2005

A low pressure area formed over southeast Bay of Bengal and adjoining equatorial Indian Ocean on January 12, 2005. It concentrated into a depression over southeast Bay and lay centred at 131200 UTC near lat 5.5^0N/ long. 87.0^0 E. The system remained practically stationary and intensified into a deep depression at 140300 UTC. It further intensified into a cyclonic storm at 150300 UTC. The system remained practically stationary once again till 160000 UTC. Subsequently the system moved slowly westwards and lay centred near lat 5.5^0N/ long 86.5^0E at 160300 UTC. The cyclonic storm weakened into a deep depression and lay centred at 170000 UTC near lat 5.5^0N/ long 86.0^0E. It further weakened into a depression at 170900 UTC. The system weakened into a low-pressure area at 171800 UTC over southwest Bay of Bengal and adjoining equatorial Indian Ocean.

The track of the system is given in Fig. 2. The best track and other parameters are given in Table 2.1.1. A few KALPANA-1 cloud imageries of the system are shown in Fig. 2.1.1.

Realised weather:

As the system did not cross the coast and weakened out at sea; it did not cause any adverse weather in India.

Significant features:

- The formation of cyclonic storm in the month of January is very rare, last such occurrence was in the year 1987 (30 Jan. – 4 Feb) ,over the Bay of Bengal.
- The system formed at a very low latitude.
- Though the system attained the cyclonic storm intensity and remained so for about two days, its movement was very sluggish.

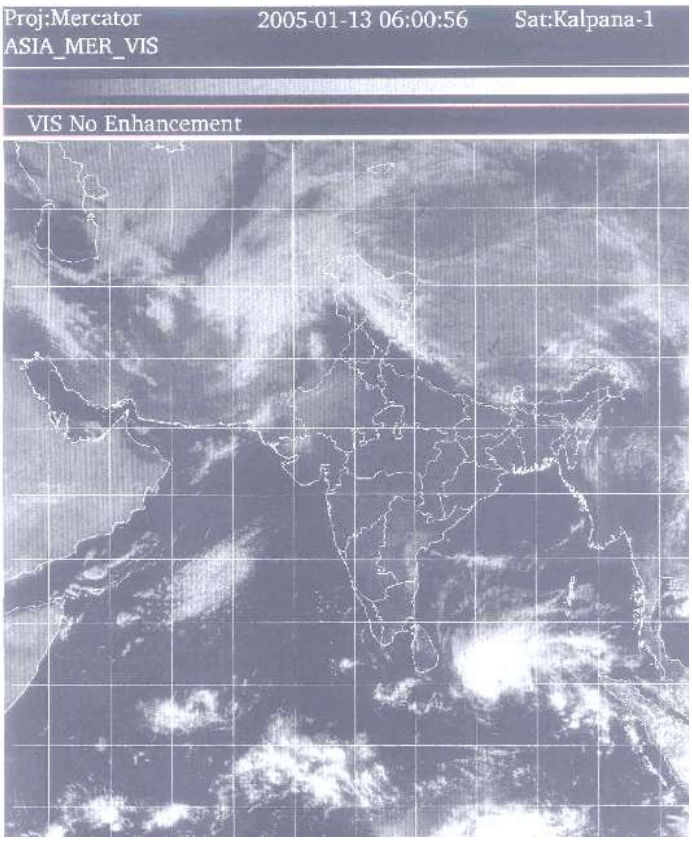
Table 2.1.1

Best track positions and other parameters for Bay of Bengal cyclonic storm, 'HIBARU' (January 13-17, 2005)

Date	Time (UTC)	Centre lat.^{0} N/ long.^{0} E	C.I. NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
13-01-2005	1200	5.5/87.0	1.5	1006	25	4	D
14-01-2005	0300	5.5/87.0	2.0	1004	30	4	DD
	1200	5.5/87.0	2.0	1004	30	4	DD
15-01-2005	0300	5.5/87.0	2.5	1002	35	6	CS
	0600	5.5/87/0	2.5	1000	35	6	CS
	0900	5.5/87/0	2.5	1000	35	6	CS
	1200	5.5/87/0	2.5	1000	35	6	CS
	1500	5.5/87.0	2.5	1002	35	6	CS
	1800	5.5/87.0	2.5	1002	35	6	CS
	2100	5.5/87.0	2.5	1002	35	6	CS
16-01-2005	0000	5.5/87.0	2.5	1004	35	6	CS
	0300	5.5/86.5	2.5	1004	35	6	CS
	0600	5.5/86.5	2.5	1004	35	6	CS
	0900	5.5/86.5	2.5	1002	35	6	CS
	1200	5.5/86.5	2.5	1002	35	6	CS
	1500	5.5/86.5	2,5	1002	35	6	CS
	1800	5.5/86.5	2.5	1004	35	6	CS
	2100	5.5/86.5	2.5	1004	35	6	CS
17-01-2005	0000	5.5/86/0	2.0	1004	30	4	DD
	0300	5.0/86.0	2.0	1004	30	4	DD
	0600	5.0/86.0	2.0	1004	30	4	DD
	0900	5.0/86.0	1.5	1004	25	4	D
	1200	5.0/86.0	1.5	1006	25	4	D

The system weakened into a well marked low pressure area and lay over southwest Bay of Bengal and adjoining equatorial Indian Ocean in the night of January 17, 2005

(a)



(b)

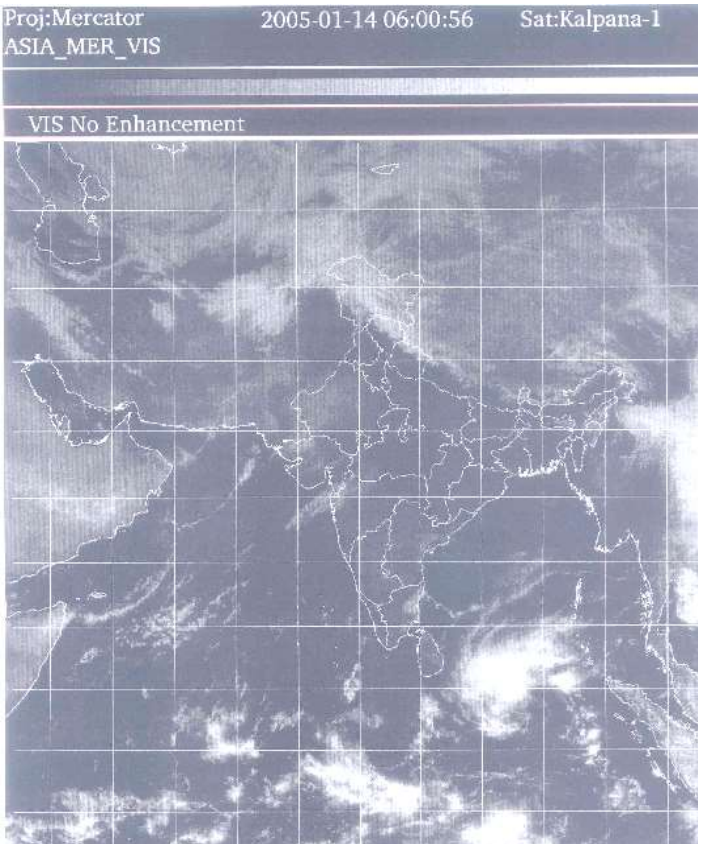


Fig. 2.1.1. Kalpana-1 imageries (a) at 0600 UTC of January 13, 2005 showing the organization of the vortex in association with the depression and (b) at 0600 UTC of January 14, 2005 showing shear pattern of cloud mass in association with the system.

(c)

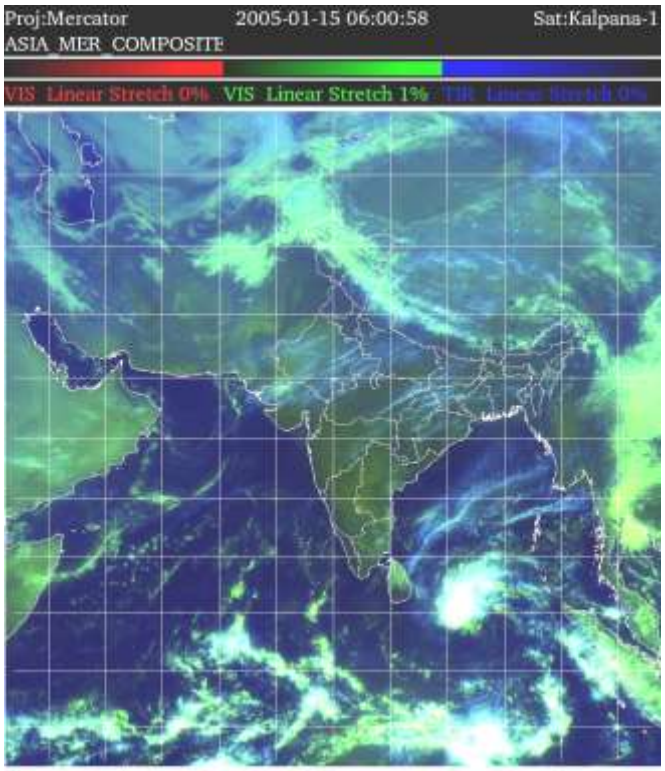


Fig. 2.1.1. (contd). Kalpana-1imagery (c) at 0600 UTC of January 15, 2005 showing the dense convective cloud mass to the southwest sector of the low cloud system centre in association with the cyclonic storm, “HIBARU”.

2.2 Depression over northeast Arabian Sea (June 21-22, 2005)

A deep convective cloud cluster developed over northeast Arabian Sea in association with the off shore trough ahead of the monsoon current during the third week of June. Under its influence a depression formed over northeast Arabian Sea and adjoining Saurashtra and Kutch and lay centred at 210300 UTC near lat 21.5^0N/ long 68.5^0 E. Moving in a northwesterly direction, it lay centred at 220300 UTC near lat. 22.0^0N/ long.68.0^0E. Thereafter it moved in a westerly direction and weakened into a well marked low pressure area over northeast Arabian Sea on 23rd morning.

The track of the system is given in Fig.2. The best track and other parameters are given in Table 2.2.1. A few KALPANA-1 cloud imageries of the system are shown in Fig.2.2.1.

Realized weather:

Under the influence of this depression fairly widespread rainfall occurred over Gujarat State. Significant amounts of rainfall in cm are below;

21-06-2005 Naliya – 3
22-06-2005 Veraval – 7, Porbandar – 5.

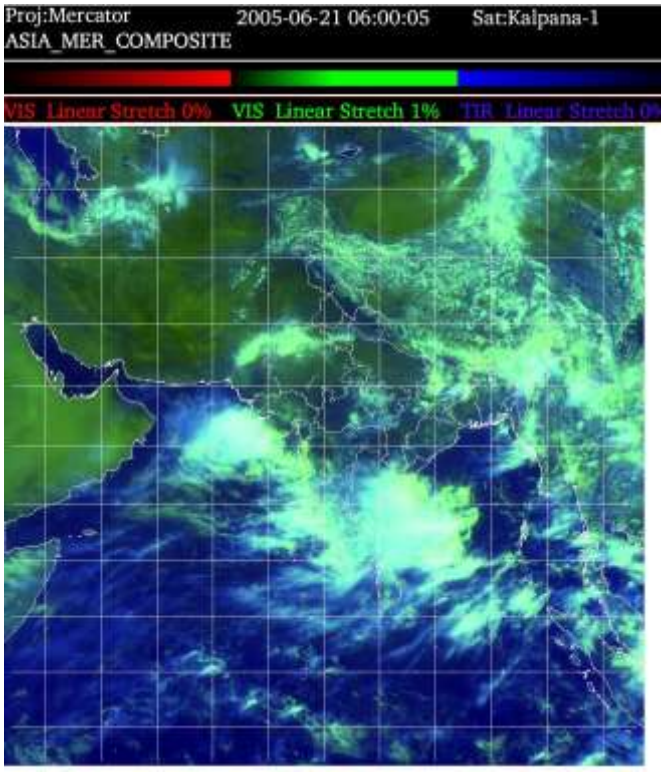
Damage: There was no damage reported in India due to the system.

Table 2.2.1
Best track positions and other parameters for Arabian Sea depression (June 21-22, 2005)

Date	Time (UTC)	Centre lat.^{0}N/ long.^{0} E	C.I. NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
21-06-2005	0300	21.5/68.5	1.5	992	25	4	D
	1200	22.0/68.0	1.5	994	25	4	D
22-06-2005	0300	22.0/68.0	1.5	994	25	4	D
	1200	22.0/67.0	1.5	992	25	4	D

The system weakened and lay over northeast Arabian Sea on 23rd morning.

(a)



(b)

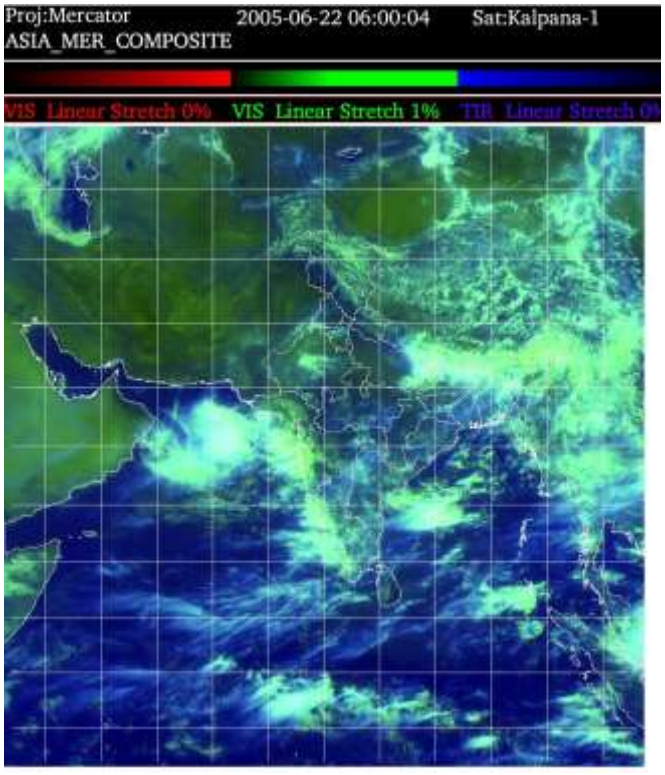


Fig. 2.2.1. Kalpana-1 imageries (a) at 0600 UTC of June 21, 2005 showing the shear pattern of cloud mass in association with the depression over Arabian Sea and (b) at 0600 UTC of June 22, 2005 showing deep convective cloud clusters in the western sector of the system.

2.3 Land depression (June 27 to July 05, 2005)

The low pressure area formed over northwest Bay of Bengal on the morning of 27th June . It rapidly moved inland and concentrated into a depression over Gangetic West Bengal close to Kolkata (42807) at 1200 UTC of 27th.It moved west-northwestwards and lay centred at 290300 UTC near Jamshedpur (42798). The system further moved west-northwestwards with the same intensity and lay centred close to Khajuraho (42567) at 0300 UTC of July 3. The system weakened into a well marked low pressure area over southwest Uttar Pradesh and adjoining northwest Madhya Pradesh at 060300 UTC.

The track of the system is given in Fig. 2. The best track and other parameters are given in Table 2.3.1. A few KALPANA-1 cloud imageries of the system are shown in Fig. 2.3.1.

Realised weather :

Under the influence of this depression, widespread rainfall with isolated heavy falls occurred on 28 & 29 June over Gangetic West Bengal; on 30 June over Jharkhand; on 2-5 July over east Madhya Pradesh, on 4-7 July over west Madhya Pradesh and east Rajasthan. The significant amounts of rainfall (in cm) are given below.

Gangetic West Bengal

28-06-05	Bagati (Magra)-11, Kolkata Airport-8, Digha & Diamond Harbour-7 each.
29-06-05	Sriniketan & Krishnanagar-5 each.

Jharkhand

30-06-05	Daltonganj-6.

East Madhya Pradesh

02-07-05	Satna-19, Jabalpur-7.
03-07-05	Satna-19, Sagar-12, Nowgong & Khajuraho-7 each.
04-07-05	Sagar-48, Jabalpur-17.
05-07-05	Jabalpur-8.

West Madhya Pradesh:

04-07-05	Chachauha & Guna-7each.
05-07-05	Bhopal & Hoshangabad-9 each,
06-07-05	Bhora-10, Chechora, Chanderi-9 each,Vidisha-7.

Rajasthan:

04-07-05	Mount Abu-13.
05-07-05	Ansawar-19, Aklera, Sangod-17 each, Khanpur-16,Jhalarapatan-13, Jhalawar-11,Bakni-9. Manohar Thana-8, Jayal & Malsi-7 each.
06-07-05	Chipaboard-13.Arnod-12,Malernandgaon.Nagaur-11 each, Chabra-10,Aklera, Sikar-9 each,Khanpur, Manohar Thana & Paota-8 each. Bharatpur,Sambhar-7 each.

07-07-05 Bahadurgarh-15, Govindgarh-14, Ramgarh-13,Kishangarhwas & Mandawar-12 each, Laxmangarh-11,Nadwai & Tizara-9 each, Anta , Chabra,Kathumar,Mahuva & Nimrana-8 each,Bari, Deeg,Dhaulpaur, Nagaur-7each.

Damage: No damage was reported due this system**.**

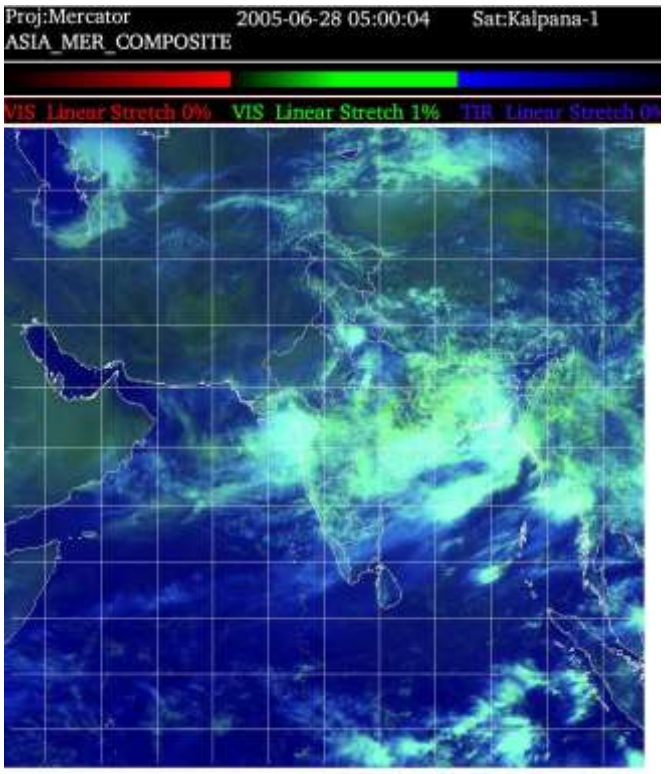
Table 2.3.1

Best track positions and other parameters for land depression
(June 27 to July 05, 2005)

Date	Time (UTC)	Centre lat.^{0}N/ long.^{0} E	C.I. No.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
27-06-2005	1200	21.5/88.0	-	990	25	4	D
28-06-2005	0300	23.0/86.0	-	990	25	4	D
	1200	23.0/86.0	-	990	25	4	D
29-06-2005	0300	23.0/86.0	-	990	25	4	D
	1200	23.5/85.5	-	990	25	4	D
30-06-2005	0300	24.0/84.0	-	990	25	4	D
	1200	24.0/82.0	-	990	25	4	D
01-07-2005	0300	24.5/80.5	-	990	25	4	D
	1200	24.5/80.5	-	990	25	4	D
02-07-2005	0300	24.5/80.5	-	990	25	4	D
	1200	24.5/80.5	-	990	25	4	D
03-07-2005	0300	24.5/80.5	-	990	25	4	D
	1200	24.5/80.5	-	990	25	4	D
04-07-2005	0300	25.0/79.5	-	990	25	4	D
	1200	25.0/79.5	-	990	25	4	D
05-07-2005	0300	26.0/80.0	-	990	25	4	D
	1200	26.0/80.0	-	990	25	4	D

The system weakened as a well marked low pressure area and lay over southwest Uttar Pradesh and adjoining northwest Madhya Pradesh at 060300 UTC

(a)



(b)

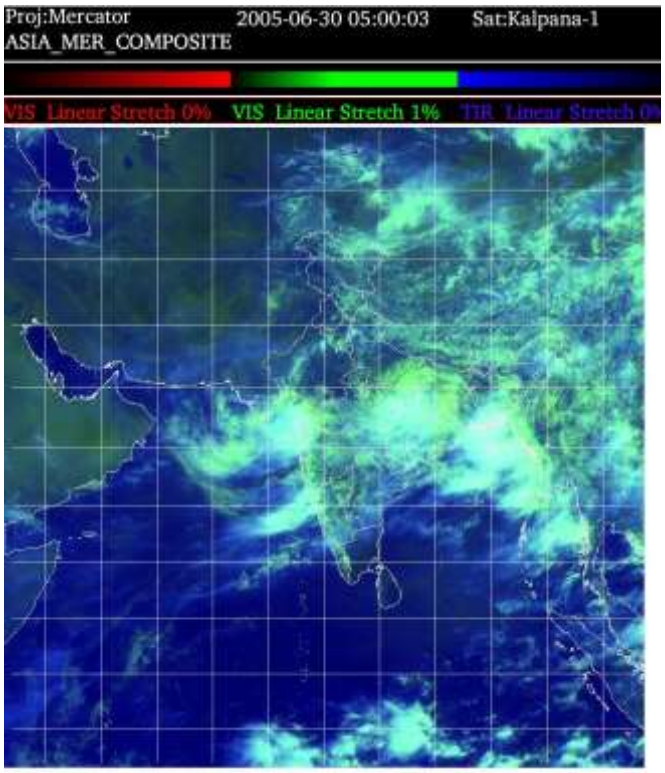
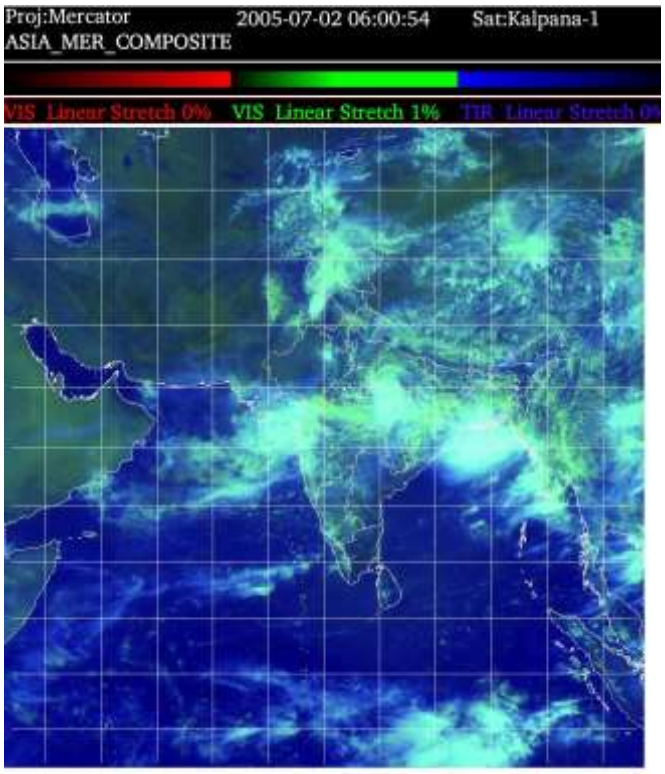


Fig. 2.3.1. Kalpana-1 imageries (a) at 0500 UTC of June 28, 2005 showing the organization of vortex in association with the depression over Jharkhand and (b) at 0500 UTC of June 30, 2005 showing distribution of convective cloud mass due to depression over Chhattisgarh and associated monsoon trough.

(c)



(d)

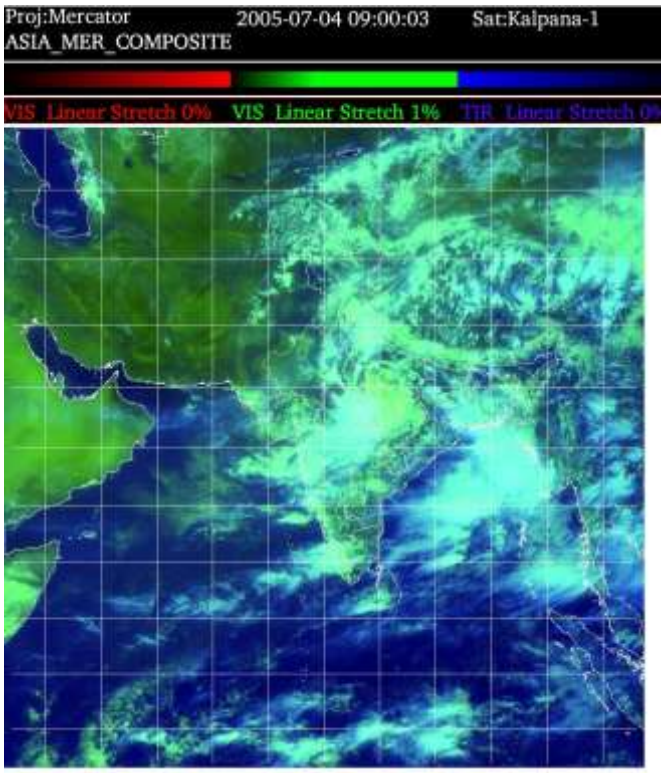


Fig. 2.3.1. (contd). Kalpana-1 imageries (c) at 0600 UTC of July 02, 2005 and (d) at 0900 UTC of July 04, 2005 showing the distribution of convective cloud mass in association with the depression over north Madhya Pradesh and neighbourhood.

2.4 Deep Depression over Bay of Bengal (July 29- 31, 2005)

A low pressure area formed over northwest Bay of Bengal on 28th July, 2005 It concentrated into a depression and lay centred at 290300 UTC near Lat. 21.5^{0}N /87.5^{0}E. It remained practically stationary till 30th morning when it intensified into a deep depression and lay over the same place. The system crossed coast near Balasore (42895) around 30th noon and lay centred at 310300 UTC near near lat. 21.5^0 N/ long. 85.5^0 E. It lay centred at 311200 UTC near Champa (42783) in Chhattisgarh. Afterwards, the system moved west-northwestwards and rapidly weakened into a well marked low pressure area over central Madhya Pradesh on the morning of 1st August.

The track of the system is given in Fig. 2. The best track and other parameters are given in Table 2.4.1. A few KALPANA-1 cloud imageries of the system are shown in Fig. 2.4.1 and the radar picture taken by DWR Kolkata is shown in Fig. 2.4.2.

Realised weather:

Under the influence of deep depression, widespread rainfall with isolated heavy to very heavy falls occurred on July 29 to 31 in Orissa and on July 31 in Chhattisgarh. Significant rainfall (in cm) are given below:

Orissa:

29-07-05 Chandbali- 25, Thakumunda- 23, Rajkanika- 19, Anandpur -9, Pallahara - 9,Swampatna, Kendrapada & Paradip –8 each.

30-07-05 Tikarapada & Rairakhol –31 each,Athagarh & Khandapada –29 each, Hindol -26, Akhuapada -25, Chandbali, Narai& Athamalik -24 each, Mundali, Rajkanika, Rajkishorenagar & Dhenkanal -22 each, Cuttack, Jamankira -21 each, Pallahara, Rengali & Talcher -20 each, Angul -19, Jenapur, Kendrapara, Binika-18 each, Narsinghpur, Bargarh & Sambalpur -17 each, K-Nagar, Bijepur & Nimapad -16 each, Phulbani & Bhubaneswar-15 each, Khiramal, Kuchinda, Nayagarh & Kantamal -14 each, Alipingal & Dunguripalli- 13 each, Jajpur, Jhumpura, Hiraqkund, Pipli, Tikabali & ,Harbhanga-12 each, Kakatpur -11, Joshipur, Sohella & Sonepur -10 each, Bolangir, Puri & Baliguda- 9 each, Jharsuguda-8, Soro, Bonth, Paraqdeep, Keonjhar, Baripada, Rairangpur & Naktideul 7 each,

31-07-05 Ambabhona -31, Pallahara- 26, Baragarh- 21, Bijepur- 20, Nakatideul,Khairamal & Rengali -19 each, Phulbani- 15,Rairakhol- 14, Sambalpur, Kuchinda, Jamankira& Athamalik- 12 each, Kantamalik -11, Padampur & Rajkishore Nagar -10 each. Deogarh,Belgaon & Harabhanga 9 each, Hirakund & Athagarh 8 each, Tikarpada 7.

Chhattisgarh:

31-07-05 Katghora -19, Raipur -18, Arang -16, Rajim & Bilaspur-15 each, Mana Airport ,Gariaband & Sarangarh -14each, Mahasamund -11, Dhamtarai & Raigarh -10 each, Mungeli,Gandai & Saraipali-8 each, Pali & Champa -7 each.

Damage: No damage was reported due to this system.

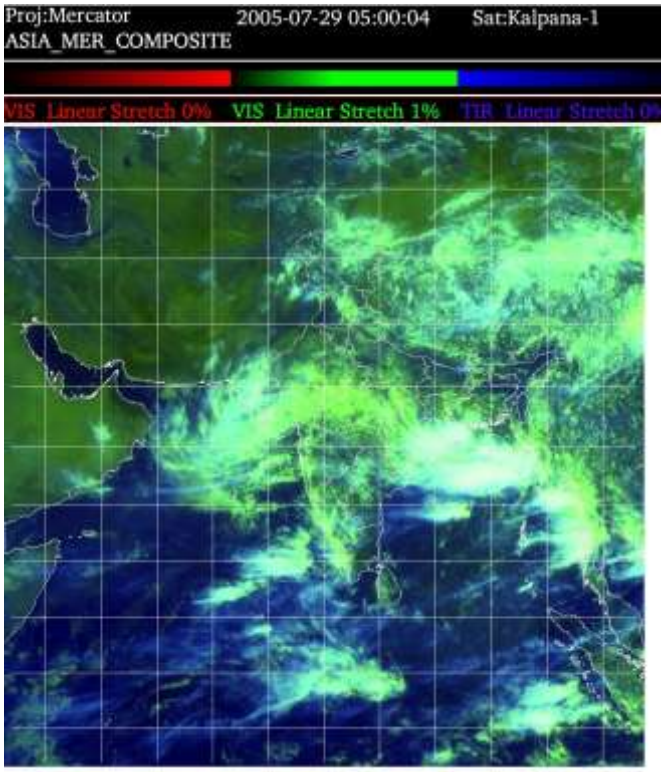
Table 2.4.1

Best track positions and other parameters for Bay of Bengal deep depression (July 29- 31, 2005)

Date	Time (UTC)	Centre lat.^{0} N/ long.^{0} E	C.I. NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
29-07-2005	0300	21.5/87.5	1.5	992	25	4	D
	1200	21.5/87.5	1.5	990	25	4	D
30-07-2005	0300	21.5/87.5	2.0	990	30	5	DD
	1200	21.5/85.5	2.0	988	30	5	DD
31-07-2005	0300	21.5/85.5	2.0	990	30	5	DD
	1200	22.0/82.5	2.0	990	30	5	DD

The system weakened rapidly into a well marked low pressure area over central parts of Madhya Pradesh on the morning of August 1, 2005.

(a)



(b)

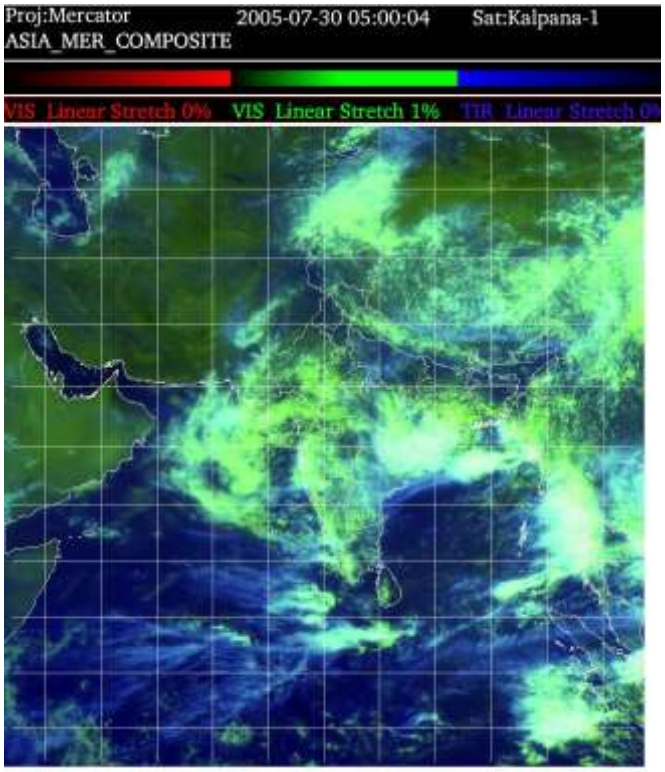


Fig. 2.4.1. Kalpana-1 imageries (a) at 0500 UTC of July 29, 2005 showing the organization of vortex in association with the depression over northwest Bay of Bengal and (b) at 0500 UTC of July 30, 2005 showing shear pattern of cloud mass in association with the system close to Balasore (India).

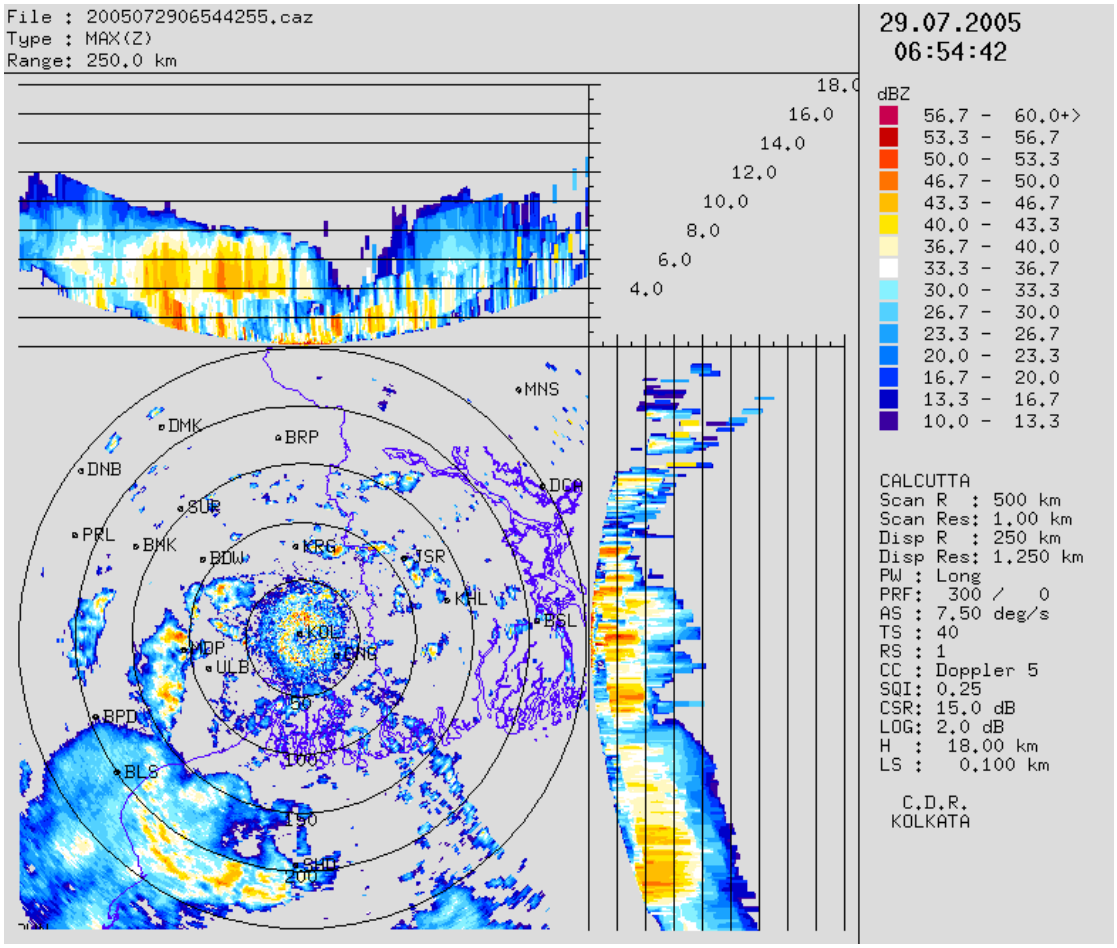


Fig. 2.4.2. Radar imagery taken by DWR Kolkata at 0654 UTC of 29th July, 2005 showing active convection in the southwest sector of the depression.

2.5 Depression over Bay of Bengal (September 12-16, 2005)

A low pressure area formed over west central and adjoining northwest Bay of Bengal on 10th September 2005. It moved over to northwest Bay of Bengal on 11th. It concentrated into a depression over northwest Bay of Bengal and lay centred at 120300UTC close to Paradip (42976). The system moved northwestwards and crossed Orissa coast near Paradip around 120900 UTC and lay centred at 121200UTC near Lat.21.0^0 N/Long 85.5^{0}E close to Keonjhargarh. Retaining the intensity of depression the system moved initially northwestwards and then northwards till 16th. It weakened into a well marked low pressure area over west Uttar Pradesh and adjoining Uttaranchal at 170300 UTC.

The track of the system is given in Fig. 2. The best track and other parameters are given in Table 2.5.1. A few KALPANA-1 cloud imageries of the system are shown in Fig. 2.5.1.

Realised weather:

Under the influence of depression, widespread to fairly widespread rainfall activity was realized from 12 to 15 September in Orissa (with heavy to very heavy falls at a few places); from 12 to 14 September in Chhattisgarh (with isolated heavy to very heavy falls); on 14 and 15 September in Madhya Pradesh (with isolated heavy to very heavy falls). It also gave fairly widespread rainfall with isolated heavy to very heavy falls in east Uttar Pradesh on 16 & 17 September and widespread rainfall activity in Uttar Pradesh & Uttaranchal on 17 & 18 September and fairly widespread with isolated heavy to very heavy falls in south Rajasthan from 14 to 16 September. The chief amounts of rainfall (in cm) are as follows.

Orissa:

12-09-05 Nowrangpur -30, Jeypore- 17, Mohana -16, Bhavanipatna -14, Udala & Tikabali -10 each, Dhenkanal, Malkangiri, Baliguda -9 each, Nilgiri, Hindol, Madanpur Rampur, Phulbani –8 each, Soro, Athangarh, Angul, Mahendragarh, Udaigiri, Junagarh, Lajigarh, Puri -7 each.

13-09-05 Bhavanipatna- 27, Hindol -23, Narsingpur- 22 , Junagarh, Nayagarh & Phulbani -21 each, Nawarangpur & Baliguda -17 each, Khariar -16, Mandanpur Rampur -15, Jaipatna -14, Komna, Jeypore, Belgaon & Kotraguda -13 each, Paradip, Barmul & Dashpalla- 12 each, Tikarapada, Paikmal, Bhanjanagar, Boudhgarh, Kantamal, Umerkote, Khandapada, Bolangir & Titlagarh -11 each, Rajghat, Chandbali ,Madhabarida & Ranpur- 10 each, Rajkanika, Mohana, Surada & Koraput -9 each. Nilgiri, Akhuapada, Athamalil & Nawapara –8 each, Bhograi, Soro, Khairamal, Padampur & Baripada - 7 each.

14-09-05 Rajghat -27, Bhograi- 22, Bangiriposh -15, Hemgiri- 13, Paikmal -12, Ambabhona, Nawapara & Balasore -8 each, Swampatna, Bijepur, Padampur, Baripada & Patnagarh- 7 each.

15-09-05 Bhograi- 16, Thakurmunda- 9, Paradip -8.

Chhattisgarh:

12-09-05 Devbhog-11, Durg-9, Raipur & Narayanpur-8 each

13-09-05 Gariaband -14, Kondagaon & Balod -13 each, Narayanpur, Mahasamund -12 each, Dongargarh -11, Jagdalpur & Kanker -10 each, Ambagarh, Chowki- 9, Rajnandgaon, Dongargaon -8 each, Raipur- 7.

14-09-05 Dongargarh-23, Dondilohara-20, Narayanpur-18, Dongargaon-12, Ambagarh, Chowki & Champa -11 each, Durg, Rajnandgaon & Gandai -9 each,Raipur & Janjgir -8 each, Arang, Gariaband & bemitara -7 each.

Madhya Pradesh:

14-09-05 Seoni –21,Betul- 8, Khandwa- 7.

15-09-05 Mandla -18, Sailana -16, Jabalpur- 15, Seoni-14, Chhindwara, Amarwara & Chansore -13 each, Multai & Keolari -11 each,Balaghat & Umaria -10 each, Bhasdehi, Bhopal, Harda & Indore- 9 each, Jaora, Pachmari,Betul & Narsingpur- 8 each, Mhow, Depalpur & Maihar -7 each

Rajasthan:

14-09-05 Pushkar -8, Hanumangarh & Sangaria -7 each

15-09-05 Danpur- 19, Kesarpura -18, Banawara -11, Bhuugra -10, Ghatol- 9, Dhambola, Galiakot & Shergarh -8 each, Arthuna -7

16-09-05 Anta -20, Baran -16, Begu- 14, Pindwara -13, Deeg- 12, Bali- 9, Gudamalani & Jalore- 8 each, Ahore, Bagoda,Telhara & Veja -7 each.

.

Uttar Pradesh:

16-09-05 Kanpur -15, Dalmau & Lucknow -13 each, Raebareilly,Hanumansetu -12 each , Bhatpurwaghat, Chillaghat ,Auriya, Ankinghat -11 each, Ayodhya & Neeemsar -10 each, Banda,Elginbridge,Fatehpur & Bareilly-9 each, Mainpuri -8, Kalpi -7.

17-09-05 Bareilly -27, Bhinga -18, Kakardharighat, Bansi & Bahraich -12 each, Ayodhya 11, Kakarahi & Katerniaghat -10 each Balrampur -9, Paliakalan-8, Regoli& Narora -7 each

Uttaranchal:

17-09-05 Srinagar & Santipuri -24 each, Nainital- 20, Kalagarh & Pantnagar- 17 each, Pati 11, Marora- 9, Karanprayag& Hardwar -7 each

18-09-05 Kalagarh- 13, Pantnagar- 10, Srinagar -9, Haridwar -8, Tehri & Marora -7 each

Damage :

As per available press reports, 6 persons died and many low lying villages were flooded by heavy rain in Madhya Pradesh. According to the Director of Agriculture, Government of Orissa, 75,343 hectors of cropped area were submerged after heavy downpour during 12-13 September.

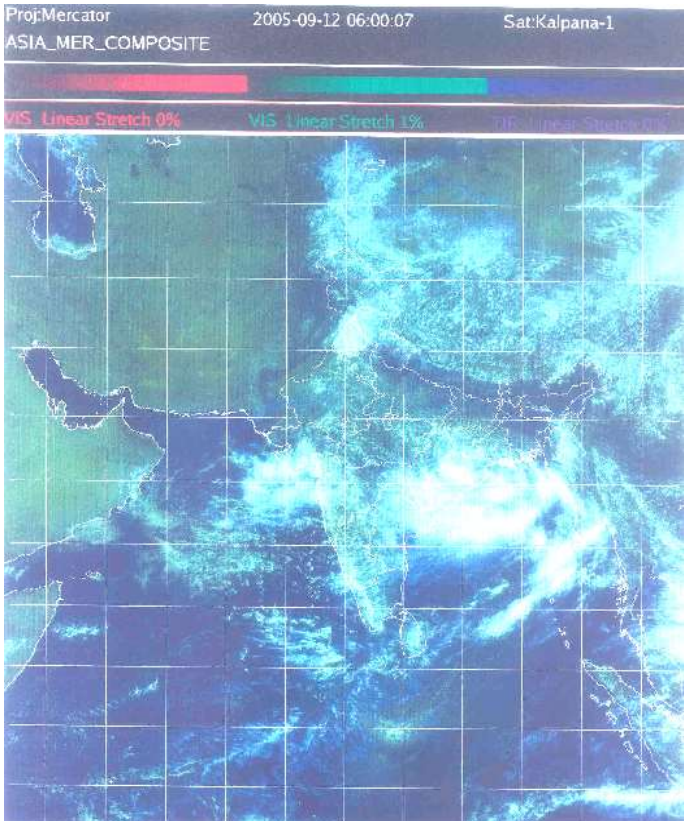
Table 2.5.1

Best track positions and other parameters for Bay of Bengal depression (12-16 September, 2005)

Date	Time (UTC)	Centre lat.^{0} N/ long.^{0} E	C.I. NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
12.09.2005	0300	20.0/88.0	1.5	992	25	4	D
	1200	21.0/85.0	1.5	992	25	4	D
13.09.2005	0300	21.5/84.0	1.5	992	25	4	D
	1200	22.0/82.5	1.5	992	25	4	D
14.09.2005	0300	23.0/80.0	1.5	996	25	4	D
	1200	23.0/80.0	1.5	998	25	4	D
15.09.2005	0300	24.5/78.5	1.5	1000	25	4	D
	1200	25.5/78.0	1.5	996	25	4	D
16.09.2005	0300	27.0/78.0	1.5	996	25	4	D
	1200	28.0/78.0	1.5	996	25	4	D

The system weakened into a well marked low pressure area and lay over west Uttar Pradesh and Adjoining Uttaranchal in the morning of September 17, 2005.

(a)



(b)

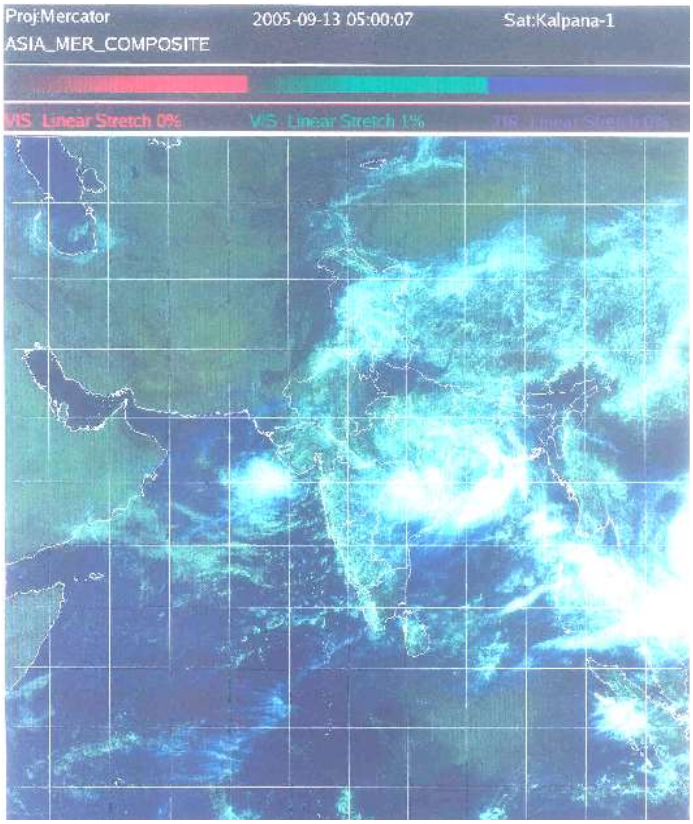


Fig. 2.5.1. Kalpana-1 imageries (a) at 0600 UTC of September 12, 2005 showing the organization of vortex in association with the depression over northwest Bay of Bengal and (b) at 0500 UTC of September 13, 2005 showing intense convective clouds in southwest sector of the system centred over northwest Orissa.

2.6 Depression over Arabian sea (September 14-16, 2005)

A low pressure area formed over south Gujarat coast and neighbourhood on 13th September morning and became well marked on the same evening. The system concentrated into a depression and lay centred at 140300 UTC near Lat.20.0^0 N/Long.68.5^0 E. The system remained practically stationary for sometime and afterwards moved slowly northwestwards and lay centred at150300 UTC near lat 20.5^0 N/ Long 68.0^0 E. The system continued to move northwestwards till 160300 UTC and then moved nearly eastwards towards Gujrat coast. The system crossed north Saurashtra coast, north of Porbandar (42830) around midnight of 16th and rapidly weakened into a well marked low pressure area over north Gujarat by 17th morning.

The track of the system is given in Fig. 2. The best track and other parameters are given in Table 2.6.1. A few Kalpana-1 cloud imageries of the system are shown in Fig. 2.6.1.

Realised weather:

Under the influence of the system, fairly wide spread rainfall with isolated heavy falls occurred over Gujarat on September 15, 2005. The chief amount of rainfall (cm) are given below

Gujarat:

15-09-05 Palanpur-9, Meghraj & Dharoi-8 each, Vyara-7

Damage :

Strong gale force winds caused destruction in Gujarat on 16th night. According to the press report, 13 people died in Gujarat due to heavy rain.

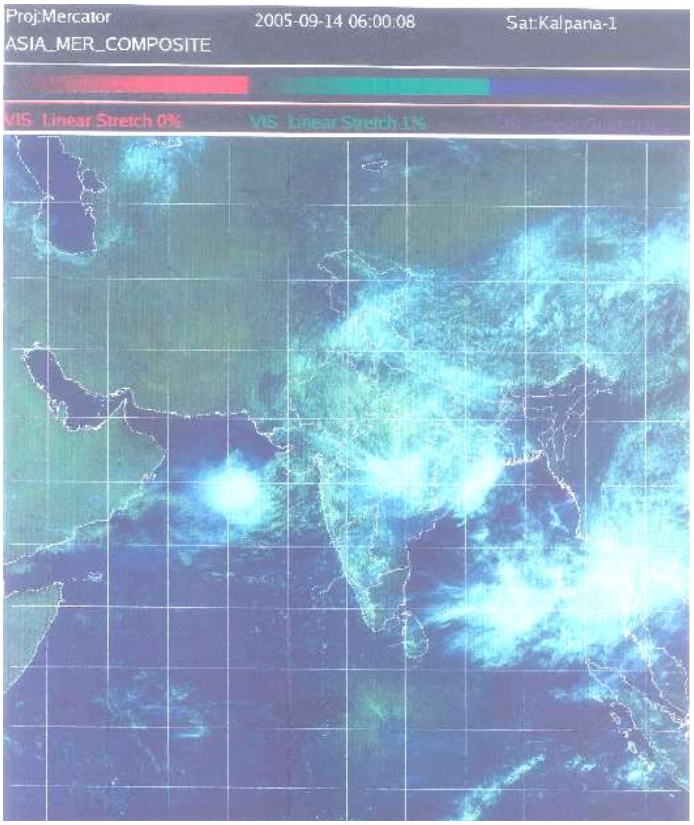
Table 2.6.1

Best track positions and other parameters for Bay of Bengal depression (September 14-16, 2005)

Date	Time (UTC)	Centre lat.^{0} N/ long.^{0} E	C.I. NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
14.09.2005	0300	20.0/68.5	1.5	996	25	4	D
	1200	20.5/68.0	1.5	996	25	4	D
15.09.2005	0300	20.5/68.0	1.5	996	25	4	D
	1200	20.5/68.0	1.5	996	25	4	D
16.09.2005	0300	21.5/67.5	1.5	996	25	4	D
	1200	21.5/69.0	1.5	996	25	4	D

The system crossed north Saurashtra coast, north of Porbandar (42830) around midnight of 16th and rapidly weakened as a well marked low pressure area over north Gujarat by 17th morning.

(a)



(b)

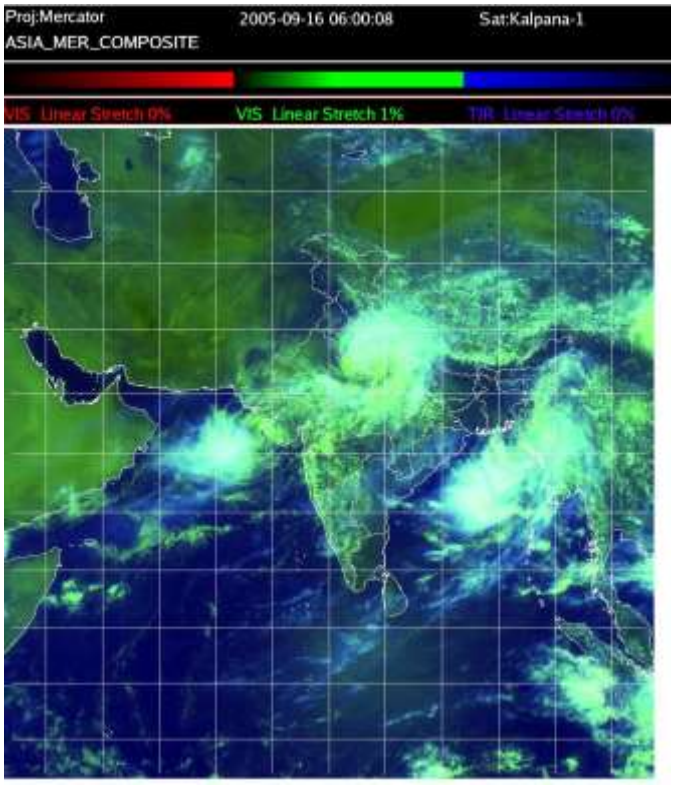


Fig. 2.6.1. Kalpana-1 imageries (a) at 0600 UTC of September 14, 2005 showing the shear pattern of cloud mass in association with the depression over northeast Arabian Sea and (b) at 0600 UTC of September 16, 2005 showing convective clouds due to the system over north east Arabian Sea.

2.7 Cyclonic Storm "PYARR" over Bay of Bengal (September 17-21, 2005)

A low level cyclonic circulation was seen over central Bay of Bengal on 14th Sept., 2005. It formed into a low pressure area over eastcentral Bay on 16th morning. Subsequently, it concentrated into a depression and lay centred at 170300 UTC over north Bay near lat 20.0^{0}N/long 90.5^0 E. Moving in a west-northwesterly direction, it intensified into a deep depression and lay centred at 180300 UTC over northwest Bay near lat 20.5^{0}N/ long 87.5^0. It further intensified into a cyclonic storm and lay centred at 181200 UTC near lat 19.5^{0}N/long 86.5^0. The system then moved southwestwards, which was rather unusual. The system crossed as cyclonic storm in the morning of 19th close to Kalingapatnam (43105) in north coastal Andhra Pradesh. The system remained practically stationary and retained cyclonic storm intensity for sometime. Thereafter moving initially west-northwestwards and then northwestwards, it weakened gradually into deep depression and lay centred at 200300 UTC near lat 19.0^{0}N/long 82.5^0 E. It further weakened into a depression and lay centred at 201200 UTC near lat 19.0^{0}N/long 80.5^0 E. Continuing its northwestward movement, it weakened as a well marked low pressure area over north Madhya Maharashtra on 22nd morning.

The track of the system is given in Fig. 2. The best track and other parameters are given in Table 2.7.1. A few KALPANA-1 cloud imageries of the system are shown in Fig. 2.7.1. The Doppler Weather Radar (DWR) picture of the system taken by DWR, Machilipatnam is shown in Fig.2.7.2. According to post cyclone survey report, the system crossed between Kalingapatnam (43105) and Gopalpur (43049) at the mouth of Bahuda river, 70 km northeast of Kalingapatnam (Srikakulam district).

Realized Weather:

Under the influence of the system, widespread Rainfall activity with isolated heavy to very heavy falls occurred in coastal Andhra Pradesh and Orissa. Significant amounts of rainfall (cm) are given below.

Andhra Pradesh :-

19-09-05 Kalingapatnam-35, Tekkali-14, Visakhapatnam, Veeraghattam & S. Kota-12 each, Visakhapatnam Airport-11, Saluru-10, Bobbili-9 Anakapalle-8, Gajapathinagaram-7.

20-09-05 Kunavaram-49, Koida-48, Kakinada-28, Khammam-24, Dowlaiswaram-21, Rajahmundry-20, Eluru & Visakhapatnam-19 each, Narsapur-18, Tuni & Sattenapalle-17 each, Visakhapatnam & Gannavaram-16 each, Chodavaram & Kaikalur-15 each, Machilipatnam-14, Yellemanchili, Prakasam Barrage, Anakapalle & Dolphin's nose-13 each, Repalle-11, Piduguralla-10, Bapatla-9

Orissa:-

18-09-05 Tikbali-15, Kotagarh-13, Daringibadi-11, Phulbani-10, Alipingal, Joshipur, Mohana & Udaigiri-9 each, Kalinga, Paradip, Kakatpur & Gudari-8 each.

19-09-05 Jeypore-20, Pottangi & Koraput-17 each, R.Udaigiri-15, Mahendragarh-13, Mohana-11, Tikbali, Kotagarh, Hindol & Gunupur-10 each, Khanapada, Nowrangpur & Rayagada-9 each.

Damage :

Damages reported in Andhra Pradesh are as follows.

Number of human deaths -1
Number of livestock died-291
Buildings partly / completely destroyed – 12041 (estimated cost Rs. 177.26 lakhs)
Crop loss– 4,82,188 hectors (estimated cost Rs 627.74 lakhs)
Total loss estimated by Government- 5029.82 lakhs

No damage was reported in Orissa.

Table 2.7.1

Best track positions and other parameters for Bay of Bengal Cyclonic Storm, "PYAAR", (September 17-21, 2005)

Date	Time (UTC)	Centre lat.^{0} N/ long.^{0} E	C.I. NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
17.09.2005	0300	20.0/90.5	1.5	1000	25	4	D
	1200	20.5/90.0	1.5	998	25	4	D
18.09.2005	0300	20.5/87.5	2.0	996	30	5	DD
	0600	20.0/87.5	2.0	996	30	5	DD
	0900	19.5/87.0	2.0	996	30	5	DD
	1200	19.5/86.5	2.5	994	35	6	CS
	1500	19.5/86.5	2.5	992	35	6	CS
	1800	19.0/85.5	2.5	990	35	6	CS
	2100	18.5/84.5	2.5	988	35	6	CS
19.09.2005	0000	18.5/84.5	2.5	988	35	6	CS
	0300	18.5/84.0 OVER LAND	2.5	988	35	6	CS
	0600	18.5/83.5	2.5	988	35	6	CS
	0900	18.5/83.5	2.5	988	35	6	CS
	1200	18.5/83.5	2.5	988	35	6	CS
	1500	18.5/83.5	2.5	988	35	6	CS
	1800	18.5/83.0	2.5	988	35	6	CS
	2100	18.5/83.0	2.0	1000	30	5	DD
20.09.2005	0000	19.0/82.5	2.0	1002	30	5	DD
	0300	19.0/82.5	2.0	1002	30	5	DD
	0600	19.0/82.5	2.0	1002	30	5	DD
	0900	19.0/81.5	2.0	1002	30	5	DD
	1200	19.0/80.5	1.5	1004	25	4	D
21.09.2005	0300	19.5/79.5	1.5	1004	25	4	D
	1200	21.0/76.0	1.5	1004	25	4	D

The system crossed the Andhra Pradesh coast near Kalingapatnam(43105) in the morning of 19th september,2005. The system weakened into well marked low pressure area over north Madhya Maharastra at 220300 UTC

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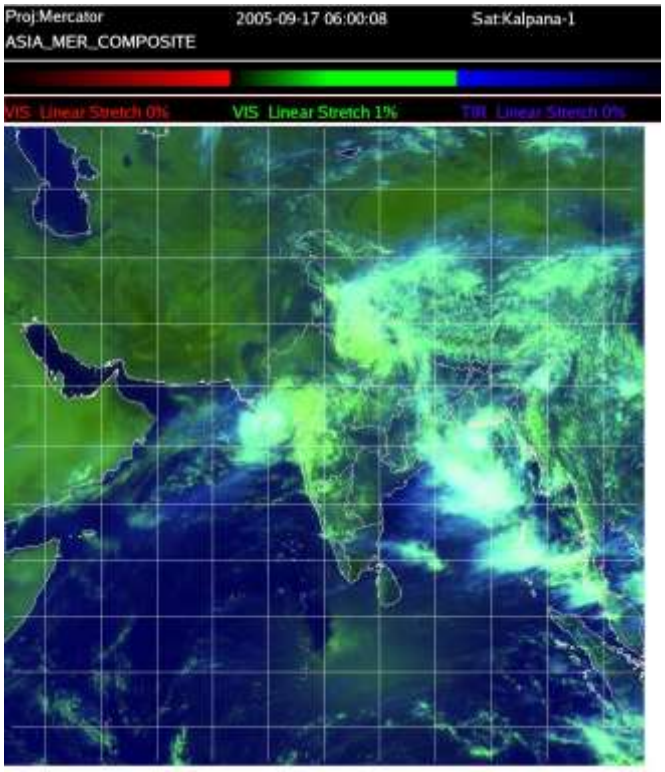
(a)



(b)

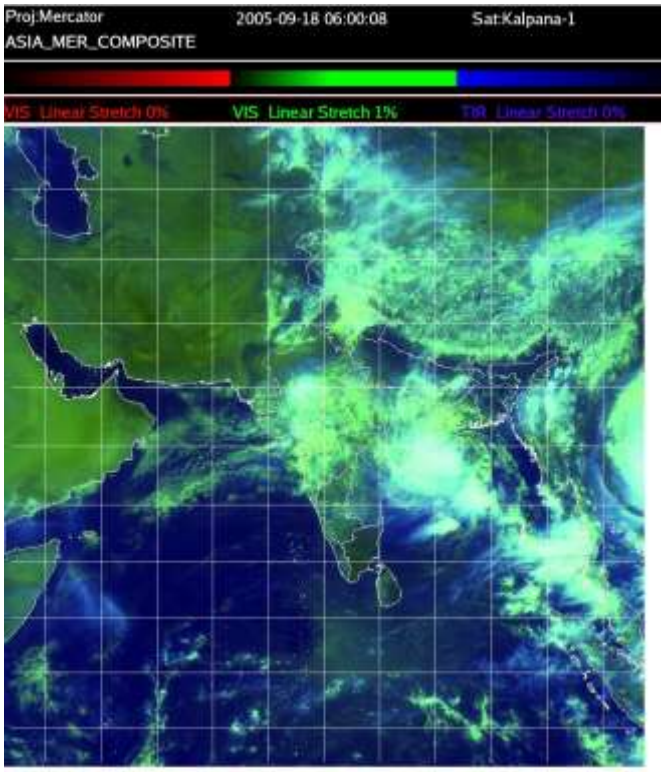
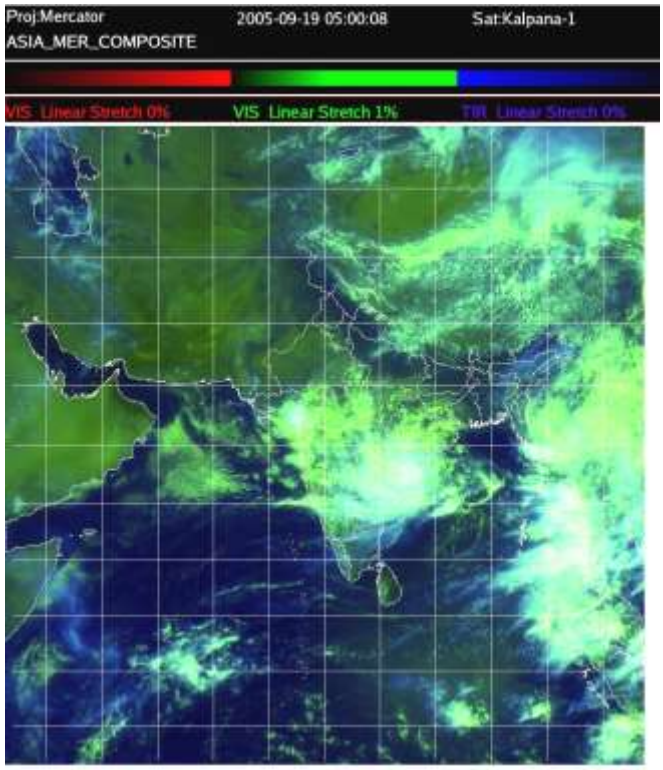


Fig. 2.7.1. Kalpana-1. imageries (a) at 0600 UTC of September 17, 2005 showing the organization of vortex leading to shear pattern in association with the depression over north Bay and (b) at 0600 UTC of September 18, 2005 showing further organisation of cloud structure in association with the system over northwest Bay.

(c)



(d)

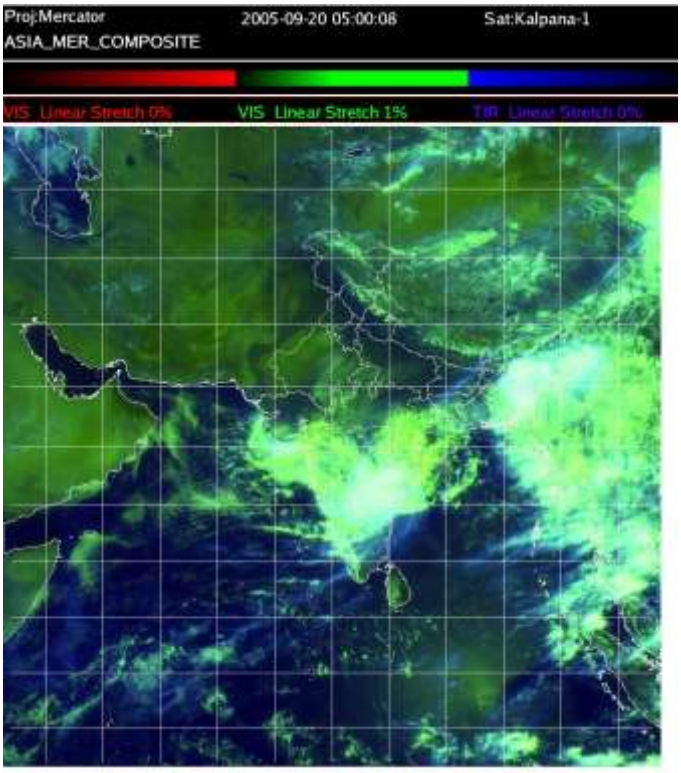


Fig. 2.7.1. (contd). Kalpana-1 imageries (c) at 0500 UTC of September 19, 2005 showing disorganisation of cloud mass after landfall of cyclonic storm near Kalingapatnam and (d) at 0500 UTC of September 20, 2005 showing intense convection in the southwest sector of the deep depression over north coastal Andhra Pradesh.

(a)

(b)

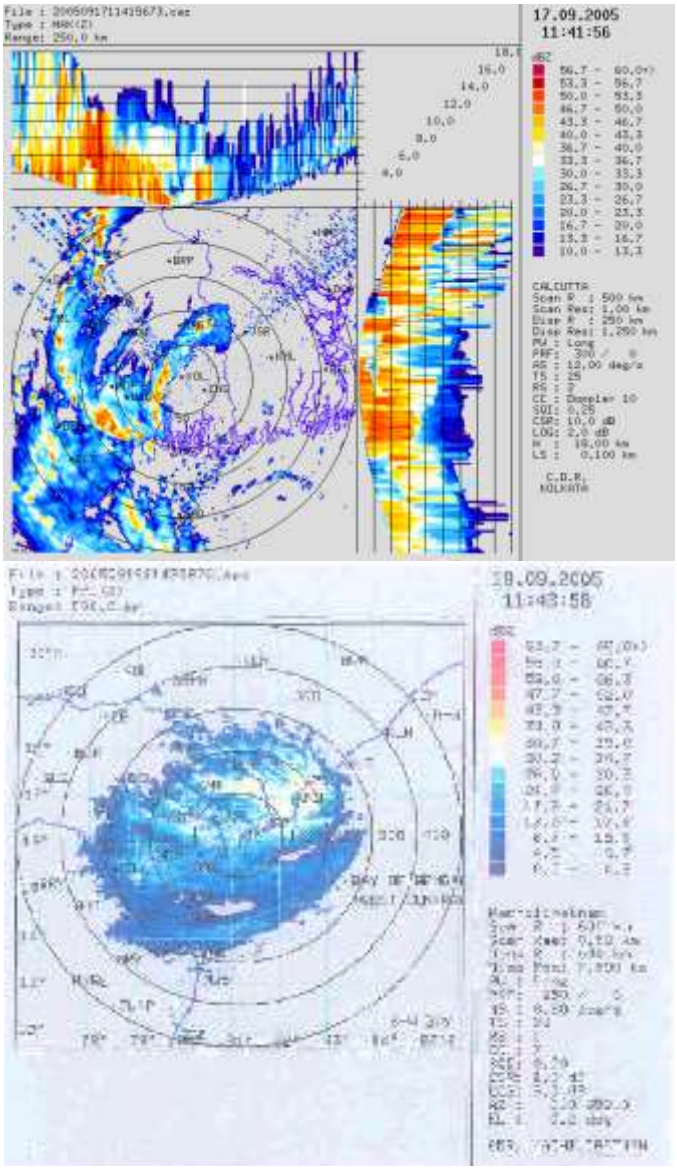


Fig.2.7.2. Doppler Weather Radar (DWR) imageries observed from Machilipatnam at (a) 11.41 UTC of September 17, 2005 showing convective clusters due to the system and (b) 11.43.58 UTC of September 19, 2005 showing the spiral bands of clouds in association with the cyclonic storm, “PYARR”.

2.8 DEEP DEPRESSION OVER BAY OF BENGAL (OCTOBER 26-29, 2005)

The low pressure area which formed over Southwest and adjoining Southeast Bay of Bengal of 25th concentrated into a depression over southwest Bay of Bengal and lay centred at 260300 UTC near lat. 12.0^0 N and long. 84.5^0 E. Moving in a northwesterly direction, the system was located near 12.5 N and 84.0 E at 261200 UTC. It remained practically stationary and further intensified into a Deep Depression at 261800 UTC. Thereafter it maintained a steady northwesterly track and lay centred at 15.5^0N and 80.0^0E, close to Ongole (43221) at 280300 UTC . The system became somewhat sluggish in its movement and crossed the coast, as suggested by the surface observations, close to Ongole around 280800 UTC. Immediately after crossing the coast it weakened into a depression and lay centred close to the west of Ongole (over land) at 281200 UTC . At 290300 UTC it was about 50 KM west of Ongole. Thereafter it further weakened into low pressure area and lay over the south coastal Andhra Pradesh and neighbourhood in the same evening.

The track of the system is given in Fig. 2. The best track and other parameters are given in Table 2.8.1. A few KALPANA-1 cloud imageries of the system are shown in Fig. 2.8.1. The Doppler Weather Radar (DWR) pictures of the system taken by DWR, Chennai and Machilipatnam are shown in Fig.2.8.2.

Realized Weather:

Widespread rainfall with heavy to very heavy falls at a few places in Coastal Andhra Pradesh and at isolated places in Tamilnadu were realized on 28 & 29 October. Significant amounts of rainfall (cm) are given below.

Andhra Pradesh

28-10-05 Kavali – 35, Nellore – 26, Sompeta – 14, Mandasi – 11

29-10-05 Kavali – 8, Visakhapatnam – 7

Tamilnadu

28-10-05 Tiruvallur – 27.Redhills – 24, Ponneri – 20, Chennai- 16, Tambaram – 13

29-10-05 Kalwakurthi- 27, Porumammala & Cumbum – 13 each.

Damage :

Damage reported in Andhra Pradesh are given below. Mostly the damage occurred in Nellore and Prakasam districts of Andhra Pradesh.

Number of human deaths – 18
Number of housed collapsed – 1045
Number of tanks breached - 44
Area of paddy submerged – 194423 hectares
Railway tracks were submerged at many places in Nellore and Prakasam districts

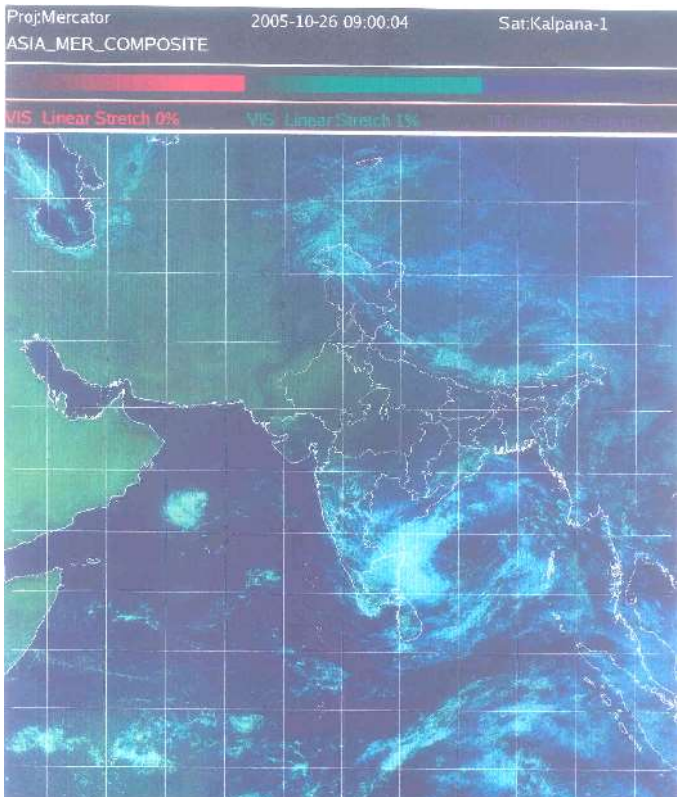
TABLE-2.8.1

Best track positions and other parameters for Bay of Bengal Deep Depression (October 26-29, 2005)

Date	Time (UTC)	Centre lat.^{0} N/ long.^{0} E	C.I. NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
26-10-2005	0300	12.0/84.5	1.5	1004	25	4	D
	0600	12.0/84.5	1.5	1004	25	4	D
	0900	12.0/84.0	1.5	1004	25	4	D
	1200	12.5/84.0	1.5	1004	25	4	D
	1500	12.5/84.0	1.5	1004	25	4	D
	1800	12.5/84.0	2.0	1004	30	5	DD
	2100	12.5/84.0	2.0	1004	30	5	DD
27-10-2005	0000	12.5/84.0	2.0	1002	30	5	DD
	0300	13.0/82.5	2.0	1002	30	5	DD
	0600	13.0/81.5	2.0	998	30	5	DD
	0900	13.0/81.5	2.0	998	30	5	DD
	1200	13.5/81.5	2.0	998	30	5	DD
	1500	14.0/81.5	2.0	998	30	5	DD
	1800	14.0/81.5	2.0	998	30	5	DD
	2100	15.0/81.0	2.0	998	30	5	DD
28-10-2005	0000	15.0/81.0	2.0	998	30	5	DD
	0300	15.5/80.0	2.0	998	30	5	DD
	0600	15.5/80.0	2.0	998	30	5	DD
	0900	15.5/80.0	1.5	1000	25	4	D
	1200	15.5/79.8	1.5	1000	25	4	D
29-10-2005	0300	15.5/79.5	1.5	1002	25	4	D

The system crossed the coast near Ongole (43221) around 280800 UTC. The system weakened into a low pressure area and lay over south Coastal Andhra Pradesh and neighbourhood at 291200 UTC.

(a)



(b)

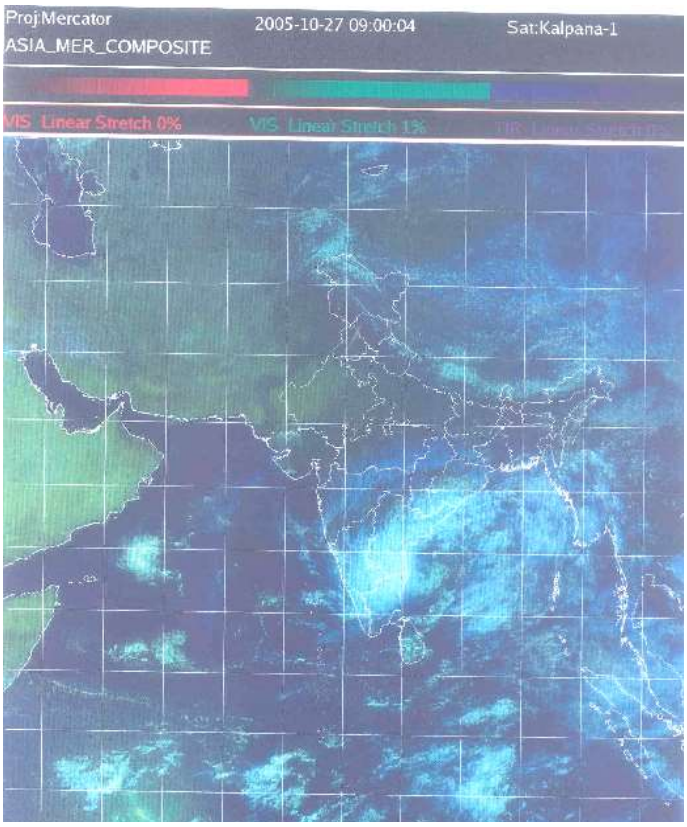
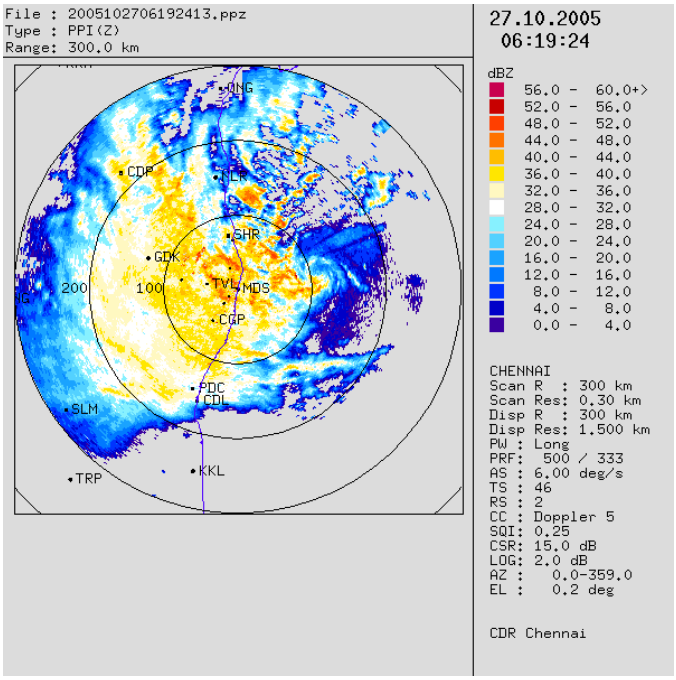


Fig. 2.8.1. Kalpana-1 imageries (a) at 0900 UTC of October 26, 2005 showing shear pattern of the cloud mass due to the depression over southwest Bay of Bengal and (b) at 0900 UTC of October 27, 2005 showing the intense convection to the west of the low cloud system center in association with the system.

(a)



(b)

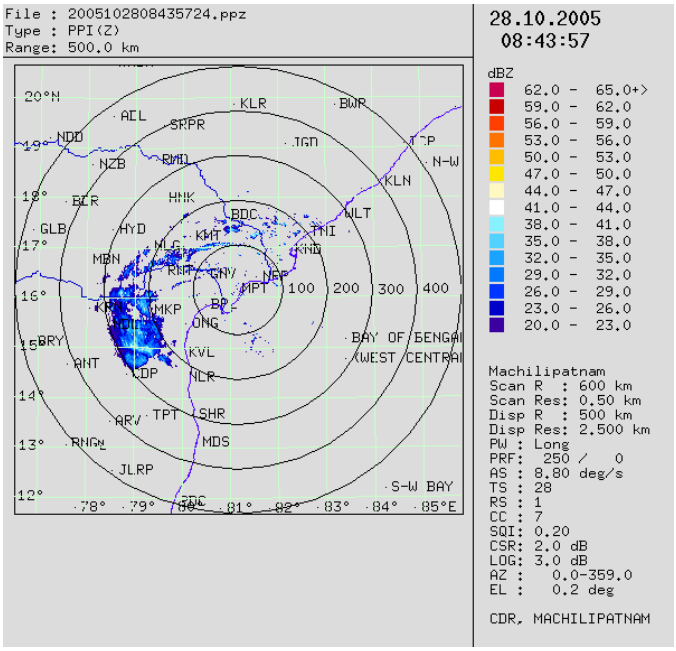


Fig.2.8.2. DWR imageries from (a) DWR Chennai at 0154 UTC of October 27, 2005 and (b) from DWR Machilipatnam at 0843 UTC of October 28, 2005 showing intense convection due to the system.

2.9 Depression over the Bay of Bengal (20-22 November, 2005)

A low pressure area was seen over southeast and adjoining southwest Bay of Bengal in the morning of 19th November. It moved in a west-northwesterly direction concentrated into a depression and lay centred at 200300 UTC over southwest Bay of Bengal near lat. 8.0^0 N and long. 84.5^0 E. It moved in a west-northwesterly direction with same intensity up to 211200 UTC. Thereafter it moved in a westerly direction till 220900 UTC and crossed Srilanka coast around 220000 UTC and subsequently emerged into Gulf of Mannar. It then weakened into a well marked low pressure area and lay over Gulf of Mannar at 221200 UTC.

The track of the system is given in Fig. 2. 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.

Realised weather :

The system caused widespread to fairly widespread rainfall with scattered heavy to very heavy falls over Tamilnadu during November 22-24.

Significant amounts of rainfall (in cm) are given below.

Tamilnadu:

22-11-05 Panruti & Parangipettai-22 each,Chidambaram-13,Cheyyar-11,Vedaranyam-10,Mayiladuthurai,Tirumayam,Pondicherry & Cuddalore-9 each.Srimushnam,K.Koil, Thanjavur, Chennai airport & Chembarapakkam-7 each.

23-11-05 Toludur-17, Udumalpet-15,Kallakurichi, Vridhachalam, Dindigul & Srimushnam-14 each, Thirukoilur, Melur & Chittampatti – 11 each; Chidambaram & Peppireddypatti – 10 each Palani, Harur & Chattrapatti – 9 each Nilakottai-8, Vallam, K.Koil, Viralimalai, Vembavur, Kodavasal & Kodaikanal-7 each.

24-11-05 Panruti-32, Kallakurichi-31, Palani-27, Dindigul-26, Vallam-25,Tholudur-24, Mayanur-23, Vembavur & Pullambadi-22 each, Natham-21, Viralimalai, Thirukattupalli, Mussuri & Lalgudi 20 each, Aravakurchi-19, Udumalpet, Thirukoilur, Nilakottai, Erode & K.Paramatti –17 each, K.Koil & Chattrapatti-16, Srimushnam, Thiruvarur,Mayiladuthurai, Ramanathapuram & Thanjavur – 15 each, Kulithalai-14, Melur, Peppireddypatti, Sirkali-13 each, Vridhachalam, Kodaikanal & Dharapuram-12 each, Parangipettai & Chittampatti – 11 each, Chidambaram & Vedasandur-10 each, Kumbakonam-9, Harur, Tirumayam & Sriperambadur-8 each, Cholavaram-7.

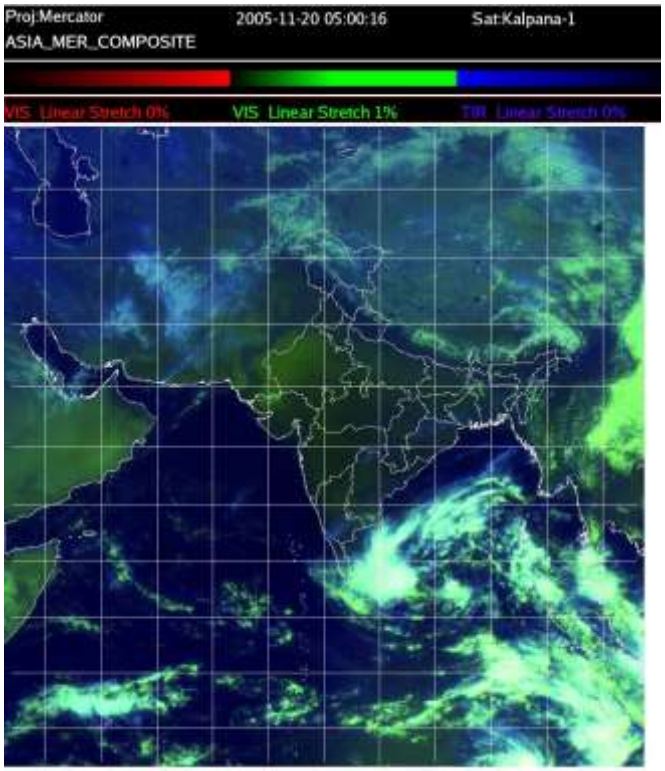
Damage : No damage was reported in India due to this system.

TABLE-2.9.1
Best track positions and other parameters for Bay of Bengal depression (November 20-22, 2005)

Date	Time (UTC)	Centre lat.^{0} N/ long.^{0} E	C.I. NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
20-11-2005	0300	8.0/84.5	1.5	1002	25	4	D
	0600	8.0/84.5	1.5	1002	25	4	D
	0900	8.0/84.5	1.5	1002	25	4	D
	1200	8.0/84.0	1.5	1002	25	4	D
	1500	8.0/84.0	1.5	1002	25	4	D
	1800	8.0/84.0	1.5	1002	25	4	D
	2100	8.0/84.0	1.5	1002	25	4	D
21-11-2005	0000	8.0/84.0	1.5	1002	25	4	D
	0300	8.5/83.0	1.5	1002	25	4	D
	0600	8.5/83.0	1.5	1002	25	4	D
	0900	9.0/82.0	1.5	1002	25	4	D
	1200	9.0/81.5	1.5	1002	25	4	D
	1500	9.0/81.5	1.5	1002	25	4	D
	1800	9.0/81.0	1.5	1002	25	4	D
	2100	9.0/81.0	1.5	1002	25	4	D
22-11-2005	0000	9.0/80.5	1.5	1002	25	4	D
	0300	9.0/80.0	1.5	1002	25	4	D
	0600	9.0/79.5	1.5	1002	25	4	D
	0900	9.5/79.5	1.5	1002	25	4	D

The depression weakened into a well marked low pressure area and lay over Gulf of Mannar at 221200 UTC.

(a)



(b)

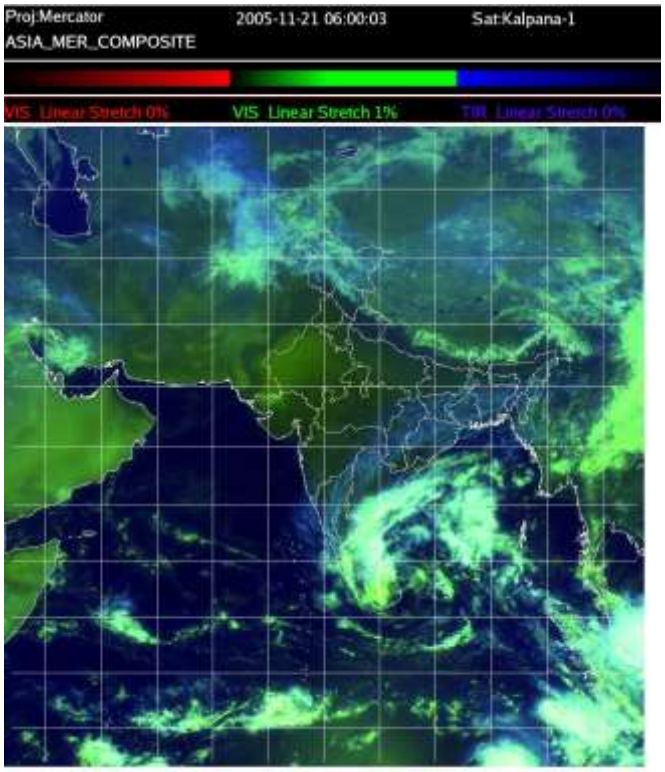


Fig. 2.9.1. Kalpana-1 imageries (a) at 0500 UTC of November 20, 2005 showing the organization of vortex in association with the depression and (b) at 0600 UTC of November 21, 2005 showing shear pattern of cloud mass away from low cloud system centre in association with the system.

2.10 Cyclonic Storm "BAAZ" over Bay of Bengal (November 28- December 02, 2005)

A well marked low pressure area lay over south Andaman sea and adjoining southeast Bay of Bengal on the morning of 27th November. It concentrated into a depression and lay centred at 280300 UTC near lat 10.5^0 N/long 90.5^0 E. It rapidly intensified into a deep depression and lay centred at 280600 UTC near lat 10.5^0 N/long 90.0^0 E Moving in a westerly direction, it intensified into a cyclonic storm "BAAZ" and lay centred at 281800 UTC near lat 10.5^0 N/long 88.0^0 E. There after it moved in a northwesterly direction till 291200 UTC. Thereafter the system became sluggish in its movement and hovered around the area till 0300 UTC of 01st December. Thereafter the system moved in a northwesterly direction and gradually dissipated over sea itself. The system was seen as a well marked low pressure area over southwest Bay of Bengal at 020600 UTC.

The track of the system is given in Fig.2. The best track and other parameters are given in Table 2.10. A few KALPANA-1 cloud imageries of the system are shown in Fig. 2.10.1. The Doppler Weather Radar (DWR) pictures of the system taken by DWR, Chennai are shown in Fig.2.10.2.

Realized weather:

Fairly widespread with isolated heavy rainfall occurred in north coastal Tamilnadu and Andhra Pradesh on 3rd and 4th December 2005. Significant amounts of rainfall are given below.

Tamilnadu:

03-12-05 Tambaram - 31, Chennai airport –28, Thiruvallur & Chennai-23 each, Arakonam – 21, Sriperumbuthur –18, Chingalpattu & Red hills –15 each, Tiruttani-14, Poondi- 13, Ponneri-11,

04-12-05 Poolabadi –18, Papanasam- 17, Vandavasi, Parangipettai, Tindivanam & Vallam-13 each, Sriperumbuthur –12, Thiruvallur- 7.

Andhra Pradesh:

03-12-05 Tada-18,Nellore-8,Tirupathi-7

04-12-05 Nellore-8, Tirupathi-6

Damages:

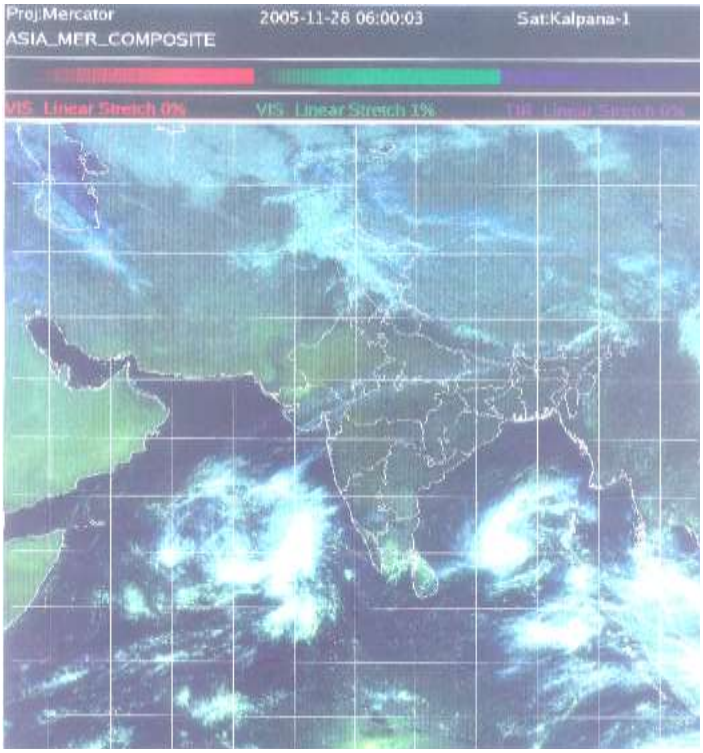
According to press reports, heavy rain caused floods in Nellore, Chittoor and Cuddapah districts of Andhra Pradesh.
Number of deaths – 11 (Nellore 7, Chittoor 3 Cuddapah 1)
Number of tanks breached – 27 (Nellore district)
Many villages were reported to be marooned in the above districts.

Table 2.10.1

Best track positions and other parameters for Bay of Bengal Cyclonic Storm, "BAAZ"
(November 28- December 02, 2005)

Date	Time (UTC)	Centre lat.^{0} N/ long.^{0} E	C.I. NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
28-11-2005	0300	10.5/90.5	1.5	1006	25	4	D
	0600	10.5/90.0	2.0	1004	30	5	DD
	0900	10.5/89.0	2.0	1004	30	5	DD
	1200	10.5/88.5	2.0	1004	30	5	DD
	1500	10.5/88.0	2.0	1004	30	5	DD
	1800	10.5/88.0	2.5	1004	35	6	CS
	2100	10.5/88.0	2.5	1004	35	6	CS
29-11-2005	0000	10.5/87.5	2.5	1002	35	6	CS
	0300	10.5/87.0	3.0	1002	45	8	CS
	0600	11.0/86.0	3.0	998	45	10	CS
	0900	11.5/85.0	3.0	998	45	10	CS
	1200	12.0/84.0	3.0	998	45	10	CS
	1500	12.0/84.0	3.0	998	45	10	CS
	1800	12.0/84.0	3.0	998	45	10	CS
	2100	12.0/84.0	3.0	998	45	10	CS
30-11-2005	0000	12.0/84.0	3.0	998	45	10	CS
	0300	12.0/84.0	3.0	998	45	10	CS
	0600	12.5/84.0	2.5	998	35	8	CS
	0900	12.5/84.0	2.5	998	35	6	CS
	1200	12.5/84.0	2.5	998	35	6	CS
	1500	12.5/84.0	2.5	998	35	6	CS
	1800	12.5/84.0	2.5	998	35	6	CS
	2100	12.5/84.0	2.5	998	35	6	CS
01-12-2005	0000	12.5/84.0	2.5	998	35	6	CS
	0300	12.5/84.0	2.5	998	35	6	CS
	0600	12.5/83.5	2.5	998	35	6	CS
	0900	12.5/83.5	2.5	998	35	6	CS
	1200	12.5/83.5	2.0	998	30	5	DD
	1500	12.5/83.5	2.0	998	30	5	DD
	1800	13.0/83.0	2.0	998	30	5	DD
	2100	13.0/83.0	2.0	998	30	5	DD
02-12-2005	0000	13.0/82.5	1.5	1002	25	4	D
	0300	13.0/82.5	1.5	1004	25	4	D

(a)



(b)

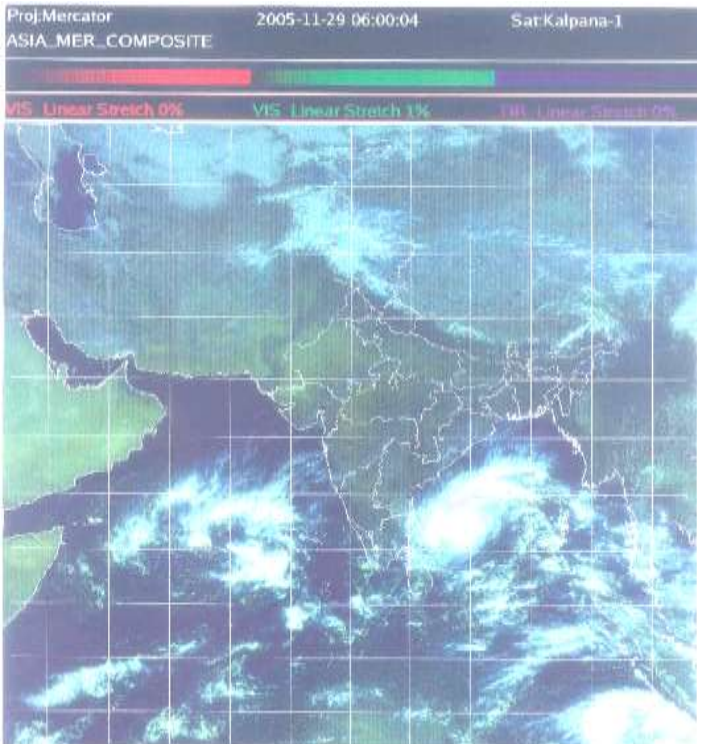
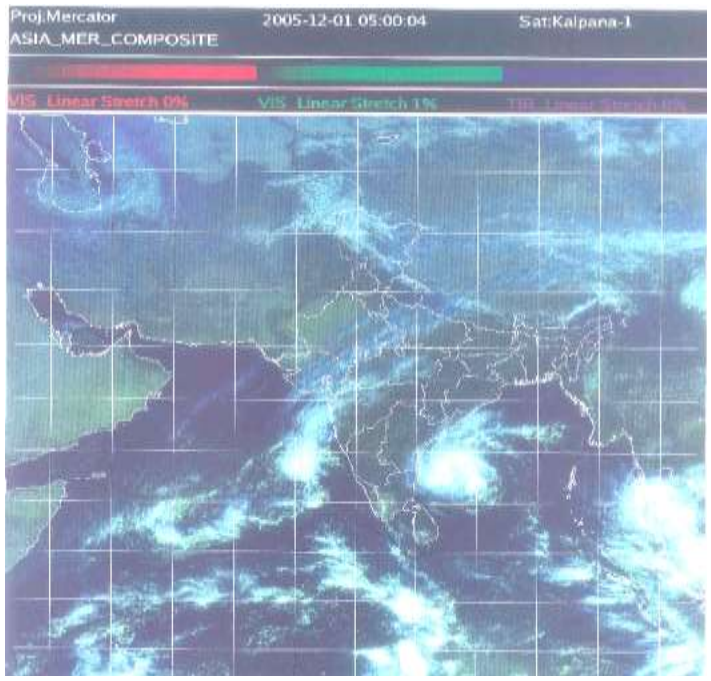


Fig. 2.10.1. Kalpana-1 imageries (a) at 0600 UTC of November 28, 2005 and (b) at 0600 UTC of November 29, 2005 showing the shear pattern of of vortex in association with the system over southwest Bay of Bengal

(c)



(d)

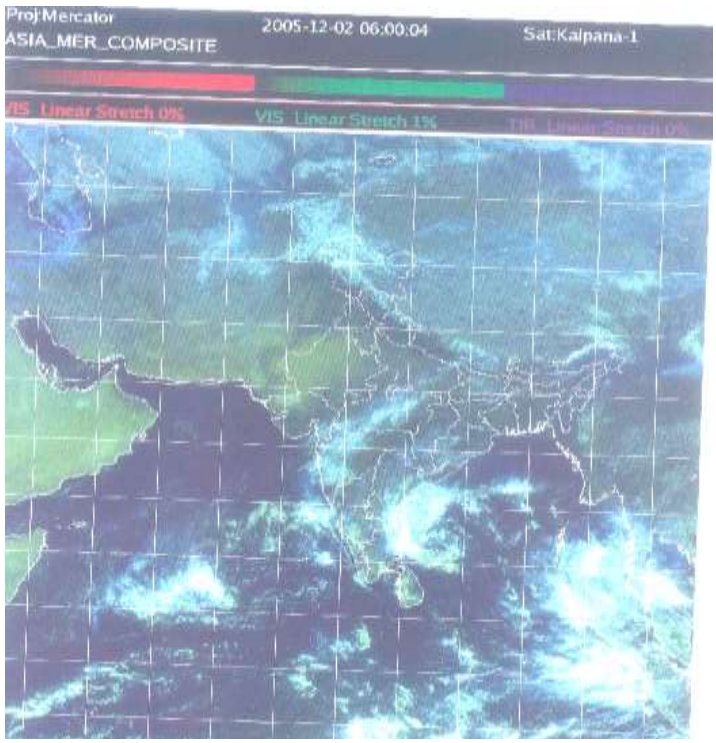


Fig. 2.10.1. (contd). Kalpana -1 imageries (c) at 0500 UTC of December 1, 2005 showing band pattern and (d) at 0600 UTC of December 2, 2005 showing disorganization of cloud mass due to weakening of the system.

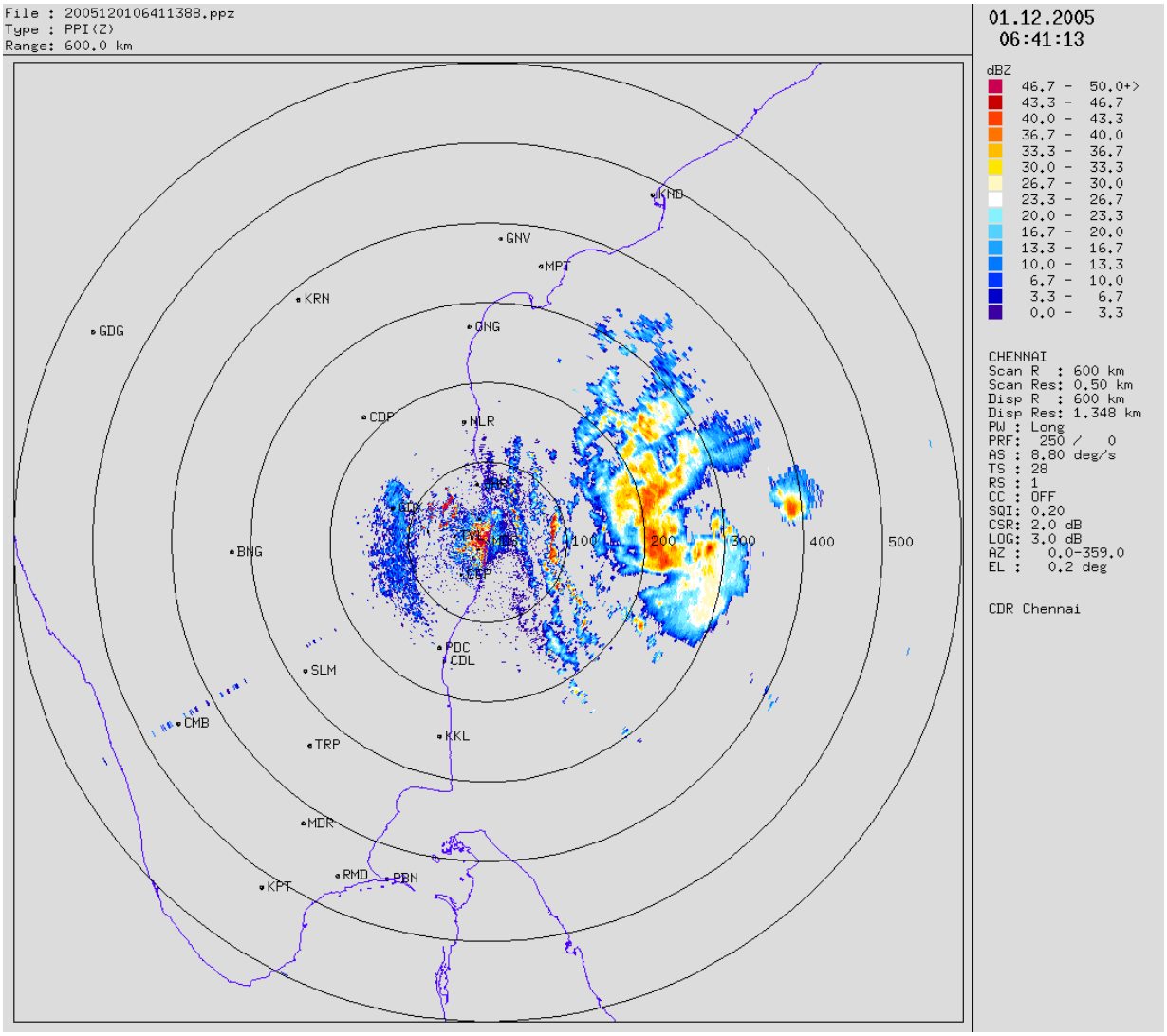


Fig.2.10.2. DWR imageries from DWR Chennai at 0641 UTC of December 01, 2005 Showing intense convection due to the cyclonic storm.

2.11. Cyclonic Storm "FANOOS" over Bay of Bengal (06-10 December , 2005)

A low pressure area formed over south Andaman Sea and neighbourhood on 4th December. Moving in a westerly direction, it became well marked over southeast Bay on 5th evening. Subsequently it concentrated into a depression and lay centred at 060300 UTC near Lat. 10.5^{O} N and Long. 89.5 ^{0} E. Initially moving in a northwesterly direction and it intensified into a deep depression and lay centred at 060900 UTC near Lat. 11.0^{O} N and Long. 89.0^{0} E. It remained practically stationary upto 061500 UTC. Thereafter it took a steady westerly direction, intensified into a cyclonic storm and lay centred at 070300 UTC near Lat. 11.0^{O} N and Long. 87.5^{0} E. It moved slightly westwards till 080000 UTC when it was located near Lat. 11.0^{0}N and Long. 86.0^{0}E. Tracking in a southwesterly direction with same intensity the system was centred at 081200 UTC near Lat. 10.5^{O} N and Long. 84.5^{0} E, at 090300 UTC near Lat. 10.5^{O} N and Long. 83.0^{0} E and at 091200 UTC near near Lat. 10.5^{O} N and Long. 82.0^{0} E. Due to proximity of coast and large vertical wind shear, the system weakened into a deep depression at 00 UTC of 10th December and lay very close to coast. The system crossed Tamilnadu coast near Vedaranyam (43349) around 100530 UTC. Thereafter, it moved westwards and weakened gradually.It was seen as a low pressure area over south Tamilnadu and neighbourhood at 110300 UTC.

The track of the system is given in Fig. 2. The best track and other parameters are given in Table 2.11.1. A few KALPANA-1cloud imageries of the system are shown in Fig.2.11.1. The Doppler Weather Radar (DWR) pictures of the system taken by DWR Chennai are shown in Fig.2.11.2.

Realised weather :

Northeast monsoon rainfall activity was significantly enhanced by this system and Tamilnadu received widespread rainfall with scattered heavy to very heavy falls on 11 and 12 December, 2005. The significant amounts of rainfall (cm) are given below:

Tamilnadu:

11-12-05 Ramanathapuram-35, Panruti-14, Senkottai-13, Pamban, Kamudhi & Madhukar-12 each, Kadaladi-11, Ambasamudram-10, Palayamkottai-7

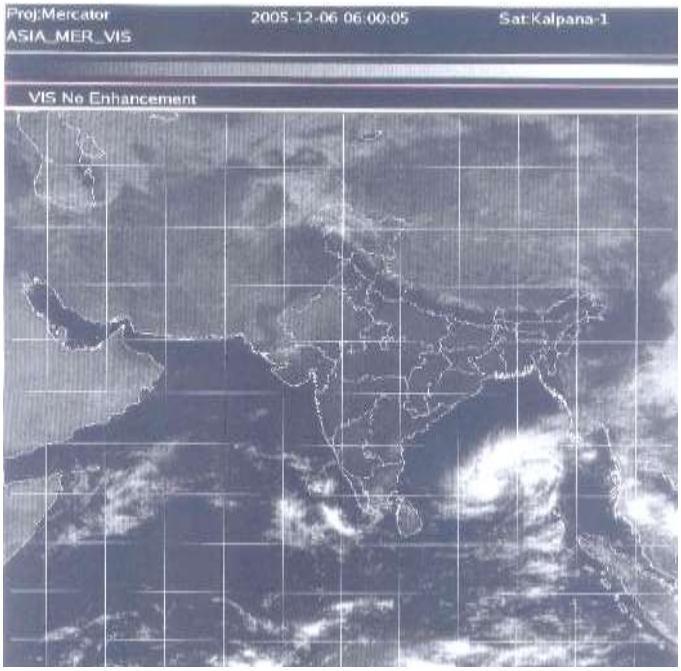
12-12-05 Ambasamudram-17, Senkottai-13, Paramakudi-12.

Damage: No damage was reported in India due to this system.

Table 2.11.1
Best track positions and other parameters for Bay of Bengal Cyclonic Storm, "FANOOS"
(December 06- 10, 2005)

Date	Time (UTC)	Centre lat.^{0} N/ long.^{0} E	C.I. NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
06-12-2005	0300	10.5/89.5	1.5	1006	25	4	D
	0600	10.5/89.5	1.5	1004	25	4	D
	0900	11.0/89.0	2.0	1004	30	5	DD
	1200	11.0/89.0	2.0	1004	30	5	DD
	1500	11.0/89.0	2.0	1004	30	5	DD
	1800	11.0/88.5	2.0	1004	30	5	DD
	2100	11.0/88.5	2.0	1004	30	5	DD
07-12-2005	0000	11.0/88.5	2.0	1002	30	5	DD
	0300	11.0/87.5	2.5	1000	35	6	CS
	0600	11.0/87.0	3.0	1000	40	8	CS
	0900	11.0/86.5	3.0	998	45	10	CS
	1200	11.0/86.5	3.0	998	45	10	CS
	1500	11.0/86.5	3.0	998	45	10	CS
	1800	11.0/86.0	3.0	998	45	10	CS
	2100	11.0/86.0	3.0	998	45	10	CS
08-12-2005	0000	11.0/86.0	3.0	998	45	10	CS
	0300	10.5/86.0	3.0	998	45	10	CS
	0600	10.5/85.5	3.0	998	45	10	CS
	0900	10.5/85.0	3.0	998	45	10	CS
	1200	10.5/84.5	3.0	998	45	10	CS
	1500	10.5/84.5	3.0	998	45	10	CS
	1800	10.5/84.0	3.0	998	45	10	CS
	2100	10.5/84.0	3.0	998	45	10	CS
09-12-2005	0000	10.5/83.5	3.0	998	45	10	CS
	0300	10.5/83.0	3.0	998	45	10	CS
	0600	10.5/83.0	3.0	998	45	10	CS
	0900	10.5/82.5	3.0	998	45	10	CS
	1200	10.5/82.0	3.0	998	45	10	CS
	1500	10.5/81.5	3.0	998	45	10	CS
	1800	10.5/81.5	2.5	1000	35	6	CS
	2100	10.5/81.0	2.5	1000	35	6	CS
10-12-2005	0000	Close to Vedaranyam (43349)			30	5	DD
	0300	Crossing the coast near Vedaranyam (10.4^{0}N/ 79.85^0 E)					DD
	0600	Close to Vedaranyam over land					D
	0900	Close to Vedaranyam over land					D
	1200	10.5/79.5 Close to Vedaranyam over land					D

(a)



(b)

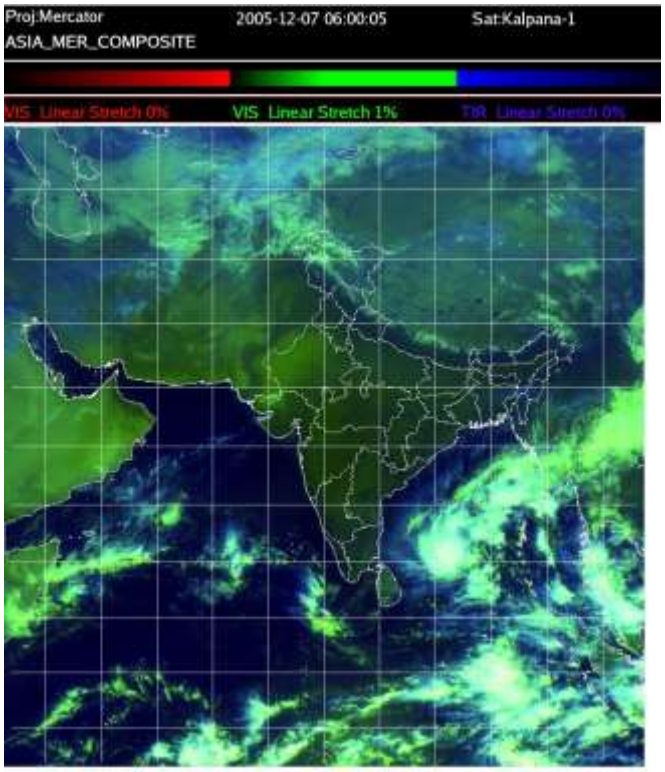
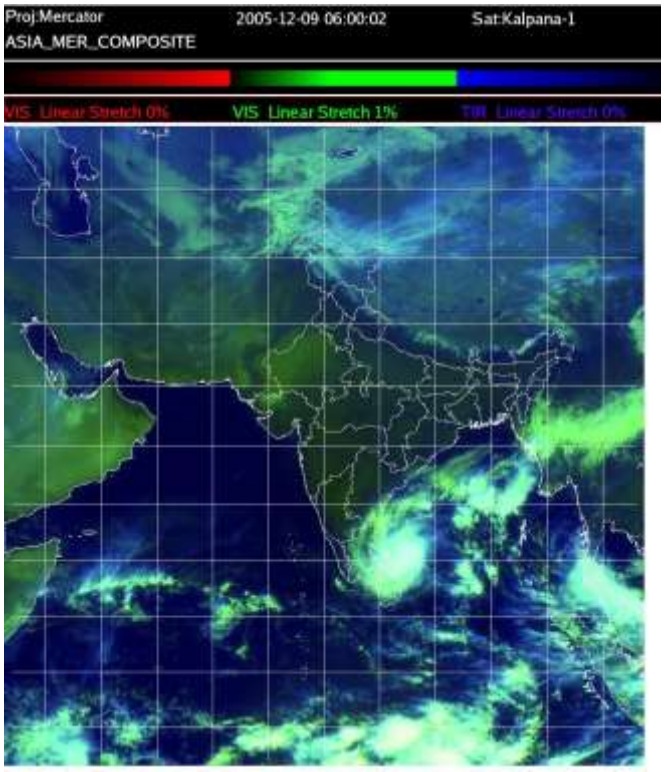


Fig. 2.11.1. Kalpana-1 imageries (a) at 0600 UTC of December 06, 2005 showing the organization of vortex leading to shear pattern in association with the depression and (b) at 0600 UTC of December 07, 2005 showing the central dense overcast (CDO) pattern of cloud mass in association with the system.

(c)



(d)

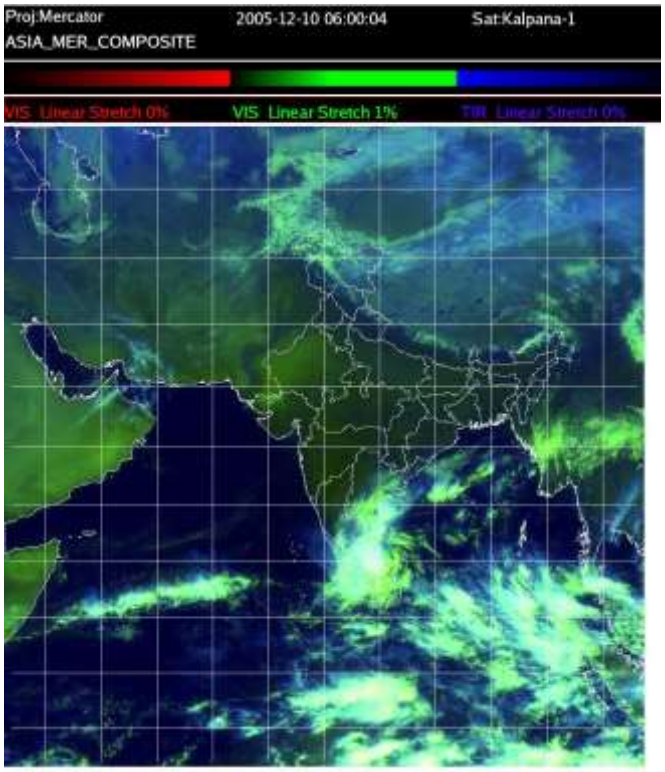
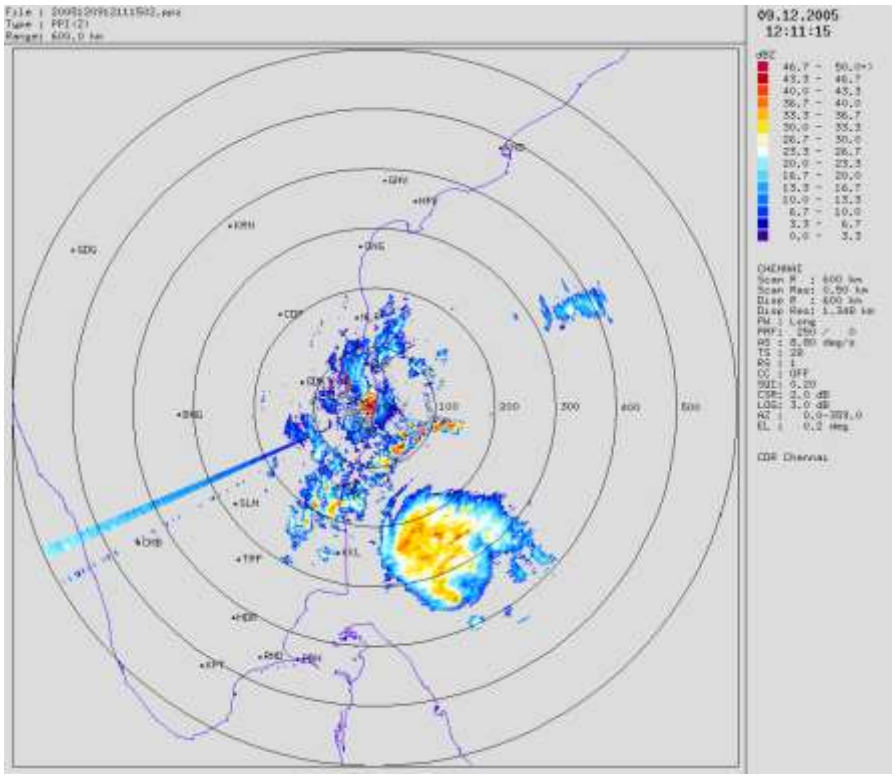


Fig. 2.11.1. (contd). Kalpana-1 imageries (c) at 0600 UTC of December 09, 2005 showing the westward movement of CDO pattern of cloud mass in association with the system and (d) at 0600 UTC of December 10, 2005 showing disorganization of cloud mass and weakening of the system due to land fall.

(a)



(b)

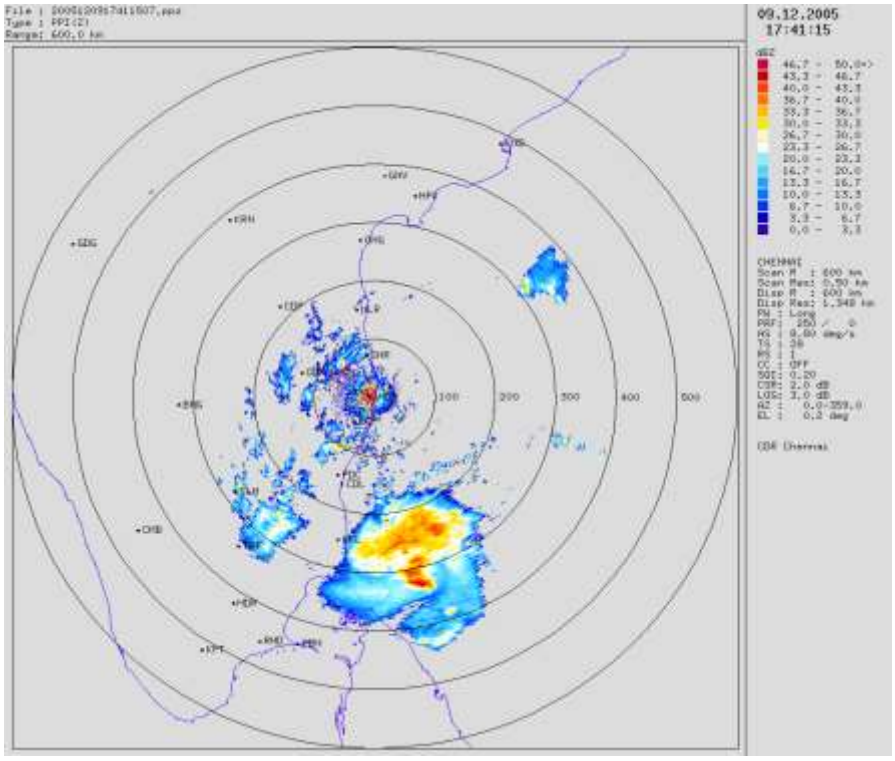


Fig. 2.11.2. Radar imagery from DWR Chennai (a) at 1211 UTC of 09th December, 2005 and (b) at 1741 UTC of 9th December,2005 showing intense convection due to the system.

2.12 Depression over Bay of Bengal (December 15-22, 2005)

A low pressure area formed over south Andaman Sea on 14 December. It concentrated into a depression over southeast Bay of Bengal and lay centred at 151200 UTC near Lat. 8.0^0 N and Long. 87.0^0 E. It moved westwards and concentrated into a deep depression and lay centred at 170300 UTC over southwest Bay near Lat. 8.0^0 N and Long. 84.0^0 E. The system moved northwestwards till 191200 UTC and then took a northeasterly movement. Moving in a northeasterly direction, the system weakened into a depression and lay centred at 200600 UTC near lat. 11.5^0 N and 84.0^0 E. Continuing its northeasterly direction, it further weakened into a well marked low pressure area and lay over southwest and adjoining central Bay of Bengal at 220300 UTC.

The track of the system is given in Fig. 2. 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. The Doppler Weather Radar (DWR) pictures of the system taken by DWR Chennai is shown in Fig.2.12.2.

Realized weather and damage:

Scattered rainfall was realized on 18 & 19 December over Tamilnadu. Significant amounts of rainfall (cm) are as follows.

18-12-05	Chennai airport-6
19-12-05	Chennai city -6

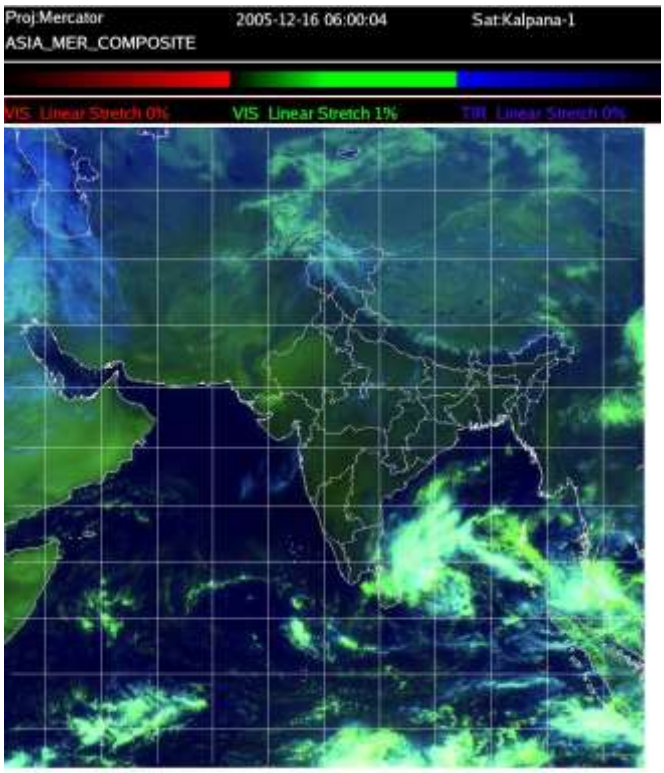
The system did not cause any damage in India.

Table 2.12
Best track positions and other parameters for Bay of Bengal Deep Depression (December 15- 22, 2005)

Date	Time (UTC)	Centre lat.^{0} N/ long.^{0} E	C.I. NO.	Estimated Central Pressure (hPa)	Estimated Max. Sustained Surface wind (kt)	Estimated Pressure drop at the Centre (hPa)	Grade
15-12-2005	1200	8.0/87.0	1.5	1006	25	4	D
	1500	8.0/87.0	1.5	1004	25	4	D
	1800	8.0/87.0	1.5	1004	25	4	D
	2100	8.0/87.0	1.5	1004	25	4	D
16-12-2005	0000	8.0/87.0	1.5	1004	25	4	D
	0300	8.0/85.0	1.5	1002	25	4	D
	0600	8.0/85.0	1.5	1002	25	4	D
	0900	8.0/84.5	1.5	1002	25	4	D
	1200	8.0/84.5	1.5	1002	25	4	D
	1500	8.0/84.5	1.5	1002	25	4	D
	1800	8.0/84.5	1.5	1002	25	4	D
	2100	8.0/84.5	1.5	1002	25	4	D
17-12-2005	0000	8.0/84.0	1.5	1002	25	4	D
	0300	8.0/84.0	2.0	1000	30	5	DD
	0600	8.0/84.0	2.0	1000	30	5	DD
	0900	8.5/83.5	2.0	1000	30	5	DD
	1200	8.5/83.5	2.0	1000	30	5	DD
	1500	8.5/83.5	2.0	1000	30	5	DD
	1800	9.0/83.0	2.0	1000	30	5	DD
	2100	9.0/83.0	2.0	1000	30	5	DD
18-12-2005	0000	9.5/83.0	2.0	1000	30	5	DD
	0300	10.0/83.0	2.0	1000	30	5	DD
	0600	10.0/83.0	2.0	1000	30	5	DD
	0900	10.5/82.5	2.0	1000	30	5	DD
	1200	10.5/82.5	2.0	1000	30	5	DD
	1500	10.5/82.5	2.0	1000	30	5	DD
	1800	11.0/82.5	2.0	1000	30	5	DD
	2100	11.0/82.5	2.0	1000	30	5	DD
19-12-2005	0000	11.0/82.5	2.0	1000	30	5	DD
	0300	11.0/82.5	2.0	1000	30	5	DD
	0600	11.0/82.5	2.0	1000	30	5	DD
	0900	11.0/82.5	2.0	1000	30	5	DD
	1200	11.0/82.5	2.0	1000	30	5	DD
	1500	11.5/82.5	2.0	1000	30	5	DD
	1800	11.5/82.5	2.0	1000	30	5	DD
	2100	11.5/82.5	2.0	1000	30	5	DD
20-12-2005	0000	11.5/83.0	2.0	1000	30	5	DD
	0300	11.5/83.5	2.0	1000	30	5	DD
	0600	11.5/84.0	1.5	1002	25	4	D
	0900	12.0/84.5	1.5	1002	25	4	D
	1200	12.0/84.5	1.5	1002	25	4	D
	1500	12.0/84.5	1.5	1002	25	4	D
	1800	12.0/84.5	1.5	1002	25	4	D
	2100	12.0/84.5	1.5	1002	25	4	D
21-12-2005	0000	12.0/84.5	1.5	1002	25	4	D
	0300	12.0/84.5	1.5	1002	25	4	D
	0600	12.0/84.5	1.5	1002	25	4	D
	0900	12.0/84.5	1.5	1002	25	4	D
	1200	12.0/84.5	1.5	1002	25	4	D
	1500	12.0/84.5	1.5	1002	25	4	D
	1800	12.0/84.5	1.5	1002	25	4	D
	2100	12.0/84.5	1.5	1002	25	4	D
22-12-2005	0000	12.0/84.5	1.5	1002	25	4	D

The system weakened into a well marked low pressure area and lay over southwest and adjoining central Bay of Bengal at 220300 UTC.

(a)



(b)

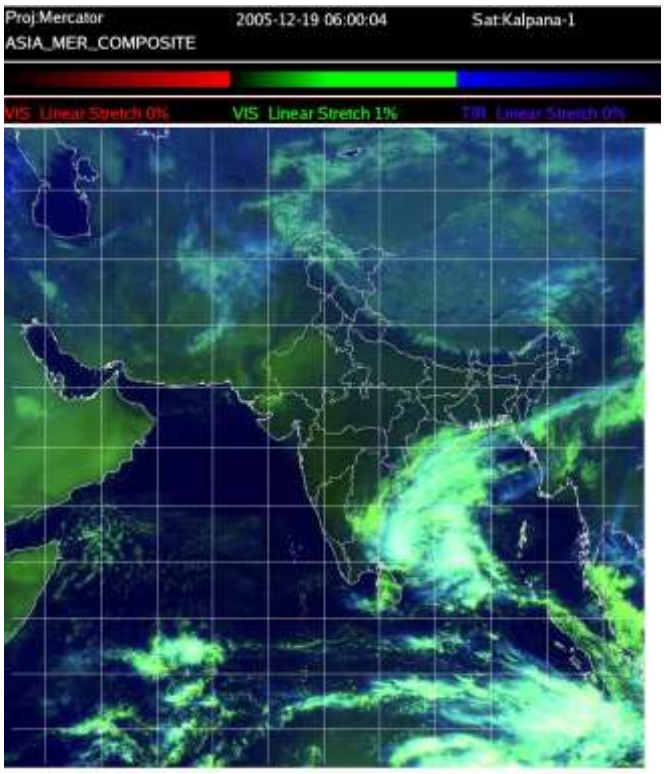
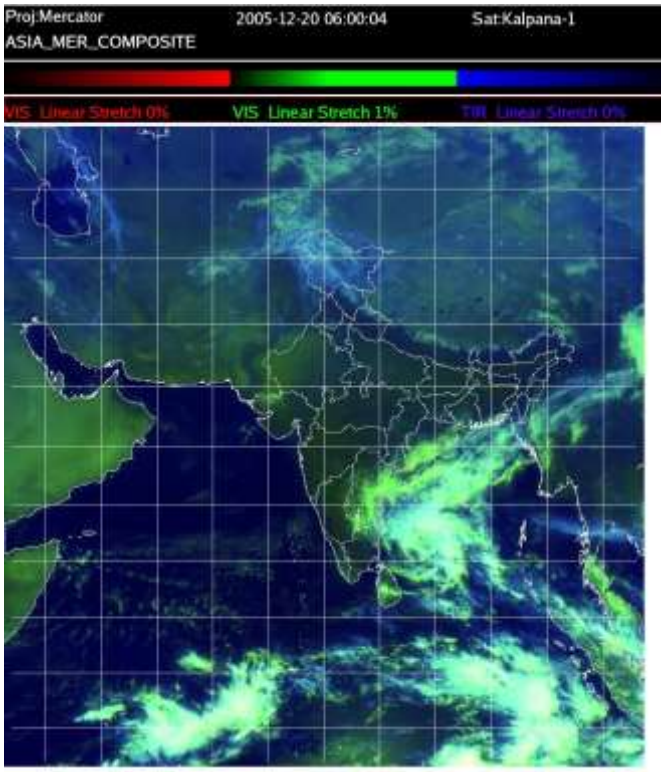


Fig. 2.12.1. Kalpana-1 imageries (a) at 0600 UTC of December 16, 2005 showing the organization of vortex in association with the depression and (b) at 0600 UTC of December 19, 2005 showing shear pattern of cloud in association with the system.

(c)



(d)

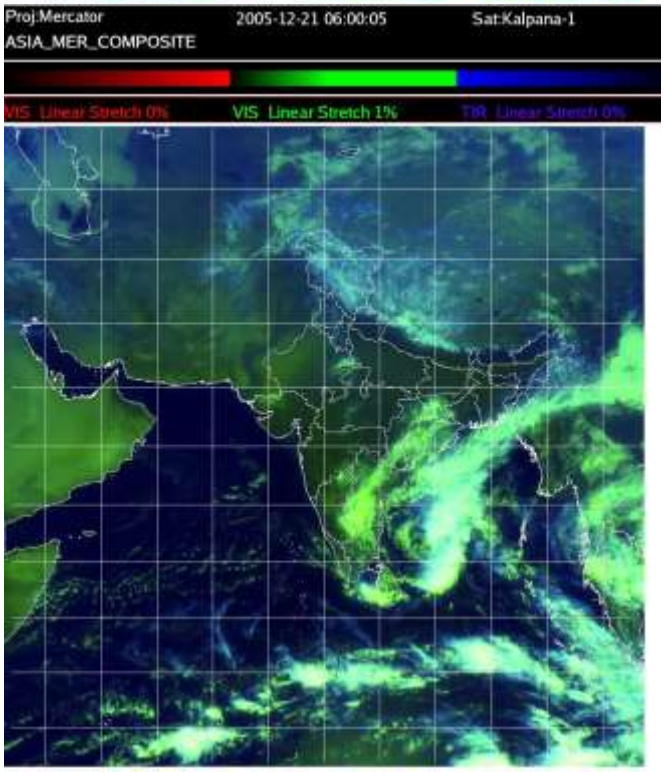


Fig. 2.12.1. (contd). Kalpana-1 imageries (c) at 0600 UTC of December 20, 2005 showing the recurvature and disorganization of the system and (d) at 0600 UTC of December 21, 2005 showing disorganization of cloud structure and weakening of the system.

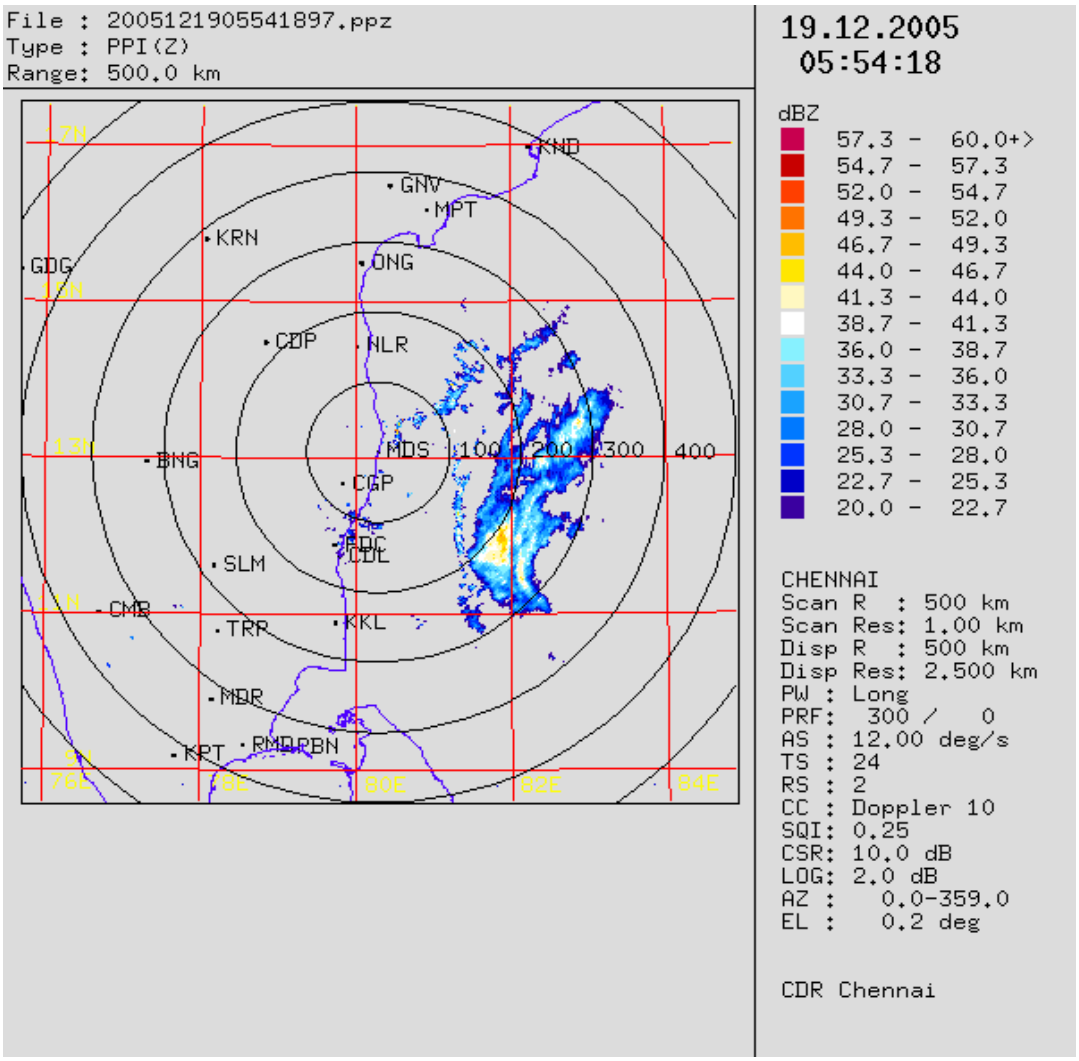


Fig.2.12.2. DWR imageries from DWR Chennai at 0554 UTC of December 19, 2005 showing intense convection due to the system.

Chapter III

Track prediction by Numerical Models

During the year 2005 LAM and QLM outputs such as initial development of the system and model predicted track forecasts were provided for the depression and cyclonic storms, which formed over the Bay of Bengal and Arabian Sea. The QLM model was run to produce track forecasts based on the initial conditions of each day of 0000 UTC and 1200 UTC observations when the disturbance was in deep depression stage, whereas the LAM forecasts were produced regularly in respect of 0000 UTC and 1200 UTC observations for day-to-day operational use.

A quantitative assessment of the performance of forecast model (QLM) was made by computation of track prediction errors. Two types of prediction errors have been computed. Direct position errors were calculated by taking the geographical distance between the predicted position in each case of forecast and the corresponding observed position. The second type of error is the angular deviation between the observed and predicted track vectors starting from a given initial position of the storm. While the former gives a measure of the absolute error of prediction, latter provides an indication of the closeness of the predicted direction of movement and the observed direction.

Table 3.1 contains the verification statistics of the mean position errors (km) and the angular deviation of the predicted tracks (for the cases of cyclonic storm) from the observed track (degrees). The computation for the cyclonic storm of September 2005 is not included as the system was very short lived (only 9 hours) over the Sea. The mean position errors for 24H forecast by QLM ranges between 132 to 230 km with an average of 174 km for these three cases and for the 48 hours forecast mean position error ranges from 229 to 367 km with an average of 306 km. The angular deviation for 24 hours forecast ranges from 11 ^{o} to 66 ^{o} with an average of 35 ^{o} and for 48 hours forecast it ranges from 12 ^{o} to 43 ^{o} with an average of 24 ^{o}. The track prediction errors for the cyclones of this year are slightly to the higher side. It may be because of erratic nature of the cyclonic disturbances. This year the systems were relatively weak and at the intensity of marginal cyclone. More over, the systems were almost stationary for quite long period at the beginning. The NWP models have certain limitations to capture these erratic behavior of cyclones.

TABLE 3.1: TRACK PREDICTION ERRORS (QLM)

Period	24 H		48 H	
	Position Error (km)	Angular Deviation (Deg)	Position Error (km)	Angular Deviation (Deg)
CS of 13-17 January (Bay of Bengal)	230	66	367	43
CS of 28 Nov. to 02 December (Bay of Bengal)	170	28	324	16
CS of 6-10 December (Bay of Bengal)	132	11	229	12
Mean of above four cases	174	35	306	24

THE MODEL FORECAST BY PERSISTENCE (P), CLIMATOLOGY (C), AND CLIPER (CLIP)

The errors in the predicted positions by PERSISTENCE (P),CLIMATOLOGY (C) AND CLIPER (CLIP) models from the actual track positions for the tropical cyclones in North Indian Ocean during 2005 are given in Table. 3.2.

Table 3.2

Forecast position errors for tropical cyclones in the Bay of Bengal and the Arabian sea during 2005 based on PERSISTENCE (P),CLIMATOLOGY (C) , AND CLIPER (CLIP) Models.

Date	PERSISTANCE (Km)			CLIMATOLOGY (Km)			CLIPER (Km)		
	12 hrs	24 hrs	36 hrs	12 hrs	24 hrs	36 hrs	12 hrs	24 hrs	36 hrs
Cyclonic storm "**PYARR**" 17-22 September	122	230	323	269	484	845	143	254	416
Cyclonic Storm "**BAAZ**" 28 Nov.- 02 Dec.	132	245	376	162	240	295	134	200	269
Cyclonic Storm "**FANOO**S" 06-10 Dec.	97	146	238	133	245	299	97	157	269
Average	**117**	**208**	**312**	**188**	**323**	**513**	**125**	**204**	**314**

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Uprooted Banyan tree fallen into the southwesterly direction at Bindi village (Vajrapu Kotturu Mandal) of Srikakulam district (Andhra Pradesh) due to the cyclonic storm, 'PYARR', which crossed north Andhra Pradesh coast near Kalingapattnam