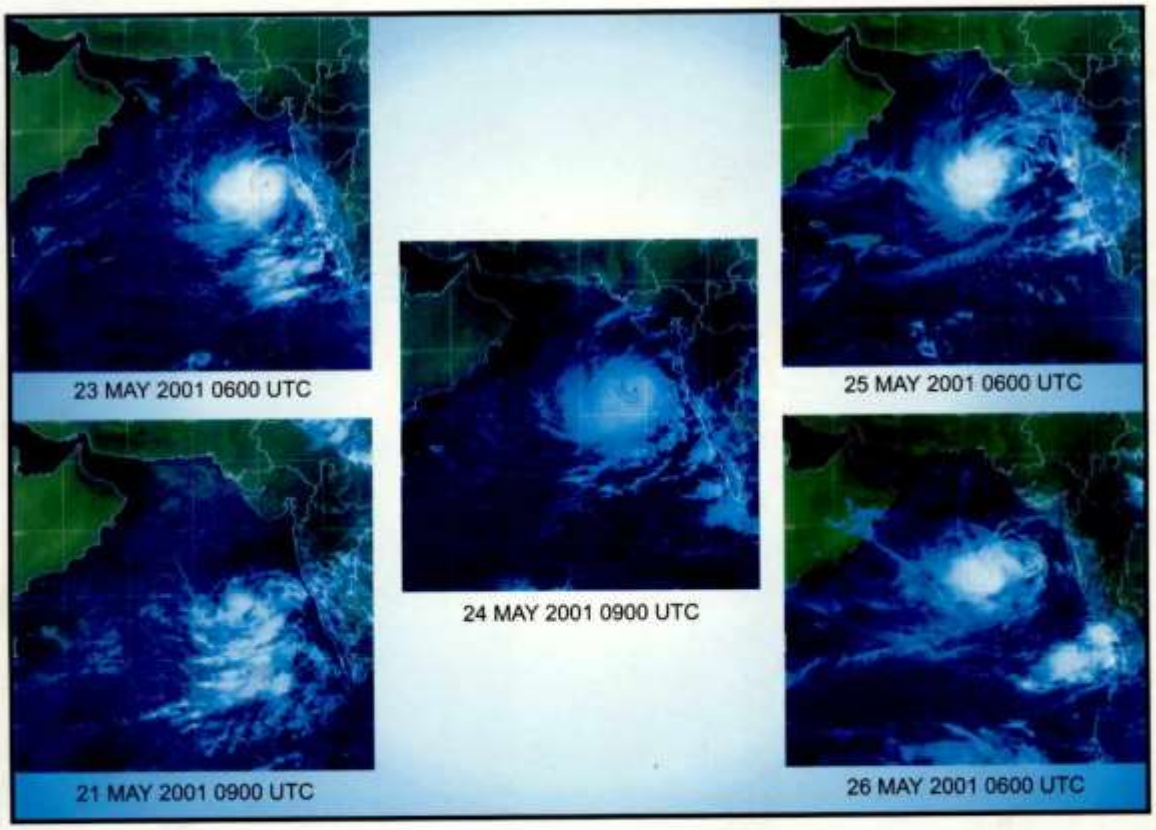
भारत मौसम विज्ञान विभाग

INDIA METEOROLOGICAL DEPARTMENT

REPORT ON CYCLONIC DISTURBANCES OVER NORTH INDIAN OCEAN DURING 2001



RSMC-TROPICAL CYCLONES NEW DELHI

FEBRUARY 2002

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CYCLONIC DISTURBANCES OVER NORTH INDIAN OCEAN DURING 2001

CONTENTS

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Activities of Regional Specialised Meteorological Centre -Tropical Cyclones New Delhi

Area of responsibility

The area of responsibility of RSMC-Tropical Cyclones New Delhi covers sea areas of north Indian ocean to the north of 5^0 N / 10^0 N between 45^0 E to 100^0 E and includes the Member Countries of WMO/ESCAP Panel on Tropical Cyclones viz., Bangladesh, India, Maldives, Myanmar, Sultanate of Oman, Pakistan, Sri Lanka and Thailand . The Centre issues Tropical Weather Outlooks and Tropical Cyclone Advisories on tropical cyclones when they develop over the north Indian Ocean.

Limited Area Model

A Quasi-Lagrangian Model (QLM) for cyclone track prediction has been implemented at RSMC New Delhi. The QLM is a multilevel primitive equation fine-mesh model cast in the sigma coordinate system ($\sigma = p/p_s$ pressure divided by surface pressure). The model has a limited area domain using a cartesian grid. The horizontal grid spacing is 40 km and the integration domain covers an area of 4440x4440 km^2 which is centred on the initial position of the cyclone. The QLM uses 16 layers in the vertical. The model incorporates physical processes. Radiation and turbulent processes, which have only marginal impact in the development, are currently excluded to minimize computational time. The numerical integration of the model is carried out by using the so called quasi-Lagrangian method.

The model provides track forecasts out to 36 hours at present. The initial analysis and lateral boundary conditions are generated from operational analysis and forecasts produced by the global spectral model of National Centre for Medium Range Weather Forecasting (NCMRWF), New Delhi.

ORIGIN-200

A new server Origin-200 system has been installed. Operational limited area analysis and forecast system has been implemented on Origin-200 computer system. Implementation of GTS data decoders in Origin -200 is on test mode. A limited area Quasi Lagrangian Model (QLM) for cyclone track prediction adapted from NCEP USA has been made operational. Limited area analysis and forecast, ECMWF forecast products have been provided in Local Area Network (LAN) of IMD, New Delhi. Current LAM analysis and 24 hours forecast products , daily weather bulletins and forecasts (texts) for all regions including special weather warnings such as tropical cyclones, heavy rainfall etc. are updated on IMD web site in real time. A storm surge model adapted from Indian Institute of Technology, Delhi for Indian coasts has been installed and is currently being validated.

Tropical Weather Outlook

Tropical Weather Outlook is issued daily at 06 UTC for use by the Member Countries of WMO/ESCAP Panel. This contains description of synoptic systems over North Indian Ocean and sub-tropical ridge position at 200 hPa level. In addition, a special weather outlook is also issued at 18 UTC in situations where a tropical depression is expected to attain the cyclone intensity. These bulletins are transmitted through the Global Telecommunication System (GTS). This year, five special weather outlooks were issued.

Global Maritime Distress and Safety System (GMDSS)

In the 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 METAREA VIII, which covers the entire North Indian Ocean and some parts of south Indian ocean. Preparation services for METAREA VIII are: (i) India, (ii) Kenya, (iii) Mauritius, and (iv) La Reunion.

Tropical Cyclone Advisories

As per one of the recommendations of the Twenty Sixth Session of the WMO/ESCAP Panel on Tropical cyclones held at Male Maldives, 2-8 March 1999, issue of 3 hourly tropical cyclone advisories for the benefit of the Member Countries of the Panel was continued during the year 2001 also.

These bulletins contain the current position of the centre, the direction and speed of movement, estimated central pressure, distribution of winds and squally weather, description of the state of the sea in and around the system and its forecast. This year 71 cyclone advisories were issued.

Satellite Activities

Under Indo-US co-operation scheme a data centre has been established to facilitate the exchange of data and products. India will be launching a Geo-stationary Meteorological Satellite (METSAT) by September 2002 over the Indian Ocean purely for the meteorological purposes and will provide imagery in VIS, IR, and WV channels. It will be followed by another Geo-stationary satellite INSAT-3A shortly after that and the meteorological payloads will be identical to those of INSAT-IIE.

Satellite bulletins were produced at every three hour interval based on the interpretation of INSAT cloud imagery. In the event of cyclonic storm, INSAT pictures were also taken at hourly interval . The bulletins contain detailed information on cloud system centre, movement and its intensity (T- number on Dvorak's scale) as well as a description of cloud organisation. Satellite derived information on tropical disturbances were also included in Tropical Cyclone Advisories.

INTRODUCTION

The North Indian Ocean witnessed development of four cyclonic storms and two depressions (Fig. 1.1) as compared to five cyclones and one depression in the previous year. Out of the four cyclones, three developed in the Arabian Sea and only one in the Bay of Bengal. No damage to life and property was caused due to cyclones in Panel member countries other than India. Even in India the damage to life and property was much less compared to some other years in the recent past. Except for the very severe cyclonic Storm in the Arabian Sea in the month of May, the remaining three cyclones were marginal ones. All the three cyclones that developed over the Arabian Sea weakened over sea itself.

Like the previous year, convective activity was generally subdued over the central Bay of Bengal during the month of October except over the South East Bay of Bengal where it was pronounced. This is evident from the mean Outgoing Long-wave Radiation (OLR) field derived from INSAT-1D IR data (Fig. 1.2) . The convection maxima was located over Sumatra and extended up to the Gulf of Thailand across neighbouring land areas. Similar conditions prevailed in November also. In December, the convection maxima shifted eastwards.

The Regional Specialised Meteorological Centre (RSMC) –Tropical Cyclones New Delhi mobilised all of its resources, both technical and human, to track the tropical disturbances evolving in the North Indian Ocean and issued advisories to WMO / ESCAP Panel countries.

The classification of cyclonic disturbances followed in the report is as given below:

S.No.	Weather System	Maximum sustained surface wind speed
1.	Low (L)	Wind speed less than 17 kt (<31 kmph)
2.	Depression (D)	Wind speed between 17 and 27 kt (31 and 49 kmph)
3.	Deep Depression (DD)	Wind speed between 28 and 33 kt (50 and 61 kmph)
4.	Cyclonic Storm (CS)	Wind speed between 34 and 47 kt (62 and 88 kmph)
5.	Severe Cyclonic Storm (SCS)	Wind speed between 48 and 63 kt (89 and 118 kmph)
6.	Very Severe Cyclonic Storm (VSCS)	Wind speed between 64 and 119 kt (119 and 221 kmph)
7.	Super Cyclonic Storm (SuCS)	Wind speed above 119 kt (above 221 kmph)

The term 'Cyclone' used in the text, is a 'generic' indicating all the four categories Of cyclonic disturbances given above under S. No. (4) to (7).

List of cyclonic disturbances during 2001 in chronological order

1.	Very Severe Cyclonic Storm over the Arabian Sea (21-28 May)
2.	Depression over the north west Bay of Bengal (12-13 June)
3.	Cyclonic Storm over the Arabian Sea (24-27 September)
4.	Cyclonic Storm over the Arabian Sea (08- 10 October)
5.	Cyclonic Storm over the Bay of Bengal (14-17 October)
6.	Depression over the Bay of Bengal (11-12 November)

Some Characteristics of cyclonic disturbances which attained cyclonic storm or higher intensity during 2001

Cyclonic Storm	Date, Time (UTC) & lat. (N /) / long .(E) of genesis	Date, Time (UTC) & lat./long of landfall.	Estimated lowest central pressure, Date &Time (UTC) & lat./long	Estimated maximum wind speed (kt) ,Date & Time & lat & long.	Maximum T. No. attained
Very Severe Cyclonic Storm over the Arabian sea 21-28 May	21 May at 1200 UTC near 13.5/69.0	Dissipated over sea off Saurashtra Coast in the morning of 29 May	932 hPa on 24.May at 0900 UTC near 17.0/69.0	115 kt on 24 May at 0900 UTC near 17.0/69.0	6.0
Cyclonic Storm over the Arabian Sea on 24-27, September	24 Sep. at 0900 UTC near 17.0/69.5	Dissipated over north-west Arabian Sea near Oman coast at 0300 UTC on 28 September	1000 hPa on 25 September at 1200 UTC near 17.0/68.0	35 kt on 25 September at 1200 UTC near 17.0/68.0	2.5
Cyclonic Storm over the Arabian Sea 08-10 October	08 October at 1200UTC near 18.3/71.0	Dissipated over East-CentralArabian Sea at 1200 UTC on 10 October	998 hPa on 09 October at 0900 UTC near 19.0/68.5	35 kt on 09 October at 0900 UTC near 19.0/68.5	2.5
Cyclonic Storm over the Bay of Bengal on 14-17 October	14 October at 1200UTC near 13.5/84.0	Crossed south Andhra Pradesh coast near Nellore around 0000 UTC of 16 October	998 hPa on 15 October at 1200 UTC near 13.7/81.0	35 kt on 15 October at 1200 UTC near 13.7./81.0	2.5

Statistical data relating to cyclonic disturbances in the North Indian Ocean during 2001

1. Synoptic class distribution of Cyclonic Disturbances (CI ≥ 2.0)

S.No	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Life Time (days)
1.	VSCS					↔								7.00
2.	Depression						↔							1.25
3.	CS									↔				2.25
4.	CS										↔			0.88
5.	CS										↔			1.63
6.	Depression											↔		1.0

Average Lifetime =	2.1 (days)

2. Frequency distribution of different intensity classes

CI	≥2.0	≥2.5	≥3.0	≥4.0	≥5.0	≥6.0	≥7.0
No. Of Disturbances	4	4	1	1	1	1	-
No. of days with Cyclone Intensity(≥2.5)	11.76	10.12	5.25	3.00	2.13	0.63	-

Note: CI = Current Intensity on Dvorak's Scale

3. Basin-wise distribution of disturbances

Bay of Bengal	3
Arabian Sea	3

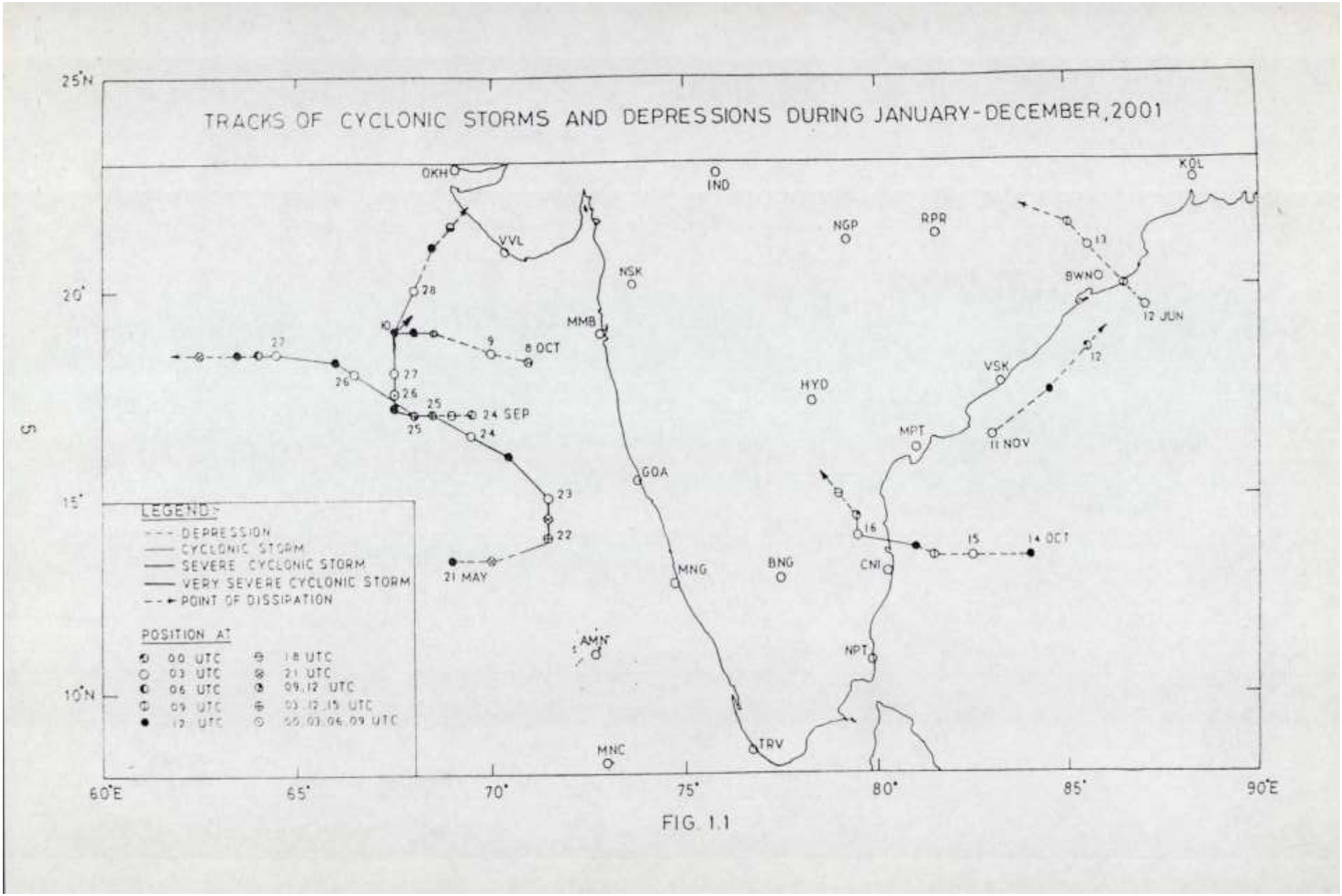

TRACKS OF CYCLONIC STORMS AND DEPRESSIONS DURING JANUARY-DECEMBER, 2001
25°N
20°
15°
10°N
60°E
65°
70°
75°
80°
85°
90°E
OKH
IND
KOL
VVL
NSK
NGP
RPR
MMB
BWNO
12 JUN
8 OCT
24 SEP
HYD
VSK
MPT
11 NOV
GOA
16
15
14 OCT
21 MAY
MNG
BNG
CNI
AMN
NPT
MNC
TRV
LEGEND:
DEPRESSION
CYCLONIC STORM
SEVERE CYCLONIC STORM
VERY SEVERE CYCLONIC STORM
POINT OF DISSIPATION
POSITION AT
00 UTC
03 UTC
06 UTC
09 UTC
12 UTC
18 UTC
21 UTC
09,12 UTC
00,03,06,09 UTC

FIG. 1.1

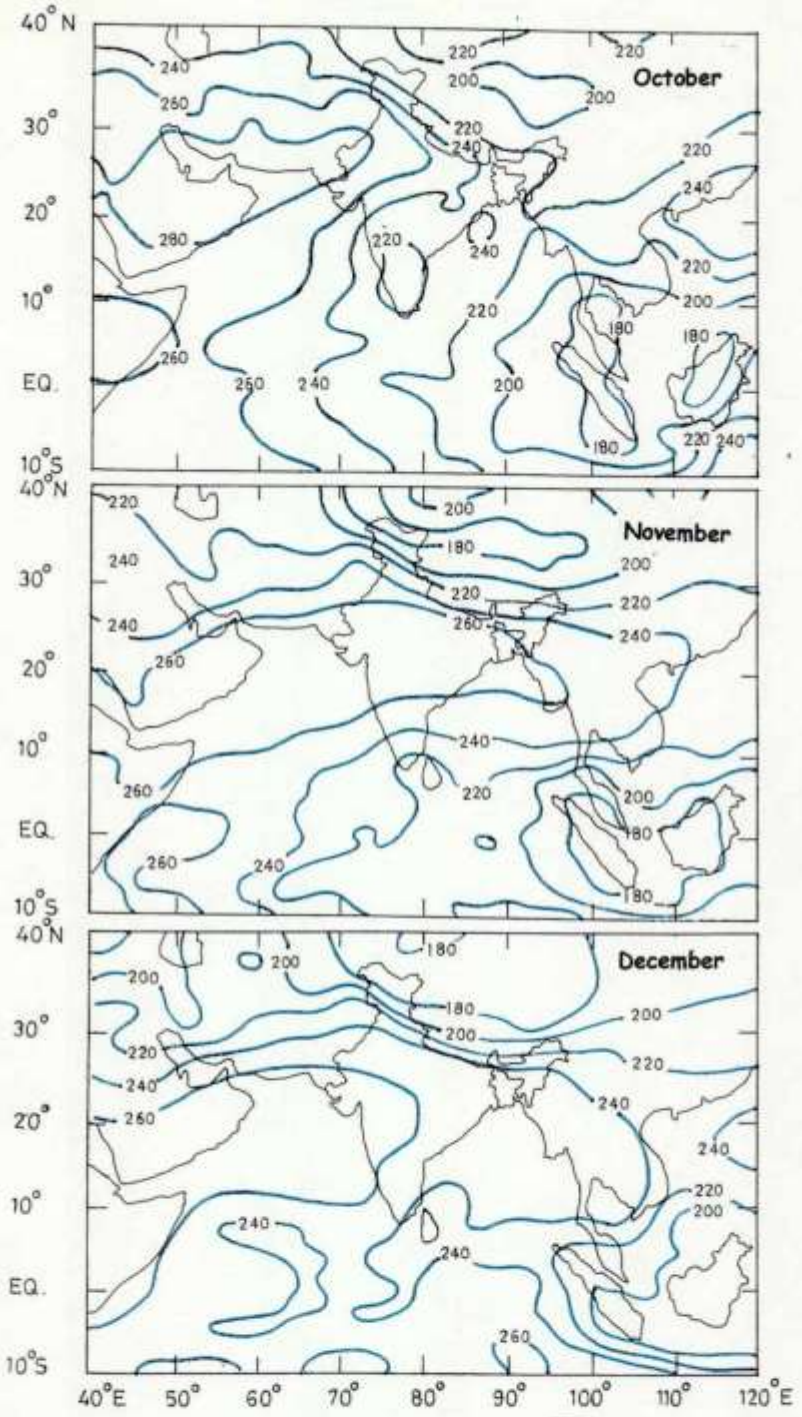


Fig. 1.2 Mean Outgoing Long Wave Radiation (OLR) from INSAT -1D in Watts/m^2 during Post Monsoon Season of 2001

CHAPTER 2

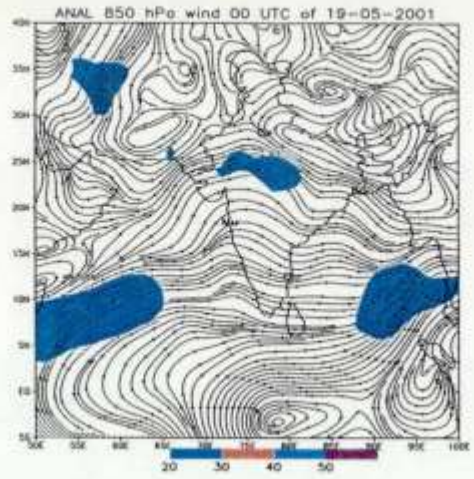
Brief Description of the Systems

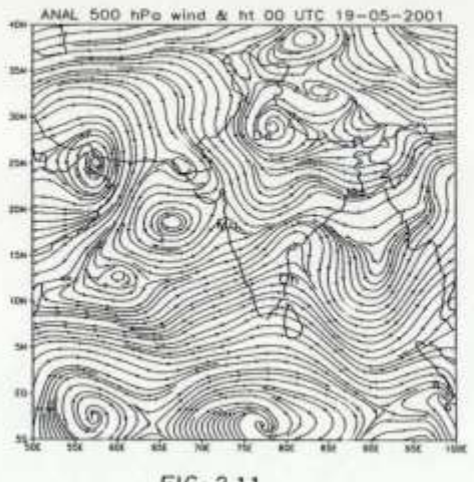
2.1 Very Severe Cyclonic Storm over the Arabian Sea (21-28 May)

The first cyclonic storm of the year formed as a depression over the East Central Arabian Sea on 21 May 2001. Moving initially in an easterly direction, it intensified into a cyclonic storm on the morning of 22 May. Thereafter it took an almost U-turn and further intensified into a very severe cyclonic storm in the morning of 23 May. The peak intensity was attained in the afternoon of 24 May when estimated maximum sustained surface wind speed reached 115 Knot. It retained this intensity till the early morning hours of 25 May and started weakening thereafter before re-curving to the north . It was seen as a well marked low pressure area over sea off Saurashtra coast on 29 May. This system remained over sea for more than a week.

Beginning of the second half of May 2001 witnessed development of an active equatorial trough in the North Indian Ocean. The Optimum Interpolation (OI) analysis showed the presence of a weak trough over central Arabian Sea in the lower troposphere on 19 May with a cyclonic circulation at 500 hPa level. Low level winds were SW'ly / 20 kts over southwest Arabian Sea. A cyclonic circulation developed, at the leading edge of surging southwest monsoon flow, in the lower troposphere over central Arabian Sea which extended upto 500 hPa. Low level winds continued to be SW'ly / 20 kts over southwest Arabian Sea. The circulation slowly moved eastwards and lay over east central Arabian sea on the morning of 20 May. Relative vorticity field also confirmed the above observations on 19 May. Relative vorticity was positive and of the order of 6 to 8 X 10^{-5} / s at 500 hPa over central Arabian Sea and between 0 and 2 X10^{-5} / s at 850 hPa. Subsequently positive vorticity field showed a gradual increase in the lower troposphere over Central Arabian Sea and was the order of 4 to 6 X10^{-5} / s on 21 May at 850 hPa. (Figs.2.1.1 and 2.1.2) . The vertical wind shear between 200 hPa and 850 hPa was generally small and of the order of 5 to 10 knots during the period 19-21 May (Fig 2.1.3) which is considered favourable for cyclogenesis and further growth. Under these favourable conditions a depression formed in the East Central Arabian Sea in the evening of 21 May and was centred at 211200 UTC near lat. 13.5 deg. N / long. 69.0 deg. E .

The system first took an eastward course and intensified into a cyclonic storm in the morning os 22 May and was centered at 220300 UTC near lat. 14.0^0 N / long. 71.5^0 E.. A Central Dense Overcast (CDO) of about 1 deg diameter was seen in the visible cloud imagery with bands hooking on to it from the northern and western sectors. An open 'eye' was seen by Cyclone Detection Radar (CDR) Goa at 221700 UTC. It reported spiral bands later until 231200 UTC. The system further intensified into a severe cyclonic storm at 221500 UTC near lat. 14.0^0 N / long. 71.5^0 E when the area of core convection further increased in size. During the next six hours the system moved in a northerly direction and acquired the stage of a very severe cyclonic storm at 222100 UTC when it was located near lat. 14.5^0 N / long.71.5^0 E. From this time onwards the warm air had started intruding into the core convection . Banding 'eye' was seen in the visible imagery at 230300 UTC. A clear circular 'eye' appeared at 230500 UTC. Hereafter it took a north-westerly direction and acquired its peak intensity with estimated maximum sustained surface wind speed of the order of 115 Knots at 240900 UTC when it was located near lat. 17.0^0 N / long. 68.5^0 E. The system retained its peak intensity till 250000 UTC. At this time the system was located near lat.17.0^0 N / long. 68.0^0 E. Thereafter the system started moving in a westerly direction and showing signs of weakening.





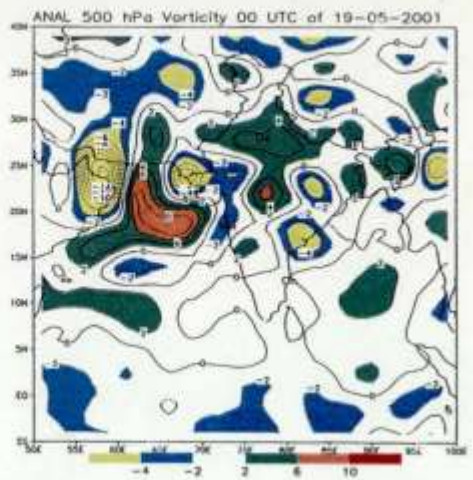
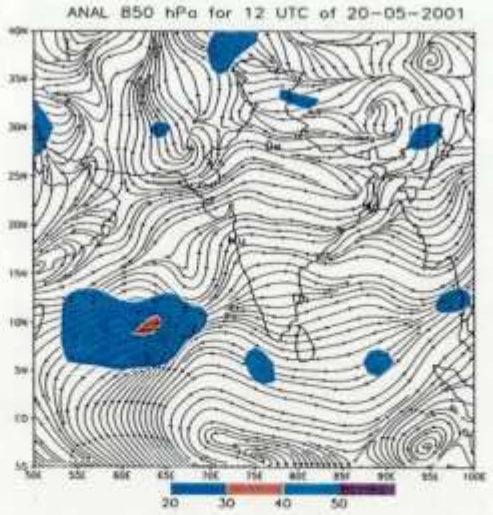


FIG. 2.1.1



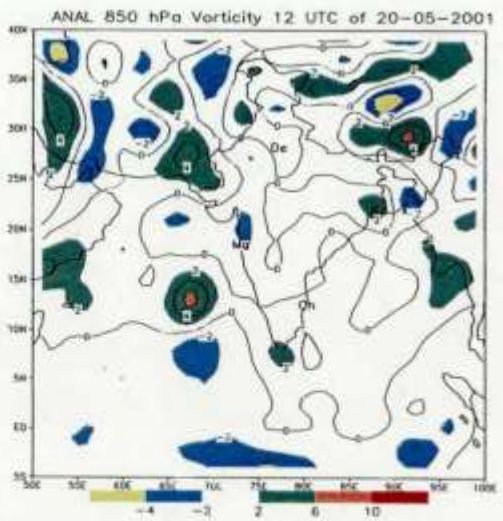


FIG. 2.1.2

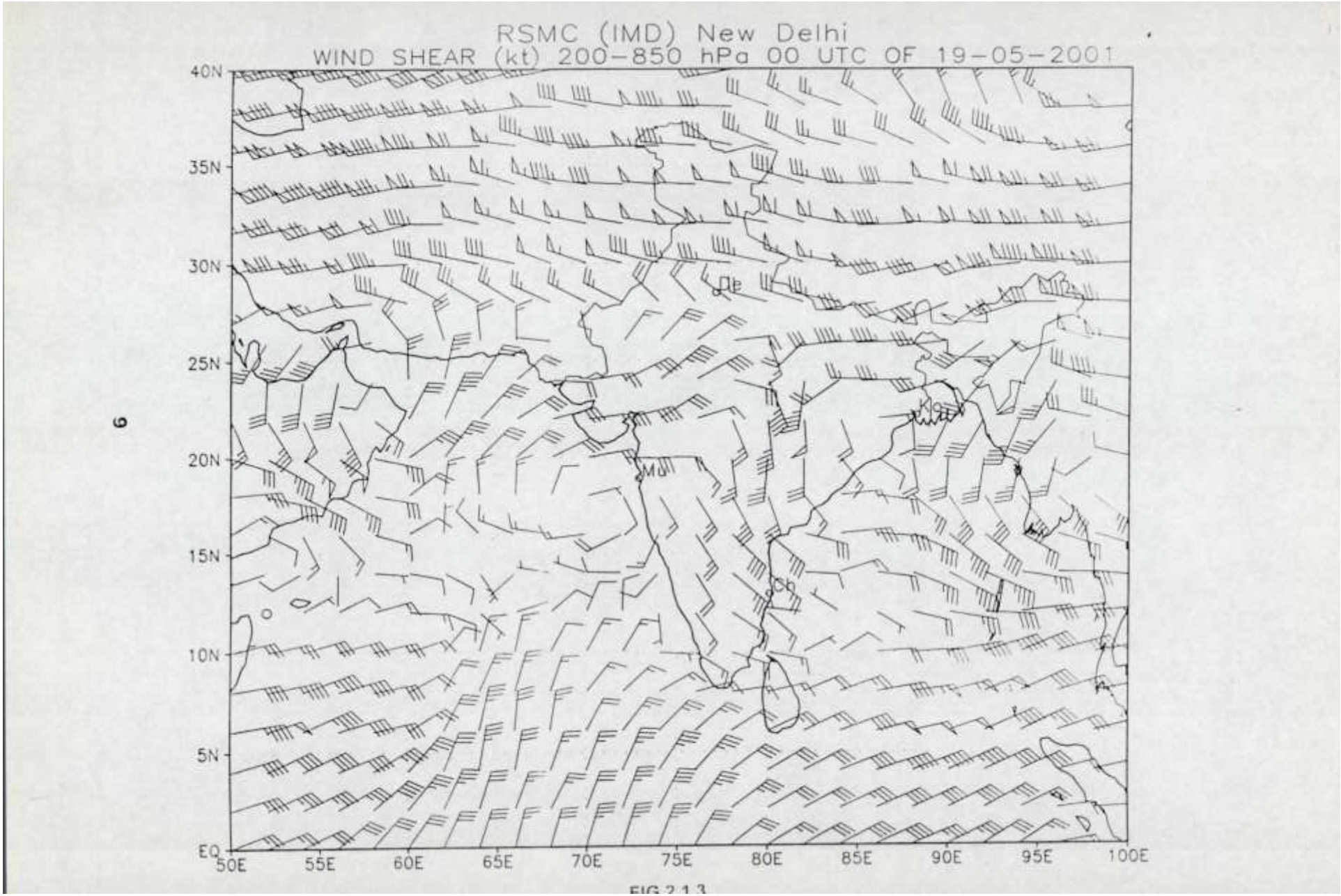

RSMC (IMD) New Delhi
WIND SHEAR (kt) 200-850 hPa 00 UTC OF 19-05-2001
40N
35N
30N
25N
20N
15N
10N
5N
EQ
50E
55E
60E
65E
70E
75E
80E
85E
90E
95E
100E

FIG 2.1.3

Remaining practically stationary near lat. 17.0° N / long. 68.0° E the system weakened when the estimated maximum sustained surface wind speed became 90 kt at 250600 UTC. In fact the eye feature had been lost by 250600 UTC when the system was undergoing shear. The convection decreased around a low- level circulation centre. However, the system started moving in a northerly direction after 251200 UTC and further weakened into a severe cyclonic storm at 260300 UTC when it was located near lat. 17.5° N / long 67.5° E. A buoy at lat. 15.5° N/ long. 69.2° E reported wind of 200° / 3o knots and surface pressure of 997.5 hPa at this stage.

The severe cyclonic storm continued to move in a northerly direction. Low level cloud lines indicated vortex centre near the eastern edge at 270300UTC when it weakened into a cyclonic storm at 270300 UTC when it was located near lat. 18.0° N / long. 67.5° The low level circulation centre became fully exposed and got displaced further away by 270900 UTC. The system maintained its northerly course till 271200 UTC. Thereafter it drifted in a north-north-easterly direction and weakened into a depression at 281800 UTC when it was centred near lat. 21.5° N/ Long. 69.0° E. It further weakened into a low pressure area in the morning of 29 May over the sea close to Saurashtra coast.

The track of the system is given in Fig. 2.1.4. The best track position and other parameters are given table 2.1.1 . The QLM model's predicted tracks for the next 36-hours are shown in Fig.2.1.5. A few satellite pictures are included Fig. 2.1.6. A few radar pictures of CDR Panjim (Goa) are included in Fig. 2.1.7.

Weather realized

The storm affected the coasts of Goa, Maharashtra and Gujarat states. The maximum sustained surface wind speed reported from Goa was 22 Kts at 221100 UTC. Subsequently the system drifted away from the Maharashtra coast and started affecting Gujarat coast after 27th evening. Along Gujarat coast, Veraval reported surface winds between 20 to 28 Kts from 271500 UTC t0 290100 UTC with the strongest winds of 32 Kts at 280100 UTC.

In association with this system, moderate rainfall was reported from stations in Goa and coastal areas of Maharashtra and Gujarat including some of the interior districts. This resulted into normal to excess rainfall along west coast.The rainfall distribution in meteorological sub-divisions for the week ending 30 May 2001 is given in Fig. 2.1.8.

Damage

No damage to life and property was reported.

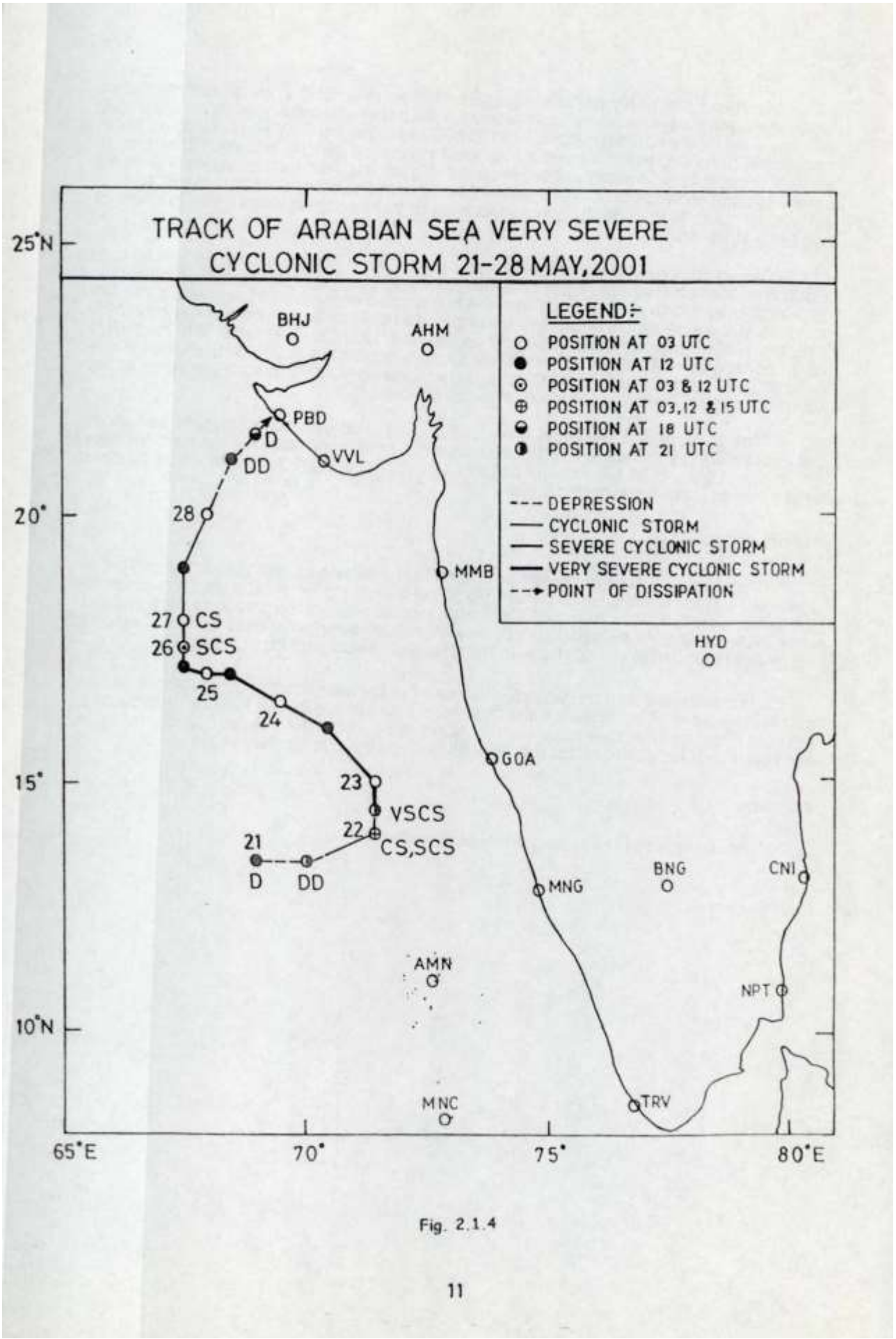

TRACK OF ARABIAN SEA VERY SEVERE CYCLONIC STORM 21-28 MAY, 2001
LEGEND:-
POSITION AT 03 UTC
POSITION AT 12 UTC
POSITION AT 03 & 12 UTC
POSITION AT 03, 12 & 15 UTC
POSITION AT 18 UTC
POSITION AT 21 UTC
DEPRESSION
CYCLONIC STORM
SEVERE CYCLONIC STORM
VERY SEVERE CYCLONIC STORM
POINT OF DISSIPATION
BHJ
AHM
PBD
VVL
D
DD
28
27 CS
26 SCS
25
24
23
VSCS
22
CS, SCS
21
D
DD
MMB
HYD
GOA
MNG
BNG
CNI
AMN
NPT
MNC
TRV
25°N
20°
15°
10°N
65°E
70°
75°
80°E

Fig. 2.1.4

Table 2.1.1

Best track positions and other parameters for the Arabian Sea
Very Severe Cyclonic Storm 21-28 May 2001

Date	Time (UTC)	Centre Lat. °N / Long .°E	C. I NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the centre (hPa)	Grade
21.05.2001	12	13.5/69.0	1.5	1000	25	4	**D**
	18	13.5/70.0	1.5	1000	25	4	**D**
	21	13.5/70.0	2.0	998	30	6	**DD**
22.05.2001	00	14.0/71.0	2.0	998	30	6	**DD**
	03	14.0/71.5	2.5	996	40	8	**CS**
	06	14.0/71.5	3.0	996	45	10	**CS**
	09	14.0/71.5	3.0	994	45	10	**CS**
	12	14.0/71.5	3.0	992	45	12	**CS**
	15	14.0/71.5	3.5	990	55	14	**SCS**
	18	14.0/71.5	3.5	988	55	16	**SCS**
	21	14.5/71.5	4.0	982	65	22	**VSCS**
23.5.2001	00	14.5/71.5	4.0	980	65	22	**VSCS**
	03	15.0/71.5	4.5	974	77	30	**VSCS**
	06	15.5/71.0	5.0	964	90	40	**VSCS**
	09	16.0/71.0	5.0	962	90	40	**VSCS**
	12	16.0/70.5	5.0	960	90	40	**VSCS**
	15	16.0/70.5	5.0	962	90	40	**VSCS**
	18	16.0/70.5	5.0	962	90	40	**VSCS**
	21	16.0/70.0	5.0	960	90	40	**VSCS**
24.5.2001	00	16.0/69.5	5.0	960	90	40	**VSCS**
	03	16.5/69.5	5.5	950	102	52	**VSCS**
	06	17.0/69.0	5.5	946	102	52	**VSCS**
	09	17.0/68.5	6.0	932	115	66	**VSCS**
	12	17.0/68.5	6.0	932	115	66	**VSCS**
	15	17.0/68.5	6.0	932	115	66	**VSCS**
	18	17.0/68.5	6.0	932	115	66	**VSCS**
	21	17.0/68.0	6.0	932	115	66	**VSCS**
25.5.2001	00	17.0/67.5	6.0	932	115	66	**VSCS**
	03	17.0/68.0	5.5	948	102	52	**VSCS**
	06	17.0/68.0	5.0	960	90	40	**VSCS**
	09	17.0/68.0	5.0	960	90	40	**VSCS**
	12	17.2/67.5	4.5	968	77	30	**VSCS**

Table 2.1.1 (Continued)

Best track positions and other parameters for the Arabian Sea
Very Severe Cyclonic Storm 21-28 May, 2001

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
25.5.2001	15	17.0/68.0	4.5	968	77	30	VSCS
	18	17.0/68.0	4.5	970	77	30	VSCS
	21	17.0/67.5	4.5	970	77	30	VSCS
26.5.2001	00	17.5/67.5	4.0	976	65	20	VSCS
	03	17.5/67.5	3.5	982	55	16	SCS
	06	17.5/67.5	3.5	984	55	16	SCS
	09	17.5/67.5	3.5	984	55	16	SCS
	12	17.5/67.5	3.5	982	55	16	SCS
	15	17.5/67.5	3.5	982	55	16	SCS
	18	17.5/67.5	3.5	982	55	16	SCS
	21	18.0/67.5	3.5	982	55	16	SCS
27.5.2001	00	18.0/67.5	3.5	984	55	16	SCS
	03	18.0/67.5	3.0	986	45	12	CS
	06	18.0/67.5	3.0	986	45	10	CS
	09	18.0/67.5	3.0	986	45	10	CS
	12	19.0/67.5	3.0	988	45	8	CS
	15	19.0/68.0	2.5	994	35	8	CS
	18	19.0/68.0	2.5	994	35	8	CS
	21	19.5/68.0	2.5	994	35	8	CS
28.5.2001	00	19.5/68.0	2.5	994	35	8	CS
	03	20.0/68.0	2.5	994	35	8	CS
	06	20.0/68.0	2.5	996	35	8	CS
	09	20.0/68.0	2.5	996	35	8	CS
	12	21.0/68.5	2.0	996	30	6	DD
	15	21.0/68.5	2.0	996	30	6	DD
	18	21.5/69.0	1.5	998	25	4	D
	21	21.5/69.0	1.5	998	25	4	D
29.5.2001	00	21.5/69.0	1.5	998	25	4	D
	03	The system weakened into a low pressure area over sea close to Saurashtra coast					

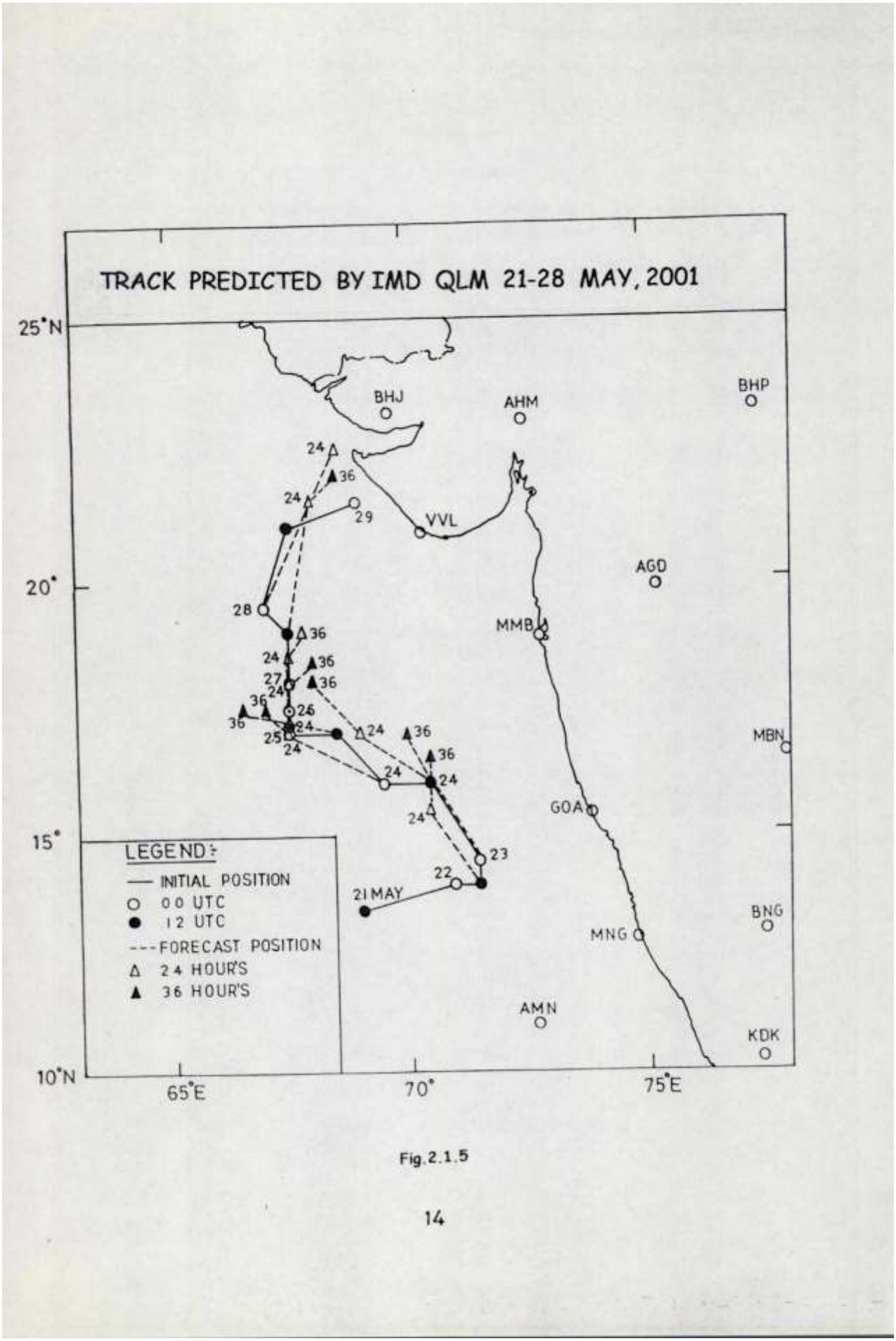
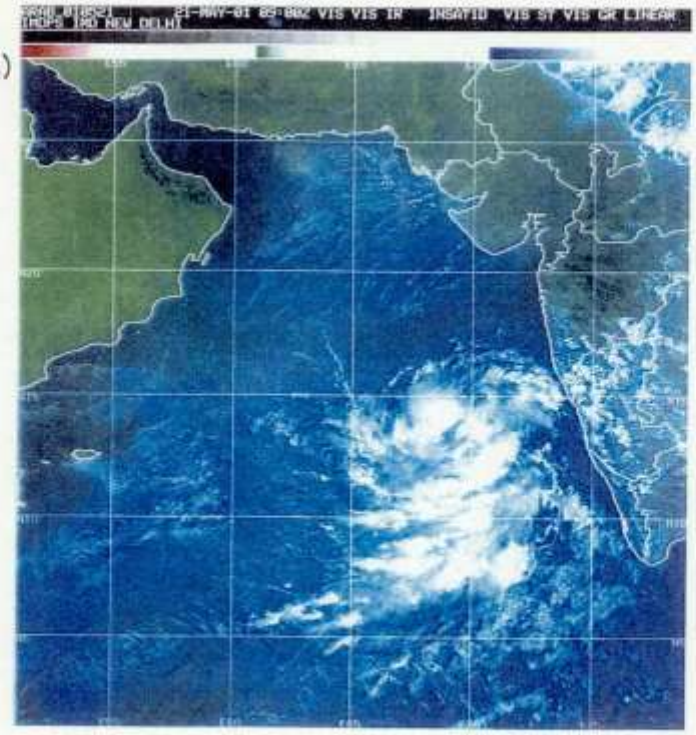

TRACK PREDICTED BY IMD QLM 21-28 MAY, 2001
25°N
20°
15°
10°N
65°E
70°
75°E
BHJ
AHM
BHP
VVL
AGD
MMB
MBN
GOA
BNG
MNG
AMN
KDK
21 MAY
LEGEND :
INITIAL POSITION
00 UTC
12 UTC
FORECAST POSITION
24 HOUR'S
36 HOUR'S

Fig.2.1.5

(a)



(b)

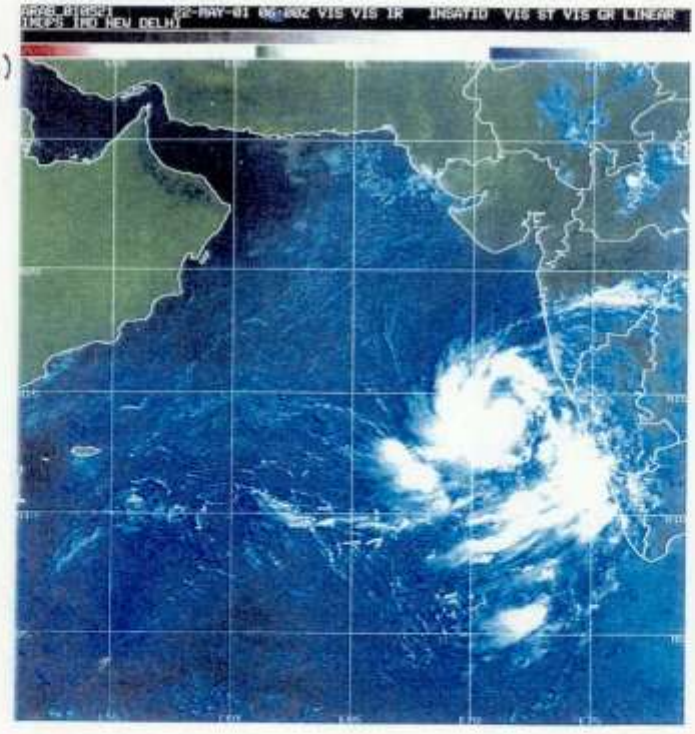


Fig. 2.1.6 ; Satellite pictures showing cloudiness in association of (a) a depression (CI 1.5) in East Central Arabian Sea on 21 May and (b) a cyclonic storm (CI 2.5) on 22 May.

(c)

(d)

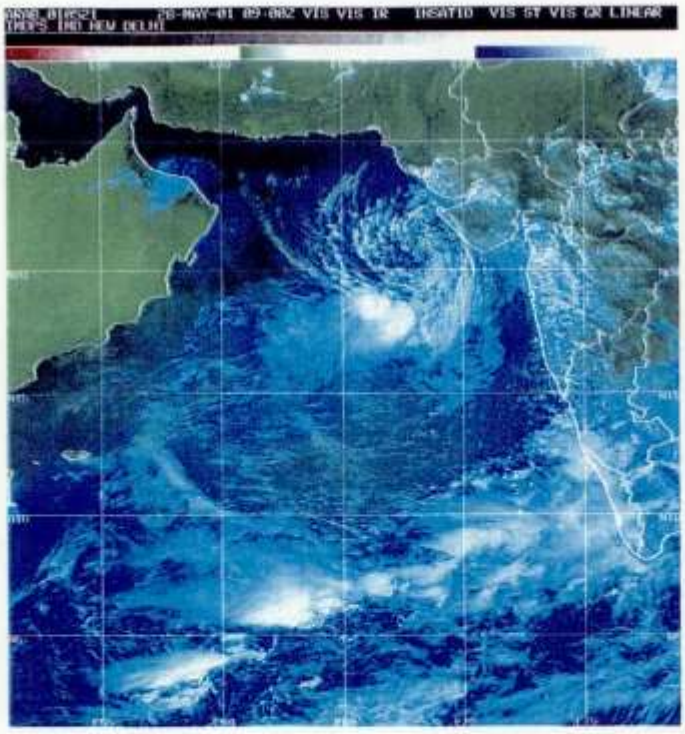
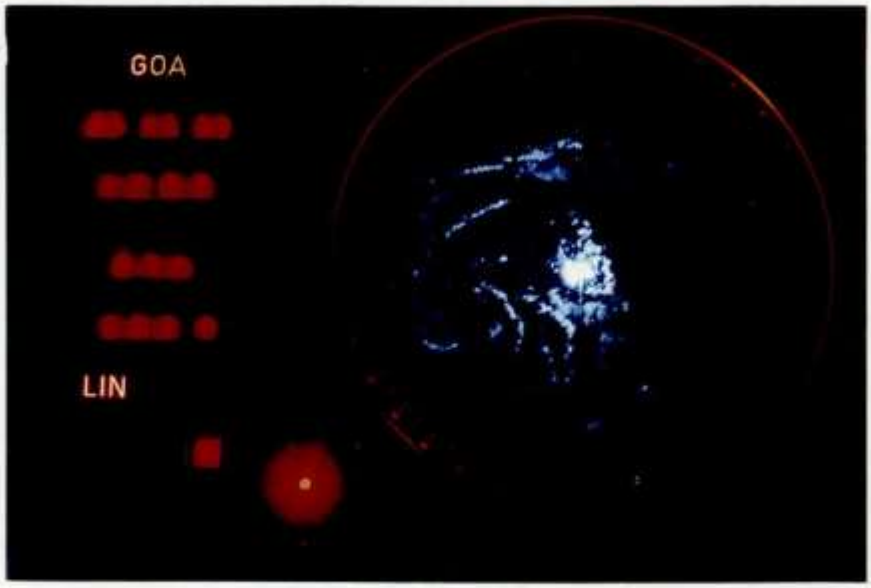


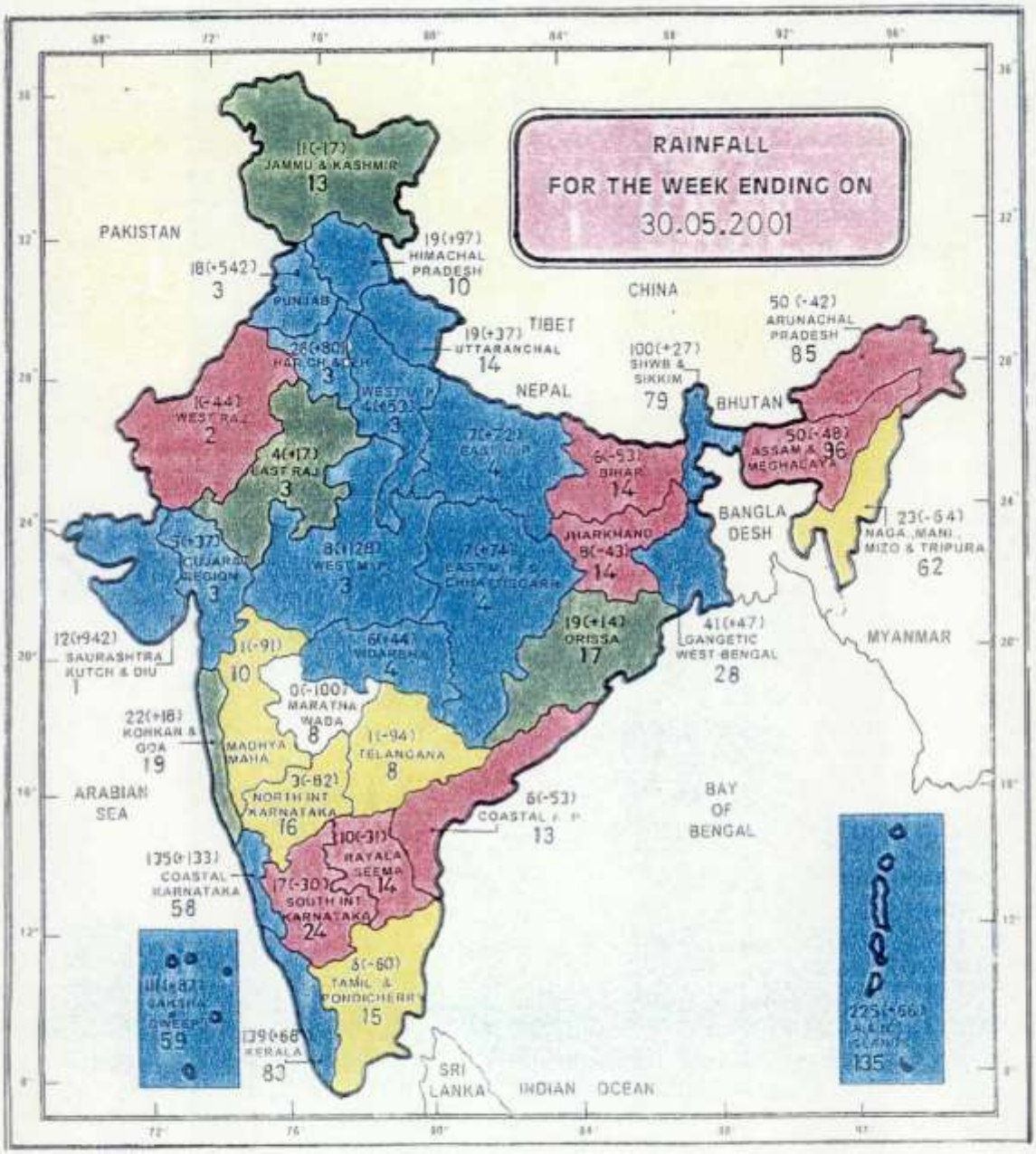
Fig.2.1.6 (contd.) : Satellite pictures showing cloudiness in association of (c) a very severe cyclonic storm with 'eye' (CI 5.0) on 23 May and (d) considerable reduction in convection over sea in the weakening stage (CI 2.5) on 28 May.



22 May 2001 1300 UTC

22 May 2001 1600 UTC

Fig. 2.1.7 : Radar pictures from CDR Goa of the system showing spiral bands defining centre of the system on 22 May.



Small figures indicate actual rainfall (mm), while bold figures indicate normal rainfall (mm). Percentage departures of rainfall from normal are shown in brackets.

FIG. 2.1.8

2.2 Depression over Bay of Bengal (12- 13 June)

A low pressure area that formed over North West Bay of Bengal on 10 June, concentrated into a depression on 12 June before crossing Orissa coast near Paradip (42976). It lashed Orissa with some exceptionally heavy rains on 12 and 13 June.

The first low pressure area of southwest monsoon season formed on the leading edge of the monsoon current in the Northwest Bay of Bengal on 10 June. A low level circulation centre was seen in the satellite imagery on 12 June a with a deep layer cluster located to the west over northwest Bay and adjoining land areas of Orissa .This was accompanied with a surge in the southwesterly flow that strengthened on this day as seen in (Fig. 2.2.1a). Relative vorticity at 850 hPa showed increase both in the East Arabian Sea and North Bay of Bengal (Fig. 2.2.1 b) . By the morning of 12 June the surge in the south-westerlies had moved over to eastern parts of peninsular India, adjoining areas of Bay of Bengal including some parts of Central Bay of Bengal also (Fig. 2.2.1.a) . Relative vorticity (Fig. 2.2.2) increased over Orissa coast from 6 x 10^{-5} /s on 11 to 12 x10^{-5} /s on 12 June. A depression formed on 12 June and it lay centred at 120300 UTC near Lat. 19.5° N / Long. 87.0° E.

This system moved slowly in a north-westerly direction and crossed Orissa coast around 121000 UTC. It continued to move in the north-westerly direction. 24 and 48 hours forecast of wind and relative vorticity at 850 hPa level and rainfall valid for 0000 UTC of 13 June and 14 June are shown in Figs. 2.2.3 and 2.2.4 respectively. The system weakened into a low pressure area in the evening of 13 June near Raigarh (42884) in Chattishgarh region.

The forecast track as well as the track of the system are given in Fig. 2.2.5 . The best track positions and other parameters have been included in Table 2.2.1. A few INSAT cloud images of the system are given in Fig. 2.2.6.

Weather realised

Under the influence of the depression widespread rainfall with isolated very heavy to exceptionally heavy falls occurred over Orissa from 11 to 14 June. Puri (43053) received record breaking 2-days' rainfall of 70 cm (34 cm on 12 June and 36 cm on 13 June). The rainfall for the week ending on 13 June is shown in fig. 2.2.7.

Damage

No damage to life and property was reported.

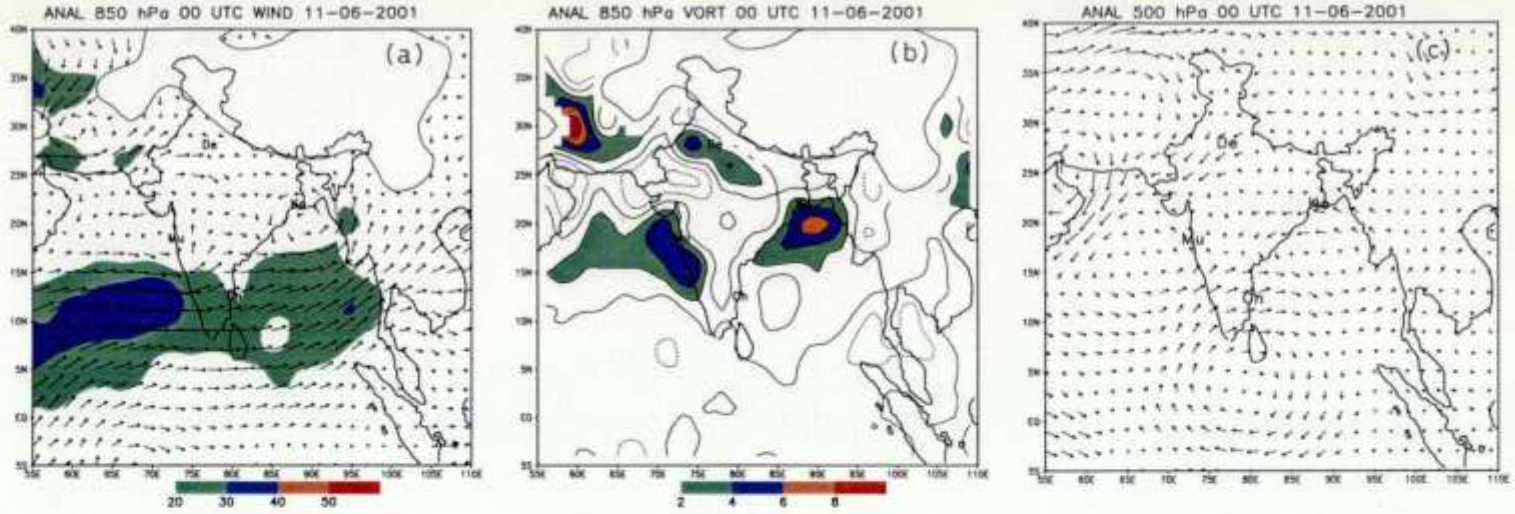


FIG. 2.2.1

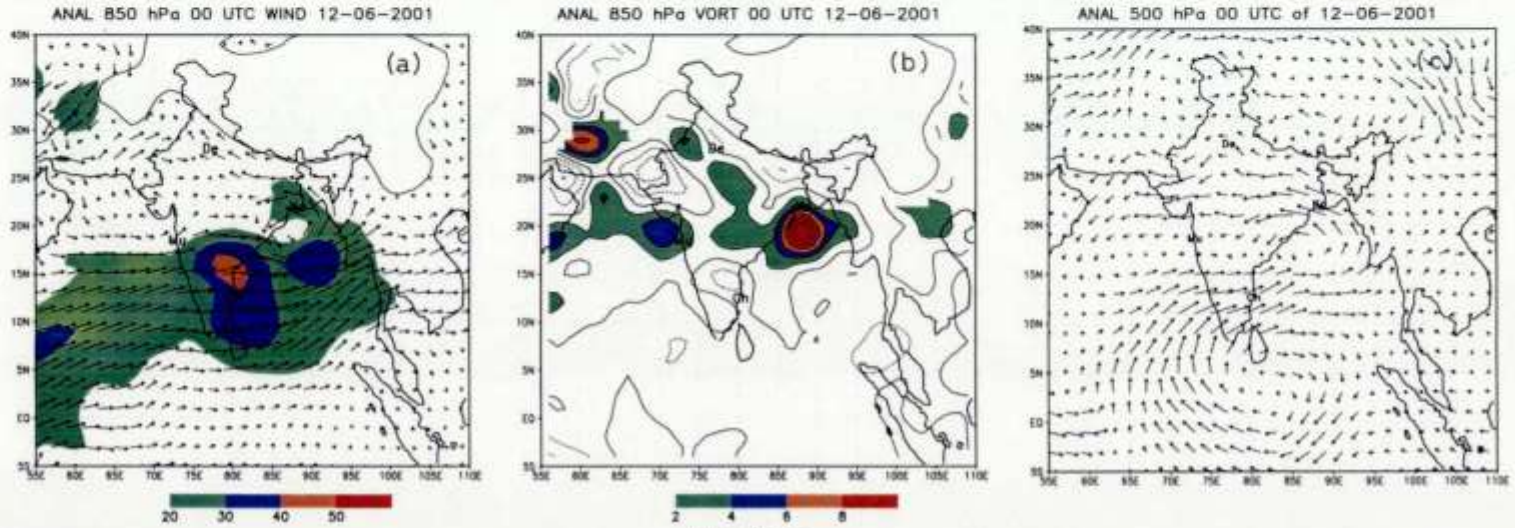
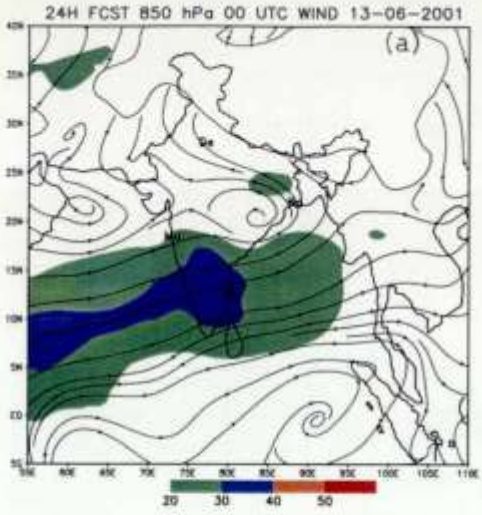
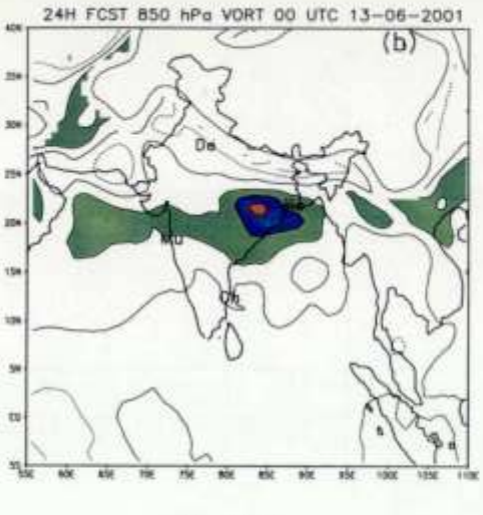


FIG. 2.2.2





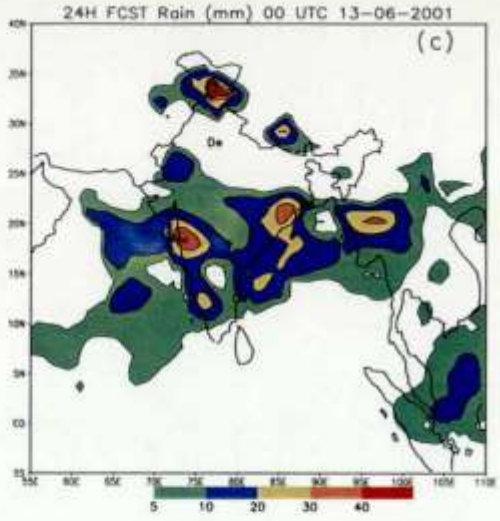
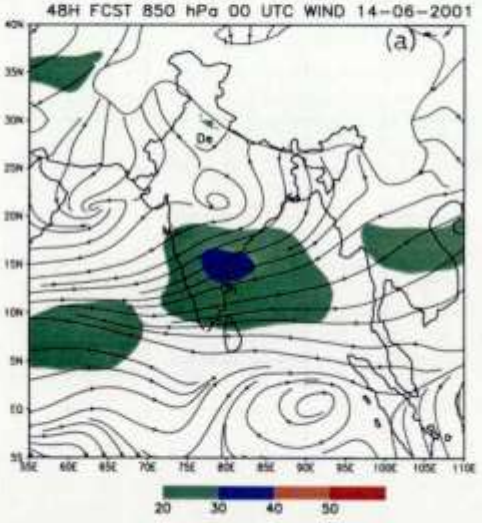
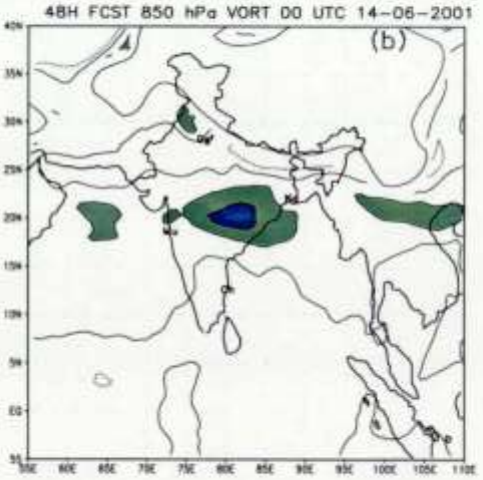


FIG. 2.2.3





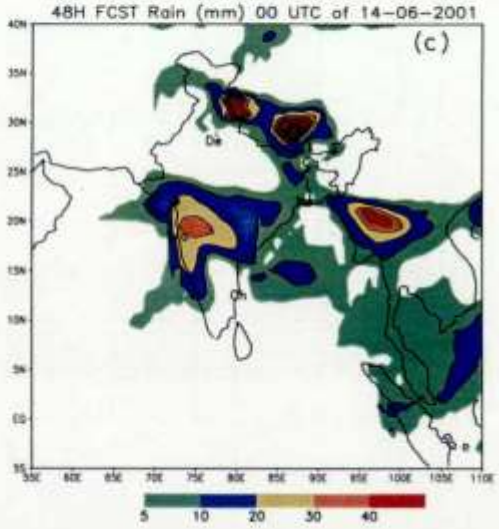


FIG. 2.2.4

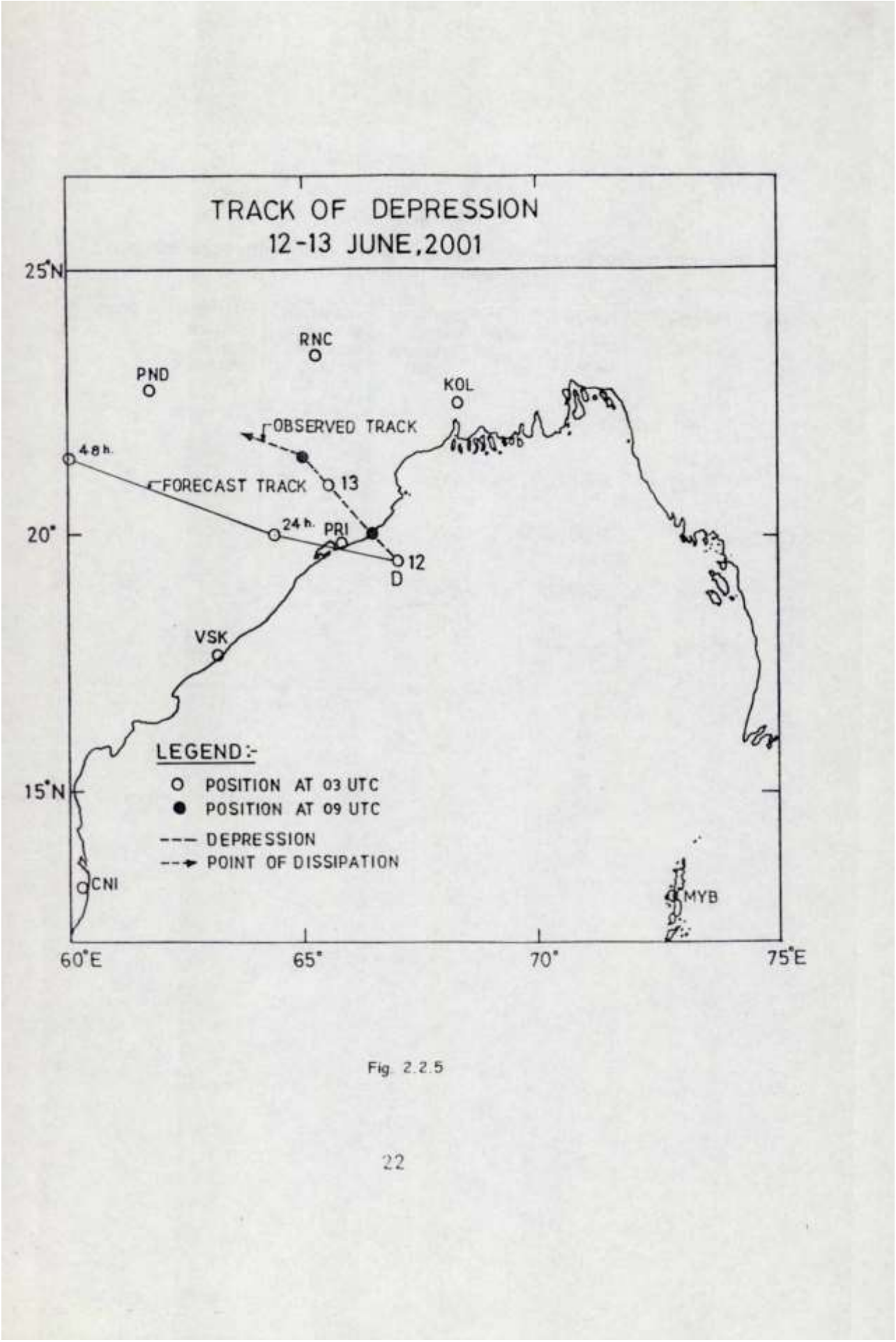

TRACK OF DEPRESSION
12-13 JUNE,2001
25°N
20°
15°N
60°E
65°
70°
75°E
RNC
PND
KOL
OBSERVED TRACK
48h.
FORECAST TRACK
13
24h.
PRI
12
D
VSK
CNI
MYB
LEGEND:-
POSITION AT 03 UTC
POSITION AT 09 UTC
DEPRESSION
POINT OF DISSIPATION

Fig. 2.2.5

Table 2.2.1

Best track positions and other parameters for the west central Bay of Bengal Depression 12-13 June , 2001

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
12.6.2001	03	19.5/87.0	1.5	990	25	4	D
	12	20.0/86.5	1.5	990	25	4	D
13.6.2001	03	21.0/85.5	1.5	994	25	4	D
	09	21.0/85.0	1.5	994	25	4	D
	12	21.5/84.5					L

(a)

(b)

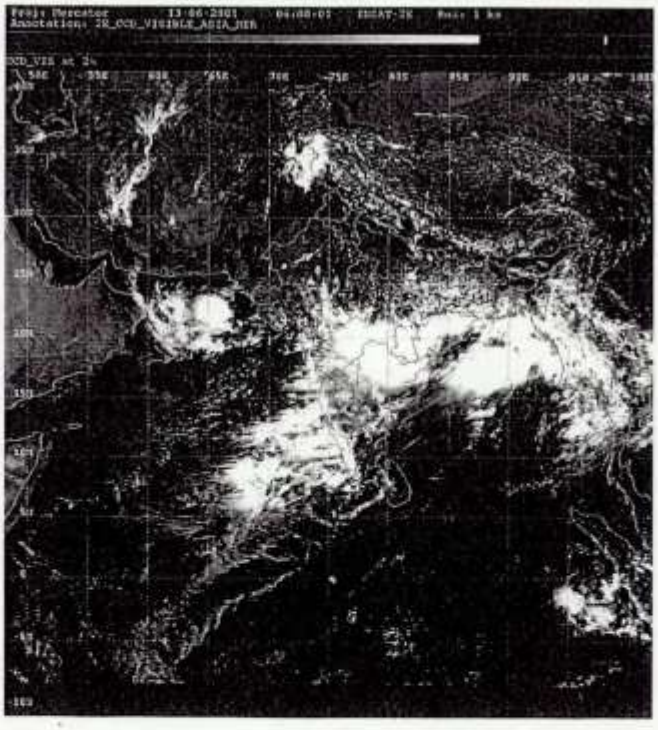
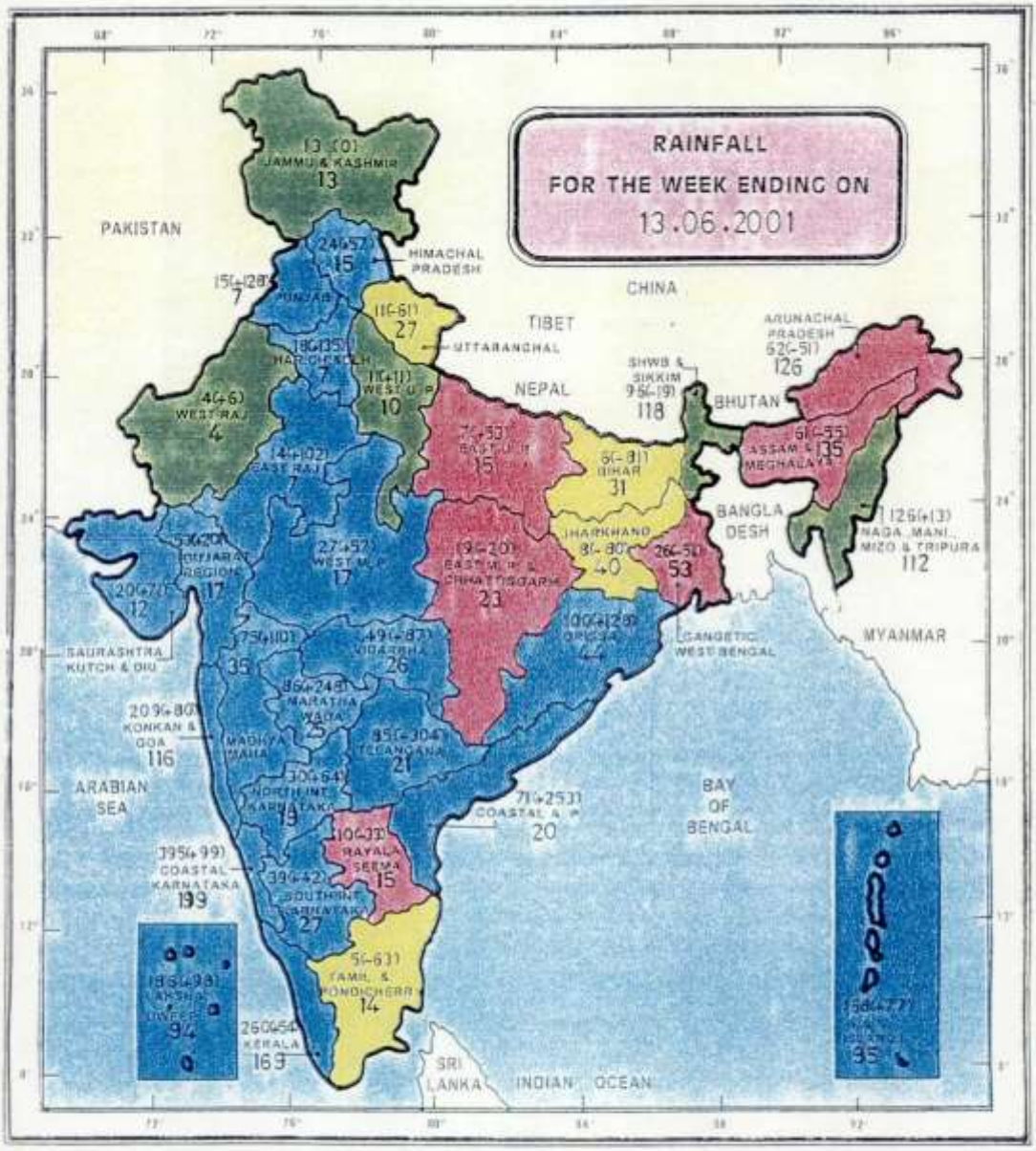


Fig.2.2.6 : Satellite pictures showing intense convection in association with a depression (a) on 12 June and (b) on 13 June.



Small figures indicate actual rainfall (mm), while bold figures indicate normal rainfall (mm). Percentage departures of rainfall from normal are shown in brackets.

Fig. 2.2.7

2.3 Cyclonic Storm over the Arabian Sea (24- 27 September)

A depression developed over the East Central Arabian Sea on 24 September. Moving north-westwards it intensified into a cyclonic storm on 26 September. However, it weakened and dissipated over the sea. Development of a cyclonic strom in the Arabian Sea during the month of September is rare. Cyclonic stroms had earlier developed over Arabian Sea in September in the years 1974 and 1979. They also weakened and dissipated over sea.

The week beginning from 20 September witnessed northward propagation of maximum cloud zone (MCZ) from close to equator to 15° N in the Arabian Sea and Bay of Bengal. In the beginning of the week an east- west oriented shear line was seen between 2.1 Km and 4.5 Km above sea level and extended from east Arabian Sea to Andaman Sea. In this shear line a cyclonic circulation developed on 20 September over North Interior Karnataka and adjoining Konkan and Goa and extended up to 4.5 Km in the vertical tilting south-westwards with height. It moved westwards and was located over East Central Arabian Sea off Konkan- Goa coast on 23 September. Subsequently a low pressure area formed over East Central Arabian Sea off Konkan-Goa coast that concentrated into a depression over east central Arabian Sea in the afternoon of 24 September. The initial development could also be seen in the LAM analysis of 22nd and 23rd September (Fig 2.3.1 & 2.3.2). A ship (Lat. 16.3° N/Long.67.9° E) reported wind of 290/28 kt and pressure of 1004.2 hPa. The organised convection was located to the west of low level circulation centre.

Moving westwards it further intensified into a cyclonic storm in the evening of 25 September and lay centred at 251200 UTC near lat. 17.0° N/ long. 68.0° E. Thereafter it took northwesterly course till the morning of 26 September and took a westerly direction later. It maintained its intensity until evening of 27 September. The low level circulation again got displaced from the dense convection. As in earlier years, this system weakened and dissipated over the sea itself.

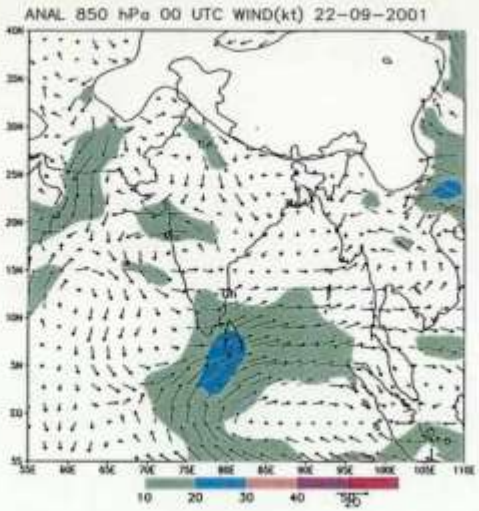
The track of the system is given in Fig. 2.3.3. The best track and other parameters have been included in Table 2.3.1. A few INSAT cloud imagery of the system are given in Fig. 2.3.4.

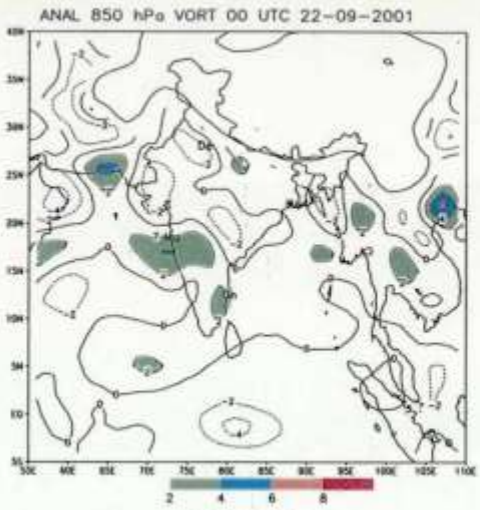
Weather realised

As the system dissipated over the sea itself, it could not produce any significant weather over the country. Isolated rainfall occurred over south Gujarat Region and Saurashtra on 26 and 27 September.

Damage

No loss of life and damage to property was reported.





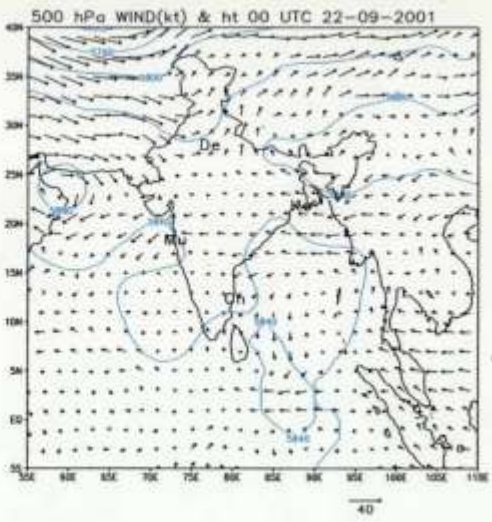
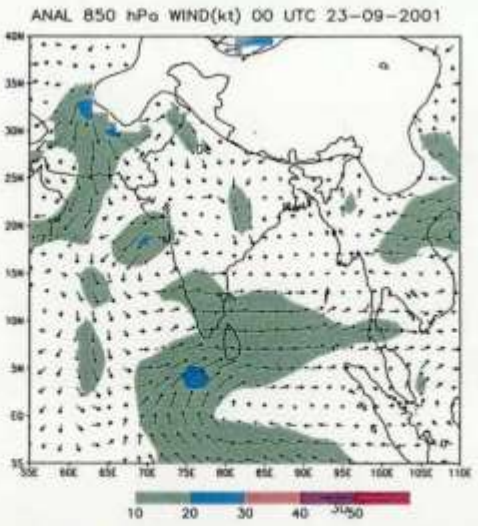
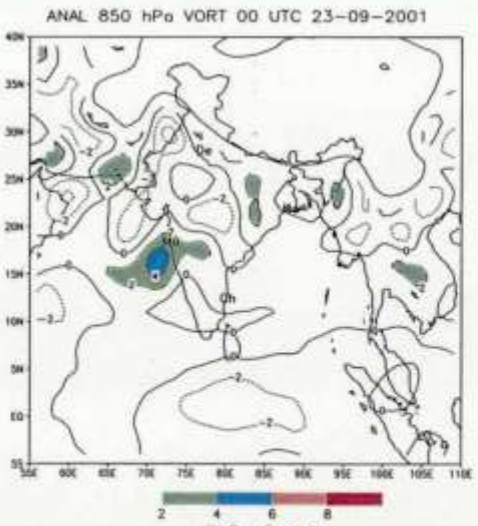


FIG. 2·3·1





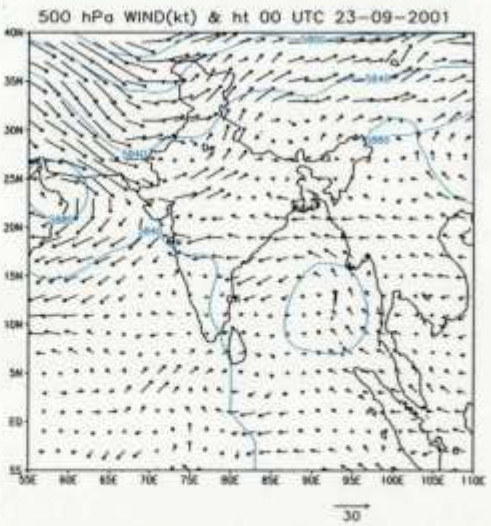


FIG. 2·3·2

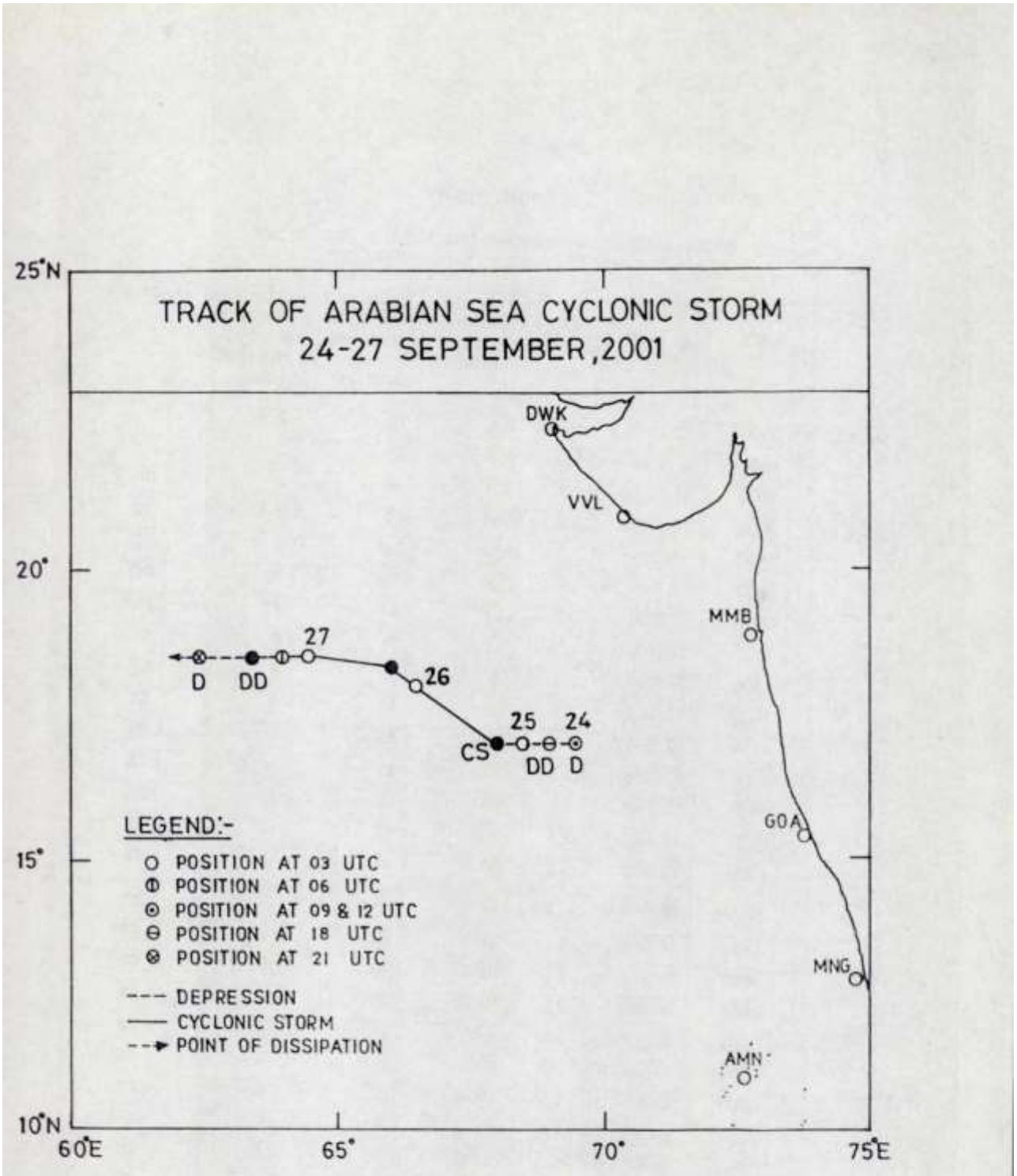

TRACK OF ARABIAN SEA CYCLONIC STORM
24-27 SEPTEMBER, 2001
25°N
20°
15°
10°N
60°E
65°
70°
75°E
DWK
VVL
MMB
GOA
MNG
AMN
27
26
25
24
D
DD
CS
DD
D
LEGEND:-
POSITION AT 03 UTC
POSITION AT 06 UTC
POSITION AT 09 & 12 UTC
POSITION AT 18 UTC
POSITION AT 21 UTC
DEPRESSION
CYCLONIC STORM
POINT OF DISSIPATION

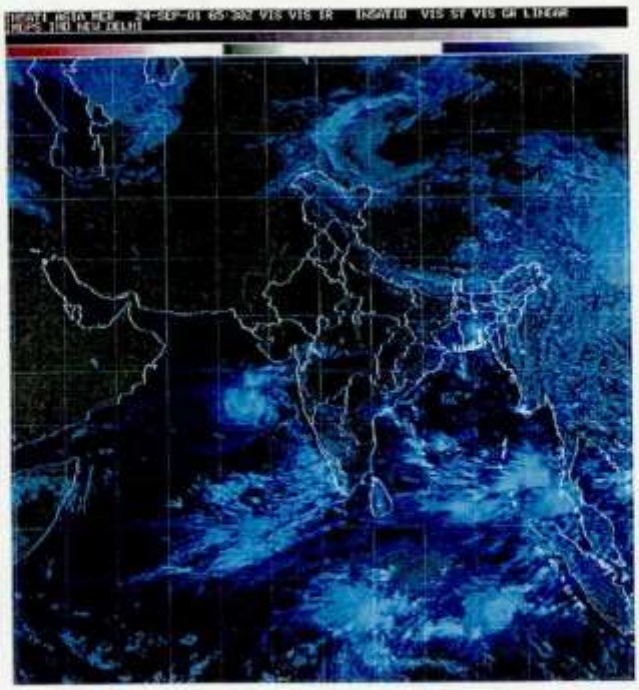
Fig.2.3.3.

Table 2.3.1

Best track and other parameters for the Arabian Sea Cyclonic Storm 24-27, September 2001

Date	Time (UTC)	Centre Lat. ° N / Long . ° E	C. I . NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the centre (hPa)	Grade
24.9.2001	0900	17.0 / 69.5	1.5	1006	25	2	D
	1200	17.0 /69.5	1.5	1006	25	2	D
	1800	17.0/69.0	2.0	1004	30	4	DD
25.9.2001	0000	17.0/69.0	2.0	1004	30	4	DD
	0300	17.0/68.5	2.0	1004	30	4	DD
	0600	17.0/68.0	2.0	1000	30	4	DD
	0900	17.0/68.0	2.0	1000	30	4	DD
	1200	17.0/68.0	2.5	1000	35	6	CS
	1500	17.0/68.0	2.5	1000	35	6	CS
	1800	17.0/68.0	2.5	1000	35	6	CS
	2100	17.0/69.0	2.5	1000	35	6	CS
26.9.2001	0000	17.0/68.0	2.5	1000	35	6	CS
	0300	18.0/67.5	2.5	1000	35	6	CS
	0600	17.5/67.0	2.5	1000	35	6	CS
	0900	18.0/66.5	2.5	1000	35	6	CS
	1200	18.3/66.0	2.5	1000	35	6	CS
	1500	18.5/66.0	2.5	1000	35	6	CS
	1800	18.5/65.5	2.5	1000	35	6	CS
	2100	18.5/65.5	2.5	1000	35	6	CS
27.9.2001	0000	18.5/65.0	2.5	1000	35	6	CS
	0300	18.5/64.0	2.5	1000	35	6	CS
	0600	18.5/64.0	2.5	1004	35	6	CS
	1200	18.5/63.5	2.0	1006	30	4	DD
	1800	18.5/63.0	2.0	1006	30	4	DD
	2100	18.5/62.5	1.5	1008	25	4	D
28.9.2001	0000	The system weakened into a low pressure area over sea.					

(a)



(b)

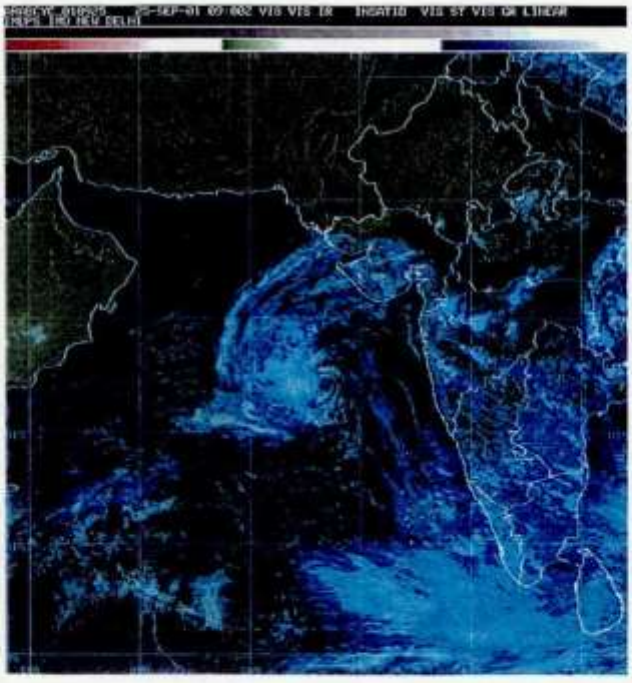
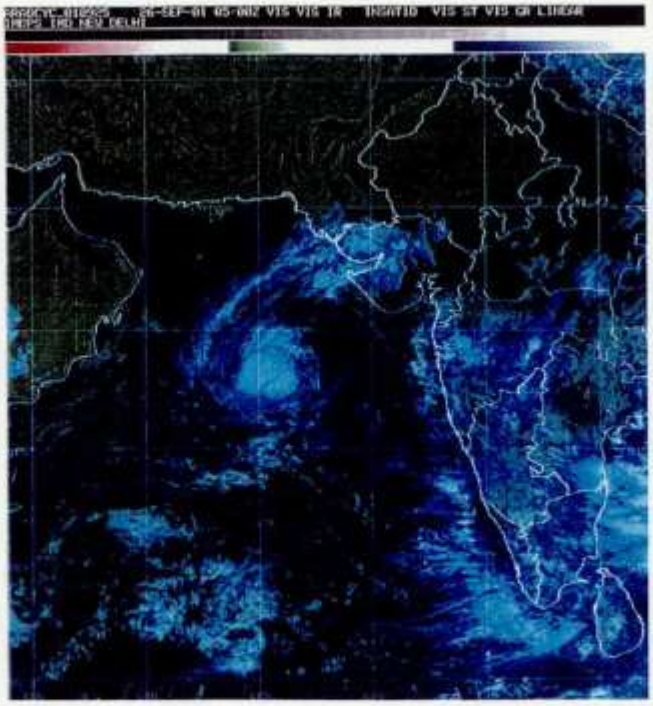


Fig.2.3.4 : Satellite pictures showing cloudiness (a) at the initial development of the system on 24 September and (b) at the cyclonic storm stage on 25 September. The low Level circulation Centre (LLCC) is seen to the east of the convection.

(c)



(d)

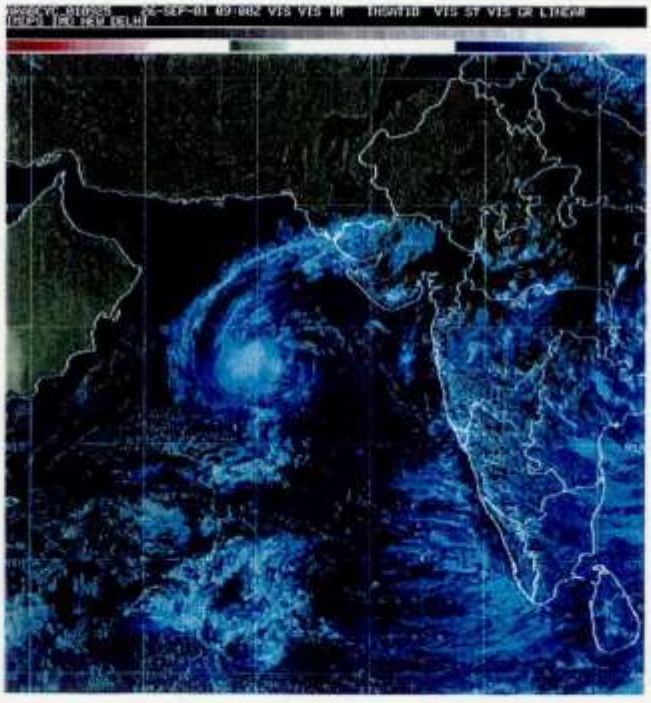


Fig.2.3.4 (contd.) : Satellite pictures showing cloudiness (c) at the cyclonic storm stage at 05 UTC on 26 September and (d) at 09 UTC on the same day. The LLCC is seen to the east of the convection..

2.4 Cyclonic Storm in the Arabian Sea 8--10 October 2001

It was a short lived system that developed as a depression over East Central Arabian Sea and intensified into a cyclonic storm within a day. Like other two earlier systems, it also weakened and dissipated over sea itself by the afternoon of the next day.

A low pressure area migrated to the east central Arabian Sea and neighbouring areas of the land on 8 October that concentrated into a depression at 082100 UTC when the satellite imagery showed a compact cloud vortex with a band on the eastern side. Moving westwards, the system further intensified into a cyclonic storm at 090900 UTC near lat. 19.0° N/ long. 68.5 ° E when the cloud organisation improved further. It moved northwestwards and until 091200 UTC and tooks a westerly course later. There was considerable decrease in the extent and organisation of deep convection that led to the weakening and dissipation of the system over the sea by evening of 10 October.

The track of the system is given in Fig. 2.4.1. The best track positions and other parameters have been included in Table 2.4.1. A few INSAT cloud pictures have been included in Fig 2..4.2.

Weather Realised:

As the system dissipated over the sea itself, there was no significant rainfall realised over the coastal areas of Maharashtra and Gujarat States

Damage:

No damage to life and property was reported.

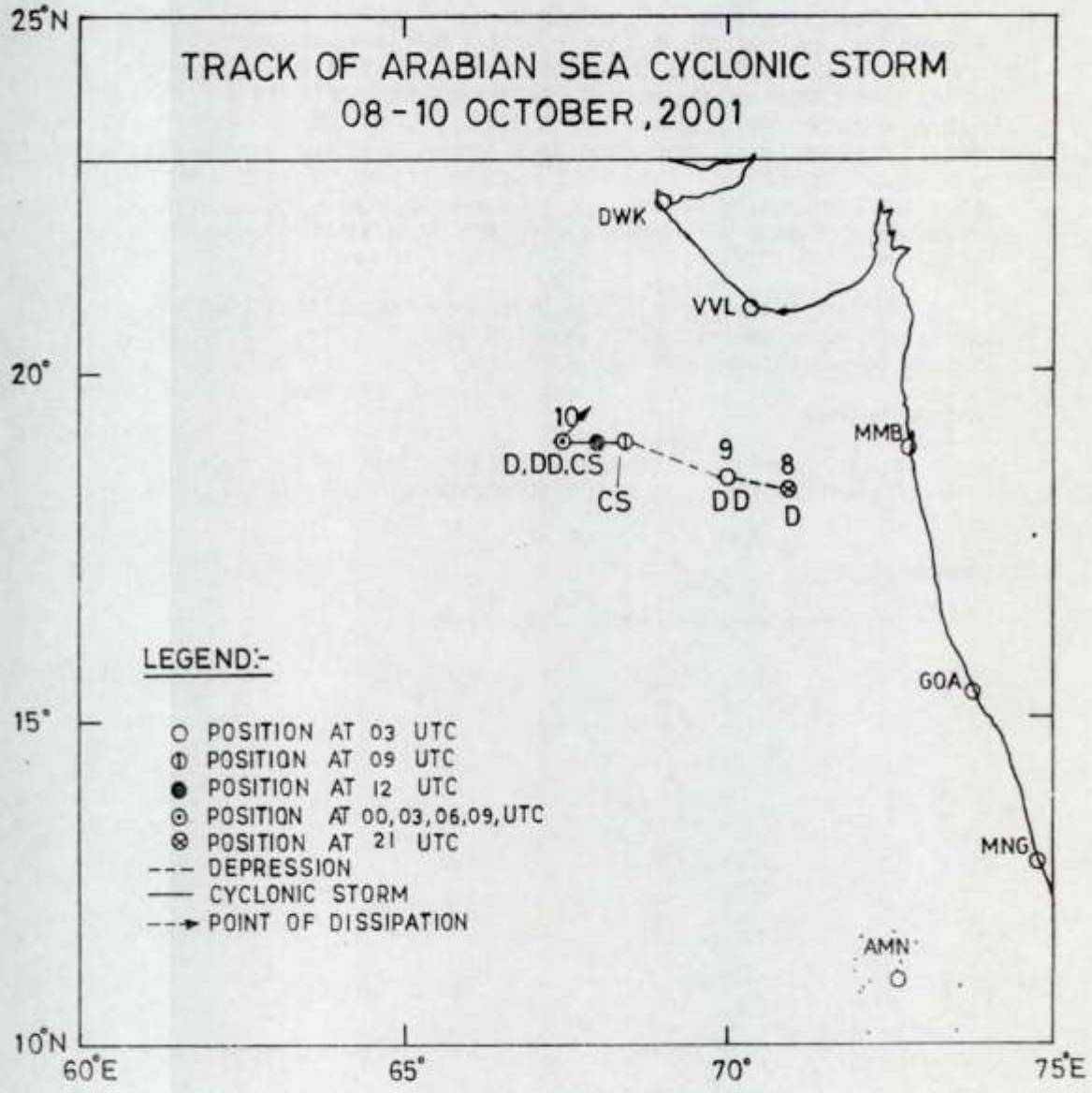

TRACK OF ARABIAN SEA CYCLONIC STORM
08 - 10 OCTOBER, 2001
25°N
20°
15°
10°N
60°E
65°
70°
75°E
DWK
VVL
MMB
GOA
MNG
AMN
10
D.DD.CS
CS
9
DD
8
D
LEGEND:-
POSITION AT 03 UTC
POSITION AT 09 UTC
POSITION AT 12 UTC
POSITION AT 00,03,06,09,UTC
POSITION AT 21 UTC
DEPRESSION
CYCLONIC STORM
POINT OF DISSIPATION

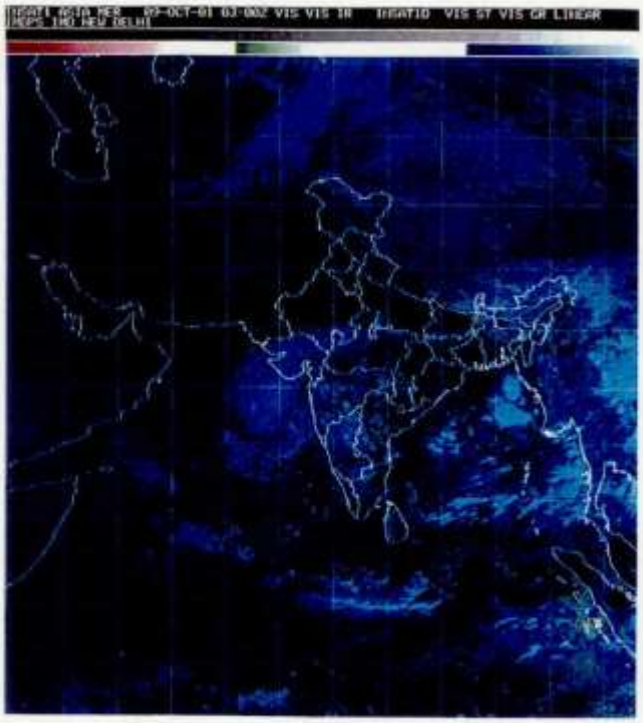
Fig. 2.4.1.

Table 2.4.1

Best track positions and other parameters for the Arabian Sea Cyclonic Storm 08-10 October 2001

Date	Time (UTC)	Centre Lat. ° N / Long. ° E	C. I . NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the centre (hPa)	Grade
08.10.2001	2100	18.3/71.0	1.5	1004	25	4	D
09.10.2001	0000	18.5/70.5	1.5	1004	25	4	D
	0300	18.5/70.0	2.0	1002	30	6	DD
	0600	18.5/69.0	2.0	1000	30	6	DD
	0900	19.0/68.5	2.5	998	35	6	CS
	1200	19.0/68.0	2.5	998	30	6	CS
	1500	19.0/68.0	2.5	998	35	6	CS
	1800	19.0/67.5	2.5	998	35	6	CS
	2100	19.0/67.5	2.5	998	35	6	CS
10.10.2001	0000	19.0/67.5	2.5	998	35	6	CS
	0300	19.0/67.5	2.0	1000	30	6	DD
	0600	19.0/67.5	2.0	1000	30	6	DD
	0900	19.0/67.5	2.0	1002	25	4	D
	1200	The system weakened into a low pressure over sea.					

(a)



(b)

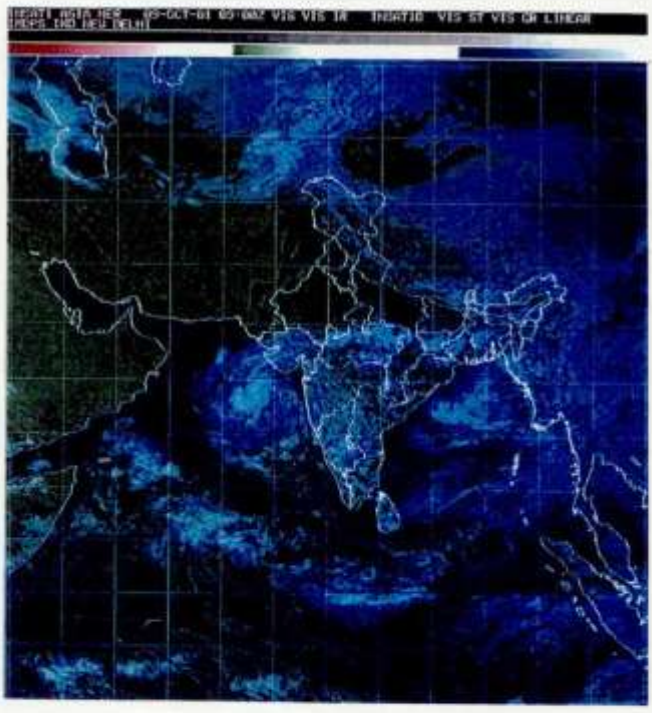
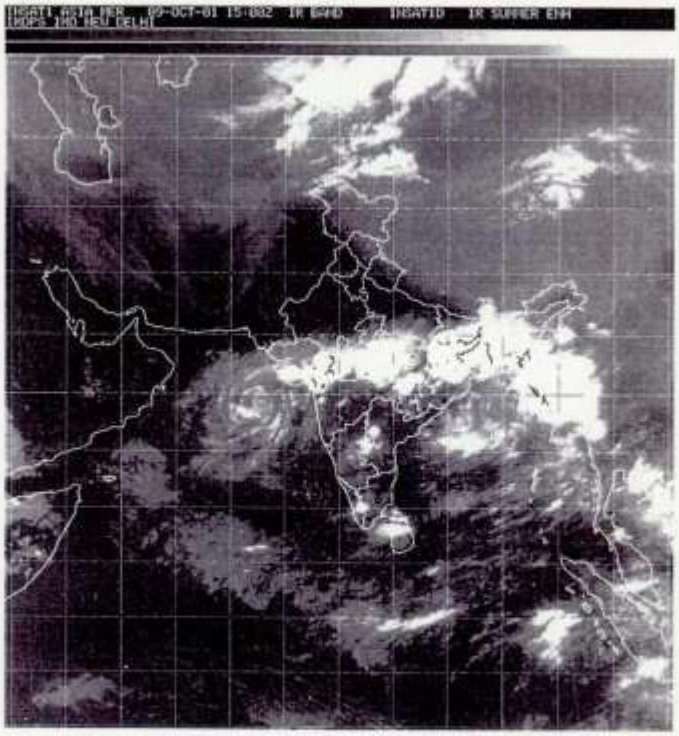


Fig.2.4.2 : Satellite picture showing (a) a weak cloud band in the southern sector of the convection at the developing stage of the System (CI 2.0) and (b) a comma cloud structure indicating minimal cyclone stage (CI 2.5) .

(c)



(d)

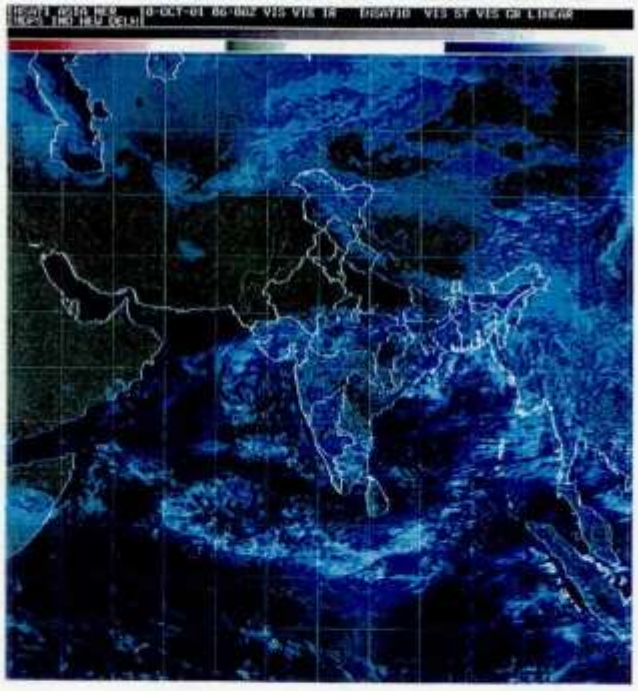


Fig. 2.4.2 (Contd.) : Cloud picture showing (c) considerable reduction in convection associated with the cyclonic storm and (d) considerable decrease in the extent and organisation of deep convection (CI 2.0).

2.5 Cyclonic Storm in the Bay of Bengal (14-17 October 2001)

This was the only storm of the post monsoon season that led to significant damages in some southern parts of Andhra Pradesh State of India due to intense rains. A low pressure area that formed over West central Bay of Bengal on 14 October intensified into a marginal cyclone before crossing Andhra Pradesh coast near Nellore (43245) on 16th morning.

A well marked low pressure area formed over west central and adjoining southwest Bay of Bengal on 14 morning. A ship (WMG) at Lat 12.5° N/Long. 84.5° E reported wind 260/24 knots and pressure of 1008.1 hPa at 140600 UTC. A cloud cluster was seen in the west central Bay in the forenoon on 14 October in which convection increased at 140900 UTC. The well marked low pressure area concentrated into a depression at 141200 UTC near lat.13.5° N / long. 84.0° E. Moving westnorthwestwards it intensified further into a cyclonic storm at 151200 UTC near lat.14.0° N / long. 81.0° E. Numerous cloud lines / bands around central area convection were noticed at this stage indicating organised convective structure associated with a marginal cyclone of T2.5 intensity. Moving westwards the cyclonic storm crossed the coast near Nellore in the morning of 16 October and was located at 160300 UTC near lat. 14.0° N/ long. 79.5° E.

The cyclonic storm moved slowly in a north-westerly direction and weakened into a depression at 161800 UTC when it was located about 100 km northwest of Nellore. It further weakened into a low pressure area on the morning of 17 October over Rayalaseema region in southern Andhra Pradesh.

The track of the system is given in Fig. 2.5.1. The best track positions and other parameters have been included in Table 2.5.1. A few INSAT cloud pictures have been included in Fig 2..5.2.

Weather Realised

Under the influence of the cyclonic storm exceptionally heavy rainfall occurred in some places in Andhra Pradesh particularly south coastal Andhra Pradesh and Rayalaseema. The rainfall for the week ending on 17 October is shown in fig. 2.5.3.

Damages
(Andhra Pradesh)

No. of deaths	:	108 people dead
No. of persons missing	:	21
No. of tanks breached	:	1635
Damage to crops(Paddy, Groundnut, Pulses etc to stagnation of water)	:	1,25,000 Hectars due
No. of houses damaged	:	55,747

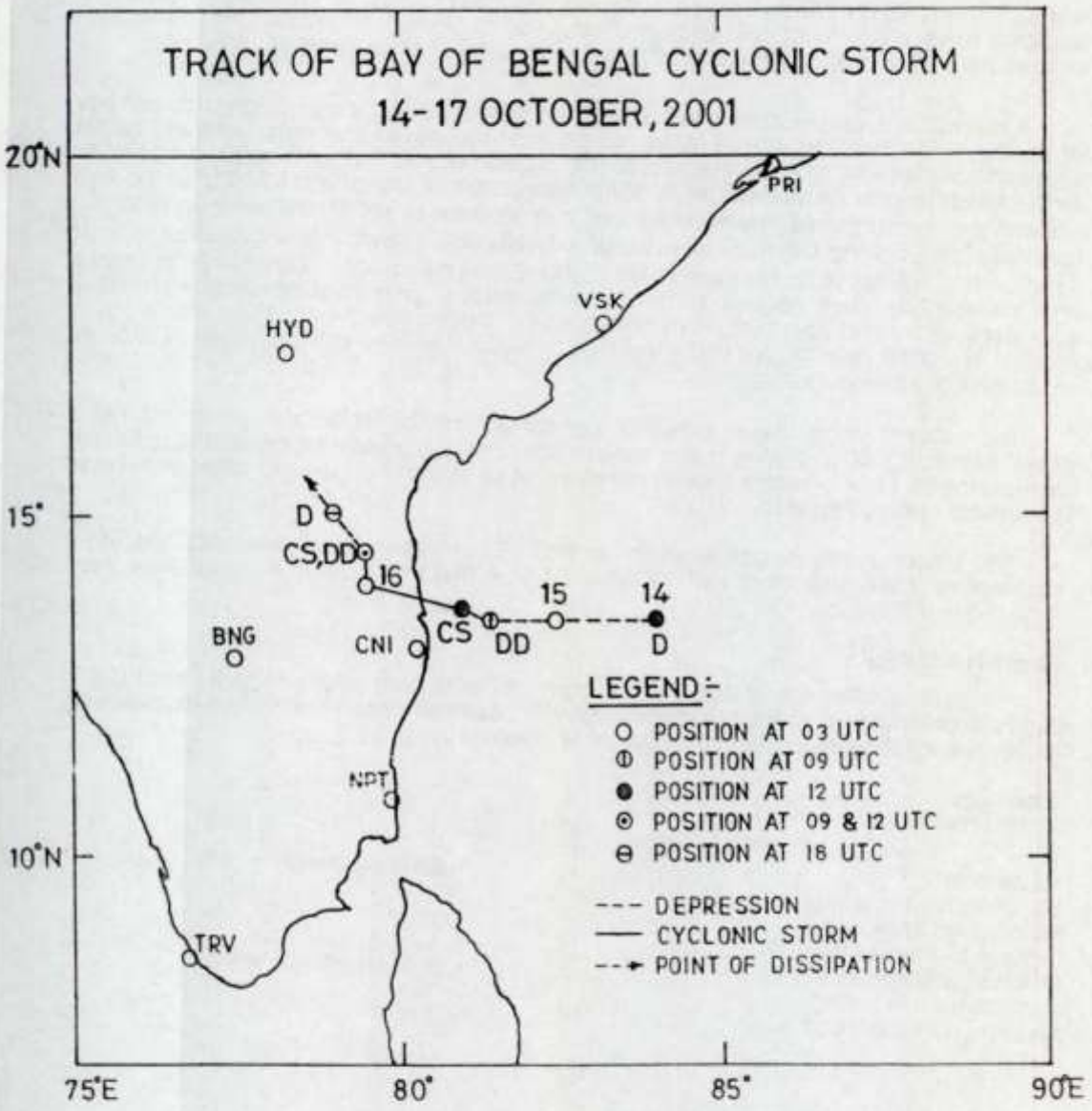

TRACK OF BAY OF BENGAL CYCLONIC STORM
14-17 OCTOBER, 2001
20°N
15°
10°N
75°E
80°
85°
90°E
PRI
VSK
HYD
BNG
CNI
NDT
TRV
D
CS,DD
16
15
14
CS
DD
D
LEGEND :-
POSITION AT 03 UTC
POSITION AT 09 UTC
POSITION AT 12 UTC
POSITION AT 09 & 12 UTC
POSITION AT 18 UTC
DEPRESSION
CYCLONIC STORM
POINT OF DISSIPATION

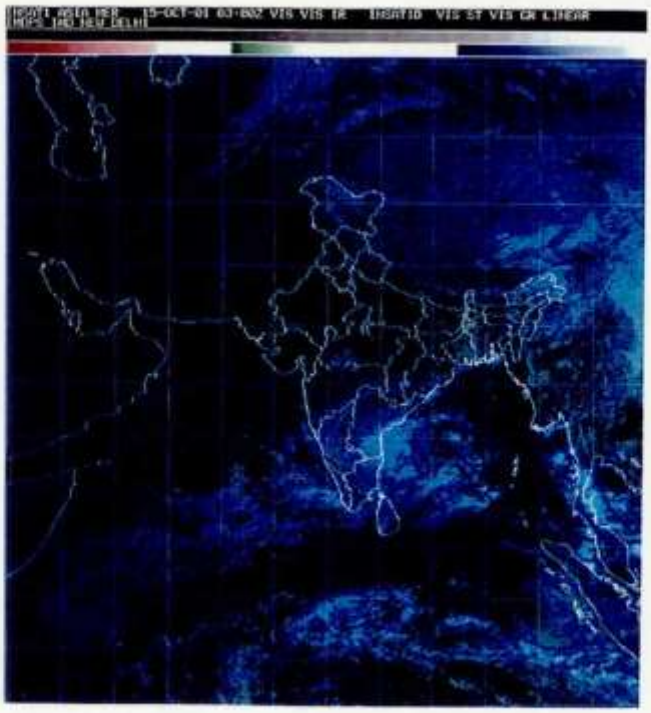
Fig.2.5.1.

Table 2.5.1

Best track and other parameters for the Bay of Bengal Cyclonic Storm 14-17 October, 2001

Date	Time (UTC)	Centre Lat. ° N / Long .° E	C. I NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the centre (hPa)	Grade
14-10-2001	1200	13.5/84.0	1.5	1000	25	4	D
	1800	13.5/83.0	1.5	1002	25	4	D
15.10.2001	0000	13.5/83.0	1.5	1002	25	4	D
	0300	13.5/82.5	1.5	1002	25	4	D
	0600	13.5/82.0	1.5	1002	25	6	D
	0900	13.5/81.5	2.0	1000	30	6	DD
	1200	13.7/81.0	2.5	998	35	8	CS
	1500	14.0/80.5	2.5	998	35	8	CS
	1800	14.0/80.0	2.5	998	35	8	CS
	2100	14.0/80.0	2.5	998	35	8	CS
16.10.2001	0000	14.0/79.5	2.5	1000	35	8	CS
	The system Crossed South Andhra Pradesh cost near Nellore around 0000 UTC .						
	0300	14.0/79.5		1000	35	8	CS
	0600	14.0/79.5		1000	35	8	CS
	0900	14.5/79.5		1000	35	8	CS
	1200	14.5/79.5		1002	30	6	DD
	1800	15.0/79.0		1004	25	4	D

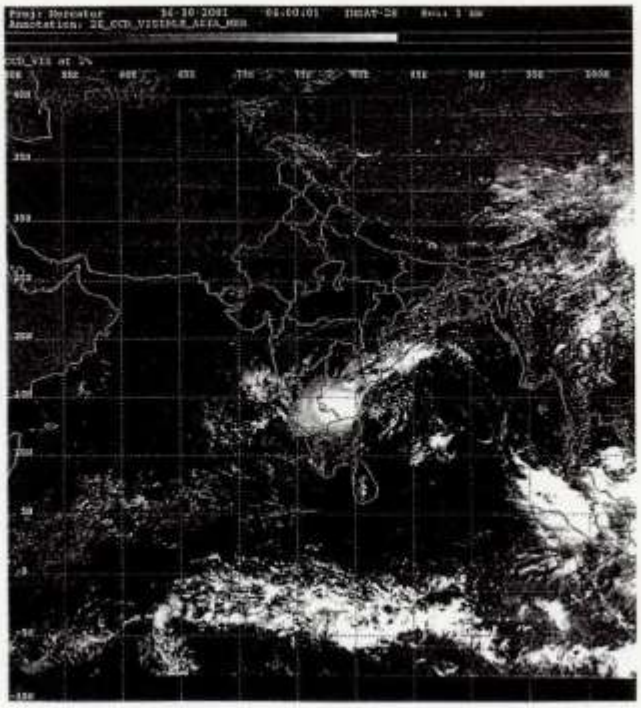
(a)



(b)

Fig. 2.5.2 : Satellite pictures showing (a) Low level circulation Centre to the east of convection (CI 1.5) and (b) increase in convection. LLCC defined by cumulus cloud lines to the east of the Convection.

(c)



(d)

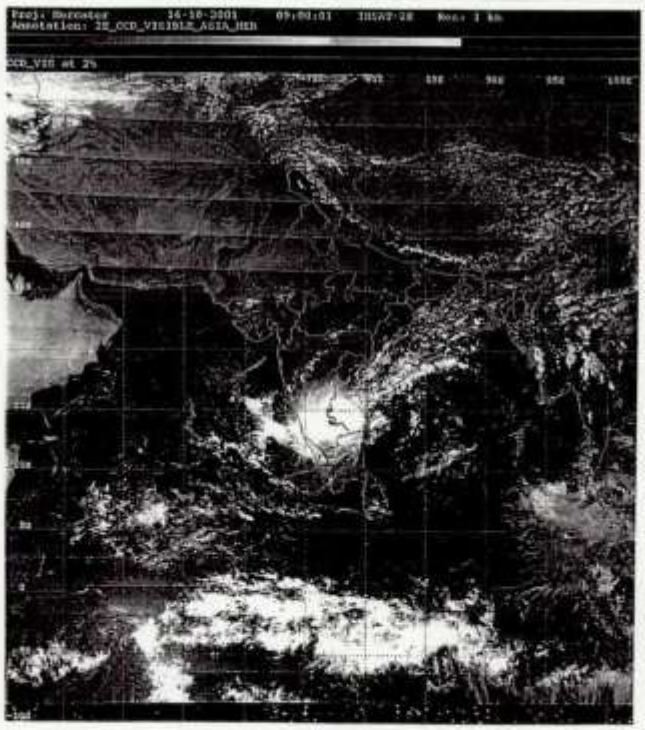
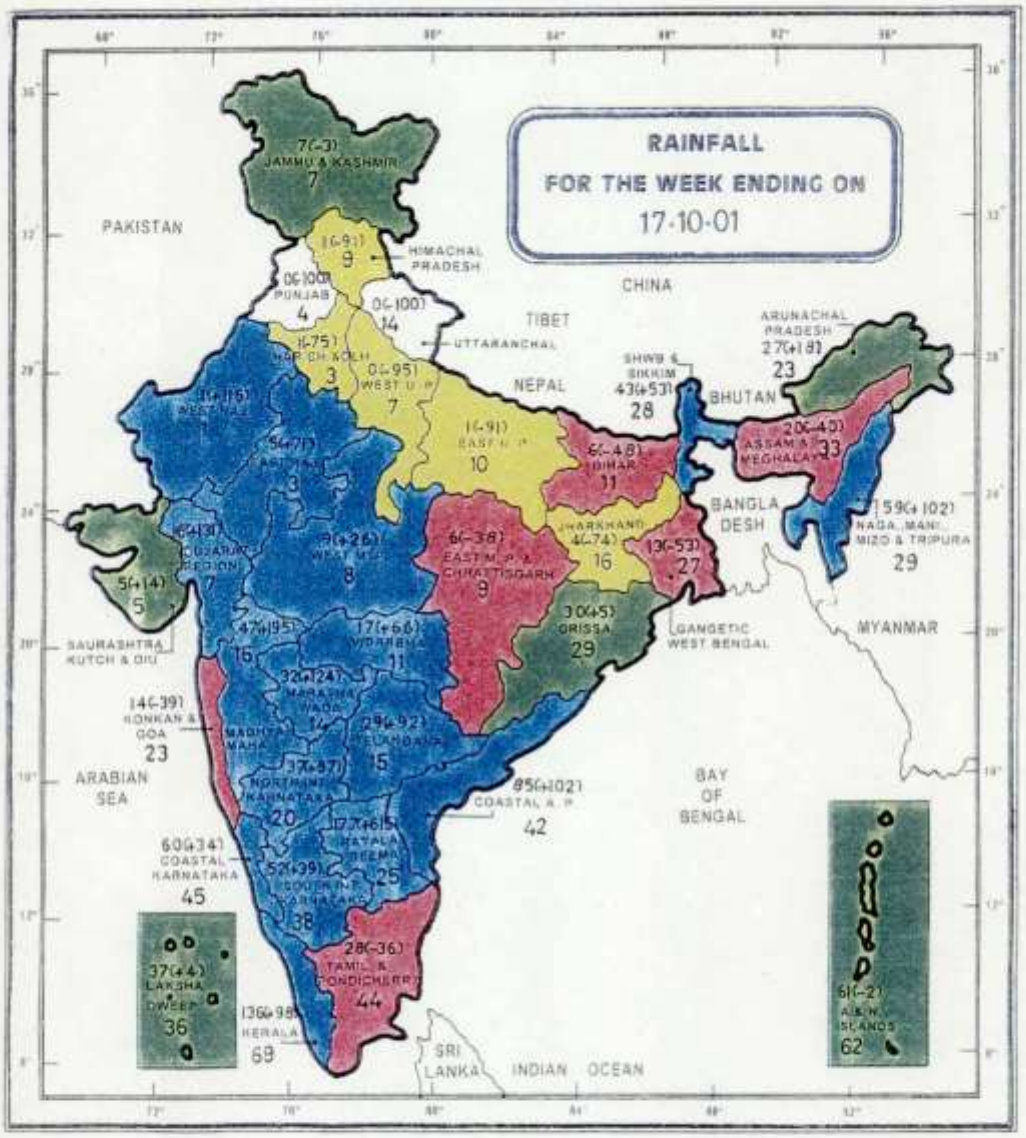


Fig.2.5.2(contd.) : Satellite pictures showing (c) convection over land and LLCC still over sea and (d) LLCC no more seen distinctly.



LEGEND:

EXCESS +20% OR MORE	NORMAL +19% TO -19%	DEFICIENT -20% TO -59%
SCANTY -60% TO -99%	NO RAIN -100%	DATA INADEQUATE

Small figures indicate actual rainfall (mm), while bold figures indicate normal rainfall (mm). Percentage departures of rainfall from normal are shown in brackets.

Fig. 2.5.3.

2.6 Depression over Bay of Bengal (11-12 November 2001)

It was case of a depression that developed and weakened over sea itself.

A low pressure area formed over southwest and adjoining west central Bay of Bengal off Andhra Pradesh and north Tamil Nadu coasts in the morning of 7 November. It became well marked on 9 November and persisted over the same area till 10 November. It concentrated into a depression in the morning of 11 November and was located at 110300 UTC near lat.16.5^0 N / long. 83.0^0 E about 100 km south of Kakinada(43189). Moving in a northnortheasterly direction it retained its intensity as depression till 120000 UTC when it was located near lat. 18.5^0 N/ long. 85.5^0 E . Thereafter it weakened into a well marked low pressure area over west central Bay of Bengal close to north Andhra Pradesh coast by the morning of 12 November. It finally dissipated over sea itself.

The track of the system is given in Fig. 2.6.1. The best track positions and other parameters have been included in Table 2.6.1. A few INSAT cloud pictures have been included in Fig 2..6.2.

Weather realised

In association with the system increased rainfall activity was reported over coastal Andhra Pradesh and coastal Orissa.

Damage

No loss of life and damage to property was reported.

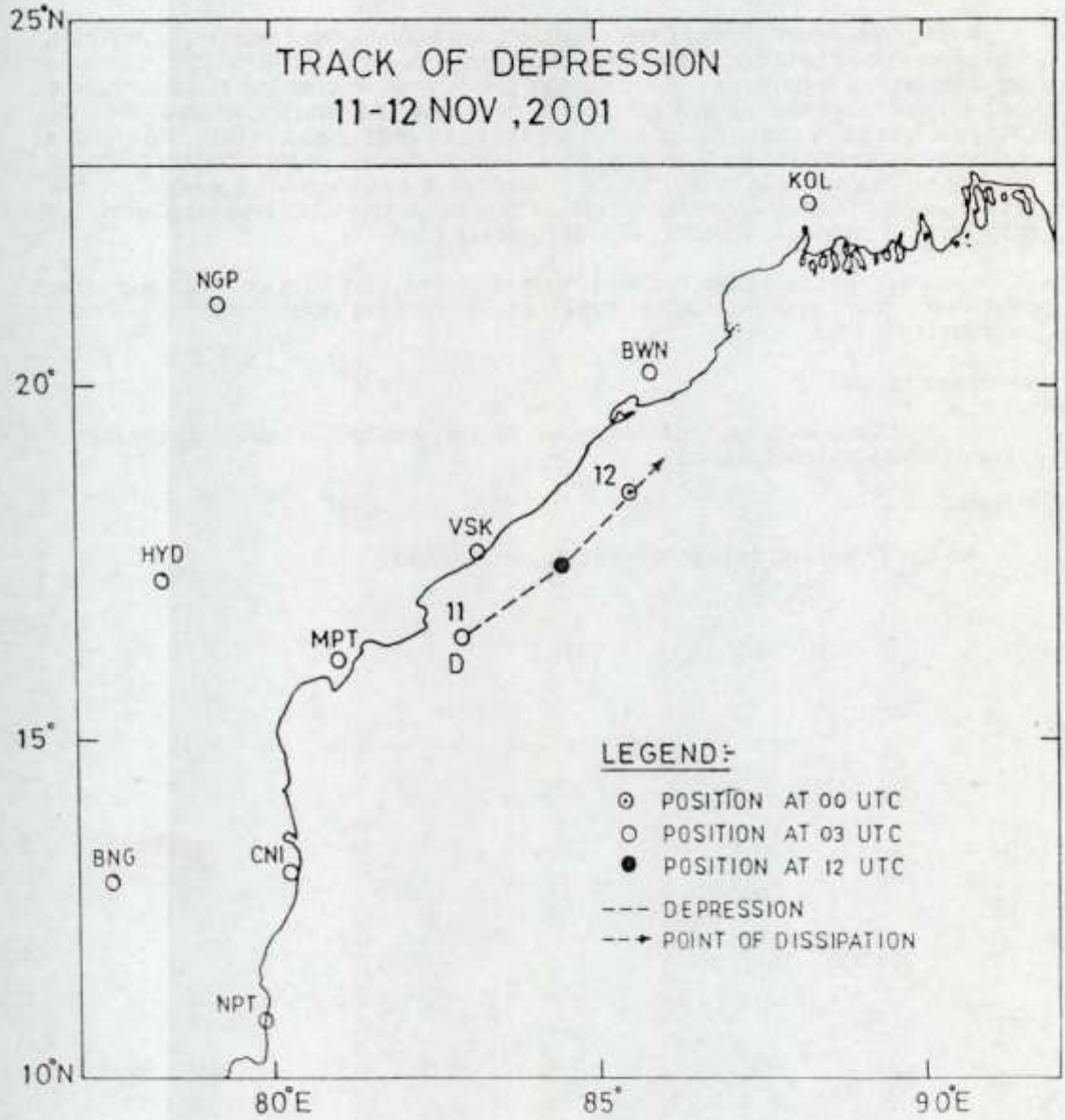

TRACK OF DEPRESSION
11-12 NOV ,2001
25°N
20°
15°
10°N
80°E
85°
90°E
KOL
NGP
BWN
12
VSK
HYD
11
D
MPT
BNG
CNI
NPT
LEGEND:-
POSITION AT 00 UTC
POSITION AT 03 UTC
POSITION AT 12 UTC
DEPRESSION
POINT OF DISSIPATION

Fig. 2.6.1

Table 2.6.1

Best track positions and other parameters for Bay of Bengal Depression November 11-12, 2001

Date	Time (UTC)	Centre Lat. ° N / Long .° E	C. I NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind (kt)	Estimated Pressure drop at the centre (hPa)	Grade
11.11.2001	0300	16.5/83.0	1.5	1004	25	4	D
	0600	17.0/83.5	1.5	1006	25	4	D
	1200	17.5/84.5	1.5	1004	25	4	D
	1800	18.0/85.0	1.5	1004	25	4	D
12.11.2001	0000	18.5/85.5	1.5	1004	25	4	D
	The system weakened over west central Bay of Bengal close to North Andhra Pradesh coast in the morning.						

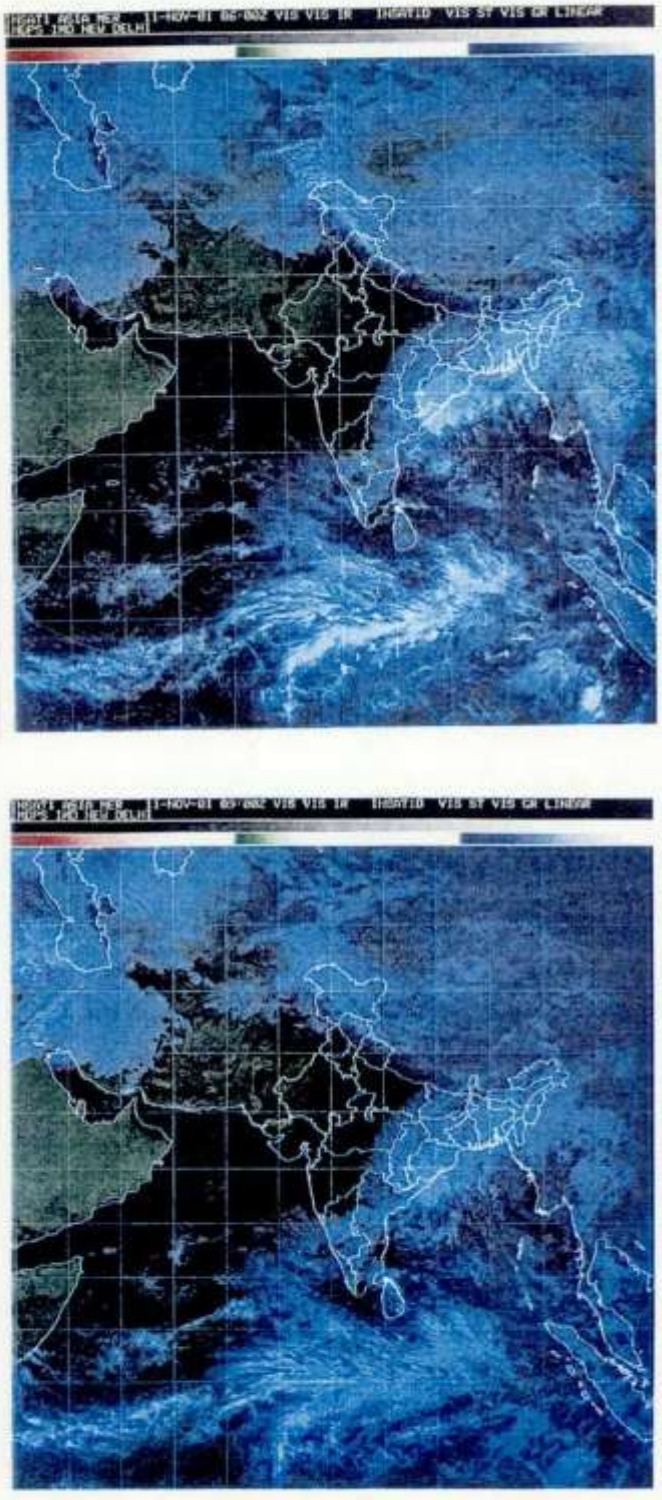


Fig.2.6.2 : Satellite pictures showing convection to the north of the low level circulation centre on 11 November.

Chapter 3

Track Prediction

3.1 Track Prediction Models

Track prediction is made operationally by RSMC- Tropical cyclones New Delhi by utilising Limited Area Forecast Model (LAM) , quasi-Lagrangian model (QLM), Climatology, Persistence and combination of both (CLIPER) and Analogue.

3.1.1 Track prediction by Numerical Models

During the season LAM and QLM outputs such as initial development of the system and model predicted track forecasts were provided for the depression and cyclonic storms formed for the year 2001. The QLM model was run to produce track forecasts based on the initial conditions of each day (00 UTC and 12 UTC) when the disturbance was in cyclonic storm stage, where as the LAM forecasts were produced regularly (00 UTC and 12 UTC) for day-to-day operational use.

A quantitative assessment of the performance of forecast model was made by computation of track prediction errors. Two types of prediction errors have been attempted. Direct position errors (DPE) have been 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, later provides an indication of the closeness of the predicted direction of movement and the observed direction.

Table 3.1 & 3.2 contains the verification statistics of the mean position errors (km) and the angular deviation of the predicted track from the observed track (degree), in respect of each case studied. The mean position errors for 24H forecast ranges between less than 90 to 120 km for QLM and 110 to 140 km for LAM. The 36 H forecast by QLM range between 160 to 210 km whereas for LAM 48 hr forecasts between 140 to 240 km.

The angular deviations vary between about 10° to 25°. The overall average position errors for all the cases taken together (shown at the bottom of the Table) workout to 106 km (24H), and 183 km (36H) in case of QLM and 117 km (24 hrs) and 204 km (48 hrs) in case of LAM and angular deviation is less than 25º for both hours.

TABLE 3.1
TRACK PREDICTION ERRORS (QLM)

Year	Period	24 H		36 H	
		Mean position error (km)	Angular deviation between observed and predicted track vectors@ (rmse) (deg.)	Mean position error (km)	Angular deviation between observed and predicted track vectors@ (rmse) (deg.)
2001	21-28 MAY	90.0	15.2	160.0	20.1
	24-27 SEP	110.0	10.1	180.0	15.1
	14-17 OCT	120.0	12.3	210.0	22.0
Mean (for 3 cases)		106.0	12.5	183.0	19.0

@ Observed track vector : Initial (at T0) to observed (at T0 + 24H or T0 + 36H) positions
Predicted track vector : Initial (at T0) to predicted (at T0 + 24H or T0 + 36H) positions.

Table 3.2
TRACK PREDICTION ERRORS (LAM)

Year	Period	24 H		48 H	
		Mean position error (km)	Angular deviation between observed and predicted track vectors@ (rmse) (deg.)	Mean position error (km)	Angular deviation between observed and predicted track vectors@ (rmse) (deg.)
2001	21-28 MAY	120.0	25.8	200.0	23.8
	12-13 JUN	80.0	15.0	140.0	25.0
	24-27 SEP	140.0	05.7	230.0	15.5
	08-10 OCT	125.0	21.0	240.0	22.0
	14-17 OCT	120.0	12.3	210.0	11.0
Mean (for 5 cases)		117.0	15.9	204.0	19.4

@ Observed track vector : Initial (at T0) to observed (at T0 + 24H or T0 + 48H) positions
Predicted track vector : Initial (at T0) to predicted (at T0 + 24H or T0 + 48H) positions

3.1.2 Track Prediction by Other Models

The errors in the predicted positions from Persistence, Climatology, and Cliper models for the tropical cyclones in North Indian Ocean during 2001 are given in table 3.3 below. Compared among themselves, in the 12 hour forecasts Cliper performed better. In 24 hour forecasts CLIPER performed better in two systems viz., 21-28 May & 24-27 September. In the case of cyclone of 8-10 October & 14-17 October Climatology performed better. Persistence performed better in the case of the cyclone of 14-17 October. In the case of 36 and 48 hour forecasts Cliper performed better than Climatology and Persistance. In 48 hour forecasts CLIPER performed better.

Table 3.3

Forecast position errors for tropical cyclones in the Bay of Bengal and the Arabian Sea in 2001 based on CLIMATOLOGY (C), PERSISTANCE (P) and CLIPER (CLIP) Models.

Date	12 Hours			24 Hours			36 Hours			48 Hours		
	P	C	CLIP	P	C	CLIP	P	C	CLIP	P	C	CLIP
21-28 MAY,2001	95	74	65	160	164	134	272	295	216	357	359	270
24-27 SEPT,2001	146	176	131	303	297	268	474	509	470	-	-	-
08-10 Oct ,2001	128	114	90	460	170	272	-	-	-	-	-	-
14-17 OCT,2001	100	105	102	155	186	200	-	-	-	-	-	-

* * *