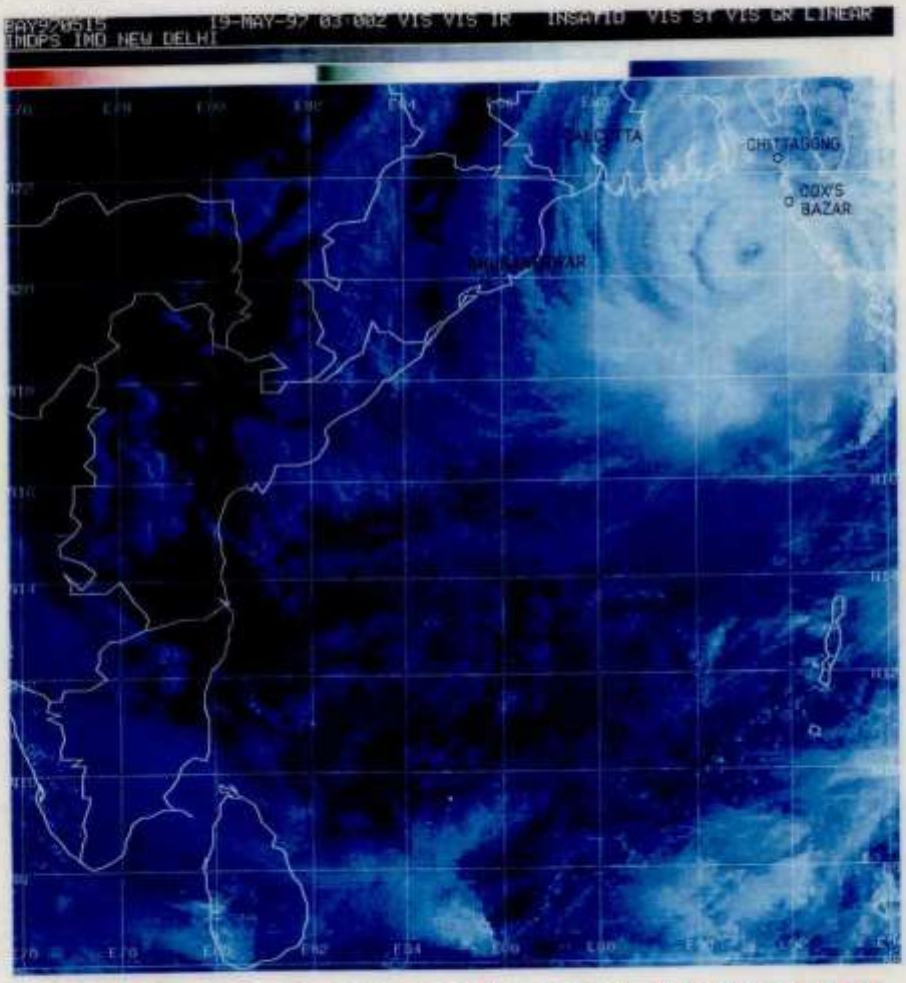
भारत मौसम विज्ञान विभाग

INDIA METEOROLOGICAL DEPARTMENT

REPORT ON CYCLONIC DISTURBANCES OVER NORTH INDIAN OCEAN DURING 1997



RSMC- TROPICAL CYCLONES, NEW DELHI

JANUARY 1998

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REPORT ON CYCLONIC DISTURBANCES OVER NORTH INDIAN OCEAN

(Abridged report for circulation during the meeting of WMO/ESCAP Panel on Tropical Cyclones)

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INTRODUCTION

This report consists of a review of the cyclonic disturbances and their associated features, that formed in the North Indian Ocean (The Bay of Bengal and the Arabian Sea) during the year 1997. The classification of cyclonic disturbances followed in the report is given below :

WEATHER SYSTEM	MAXIMUM SUSTAINED SURFACE WIND SPEED
1. Low	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 60 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 117 kmph)
6. Severe Cyclonic Storm with a Core of Hurricane Winds (SCS (H))	Wind Speed 64 kt 118 kmph or more

The term ' **Cyclone**' used in the text, is a generic indicating all the three categories of cyclonic disturbances given above under S.No. (4) to (6)

Salient features of cyclonic disturbances of 1997 :

The following are the important features of cyclonic disturbances in the North Indian Ocean during 1997.

a) This year , nine cyclonic disturbances formed over the Bay of Bengal and the Arabian Sea against the average frequency of 13 to 14 per year. Eight out of the nine disturbances formed over the Bay of Bengal and one over Arabian sea . Three out of the nine systems attained the intensity of cyclone.

b) There was normal cyclonic activity during the south west(SW) monsoon season as six cyclonic systems formed over the Bay of Bengal and caused well distributed rainfall over the country . One depression , four deep depressions and one severe cyclonic storm formed over the Bay of Bengal during the period June-September .

c) The formation of a cyclone in the month of September has occurred after a gap of 11 years (since 1985) .

d) The formation of five depressions / deep depressions during SW-monsoon season occurred after the year 1989. During the past four years, the frequency of formation of depressions has not been more than 2 per year.

e) The tracks followed by the depressions in the month of June, July and August were normal . They moved west- north – west to north-westwards across the central parts of the country . Their life span was more than two days.

f) The cyclonic storm of September made an unusual track . It formed off south Andhra Pradesh coast and moved in a north to north-easterly direction, grazing the east coast up to West Bengal . The track of the cyclone has no parallel in the history of cyclones during this month.

g) Bangladesh has been hit by atleast one cyclone every year since 1990 except in 1993 . Two cyclones hit the coast of Bangladesh this year, this was also the case of 1991.

h) This is the first year in the history of cyclones that no system of Cyclone intensity made land fall over Indian coast .

i) Nine cyclonic systems formed in the Bay of Bengal and the Arabian sea. Two out of them weakend over the sea. The number of the systems that formed over the north Indian ocean was eight each year since 1994. Thus there was no change in the frequency of the cyclonic systems inspite of the presence of EL-NINO this year.

j) Cyclonic activity over the Indian Ocean was significantly below normal during the post monsoon season. No Cyclonic system formed in the month of October , which is having highest frequency . Only in November, one cyclone emerged into the Bay of Bengal from the Gulf of Thailand and weakend later over the central Bay of Bengal . Another system formed over the south east Arabian Sea as depression on 10 November. This system also weakened over the sea later.

BRIEF DESCRIPTION OF THE SYSTEMS

The first system formed as a depression on the afternoon of 15 May 1997 near Lat. 7.0° N and Long. 90.5°E. Moving northward it intensified into a cyclonic storm by the morning of 16 May and severe cyclonic storm on 17 May. It acquired core of hurricane winds on the morning of 18 May, when it was centred near Lat. 16.5° N and Long. 90.5° E . Thereafter it moved in a north- north- easterly direction and crossed Bangladesh coast near Sitakundu (north of Chittagong) at 1200 UTC of 19 May . After crossing the coast it weakened into a depression over Mizoram and neighbourhood and further weakened by the morning of 20 May 1997.

No damage was caused to the Indian coast by this system, as it made landfall in Bangladesh where heavy damage was reported. About 155 persons were killed in Bangladesh.

During the SW-monsoon season five depressions and one cyclone formed over the Bay of Bengal and the Arabian Sea and caused widespread rainfall activity over the country.

The first depression formed on 26 June over the head Bay of Bengal near Lat. 21.0°N and Long. 91.0° E . Moving in a northwesterly direction, it intensified into a deep depression on 27 June and moved upto Gaya in Bihar on 29 June. Thereafter , it moved in a northerly direction and weakened over Nepal and neighbourhood on 30 June .

The second depression formed on 29 July over the head Bay of Bengal near Lat. 21.0°N and Long. 89.0°E and moved west- north – westward. It crossed near Chandbali on the night of 29 July as a deep depression and moved in a north-westerly direction thereafter . It finally weakened in the evening of 2 August near Sikar in East Rajasthan .

The third depression formed on 4 August near Lat. 20.0° N and Long. 91.0°E and moved in a north-westerly direction. It intensified into a deep depression and crossed West Bengal coast on the evening of 5 August. Moving west north west wards across Central India , it came over central Rajasthan by the evening of 7 August and weakened thereafter near Indo- Pak Border .

The fourth depression formed on 20 August close to north Orissa coast and intensified into a deep depression by the same evening. It moved initially in a west- north- westerly direction up to 22 August when it was centred near Gondia in Maharashtra. Thereafter, it moved in a north- westerly direction up to 27 August when it was located near Indo – Pak border(100 kms west of Ferozepur). It finally weakened over north Pakistan by the same evening.

The fifth depression formed on 28 August at 0300 UTC near Lat.19.5° N and Long. 87.0° E off Orissa coast . Moving north-westward it crossed Orissa coast close to Puri and finally dissipated over the plains of north Bihar and adjoining east UP in the evening of 20 August 1997.

Towards the end of SW-monsoon season , a depression formed off Andhra Pradesh coast on 23 September. Moving initially in a northerly direction and later grazing the east coast, it concentrated into a cyclonic storm near Lat. 16.7° N and Long. 82.9° E. Moving north- east ward and skirting the Indian coast, it crossed Bangladesh coast near Hatia as a severe cyclonic storm around 2100 UTC of 26 September 1997.

There was widespread rainfall activity over central and northern parts of the country under the influence of the above systems. However, no large scale floods were reported from any part of the country.

During the Post Monsoon Season, a cyclone formed in the Gulf of Thailand on 1 November. It emerged into north Andaman Sea near Lat. 12.5° N and Long. 98.0° E at 0300 UTC on 4 November 1997. It moved in a west –north-westerly direction up to 8 November weakened into a depression on 9 November and later into low pressure area by 10 November. No damage was caused by the system except heavy rains and strong winds over northern parts of the Bay Islands.

Another depression formed over south east Arabian sea on 10 November near Lat. 11.0° N and Long. 69.0° E at 1800 UTC and moved in a west north westerly direction. It intensified into a deep depression at 0300 UTC on 11 November near lat.11.5° N and long. 68.0° E and moved in a north-westerly direction. It weakened over the central Arabian Sea by the afternoon of 13 November.

The tracks of these systems are given in fig. 1(a) , 1(b),and 1(c).

Table 1 (A) gives the monthwise formation of cyclonic disturbances in the Bay of Bengal and Arabian Sea. It may be seen from the table that the number of systems in the pre - monsoon (March – May), SW - monsoon (June – September) and post monsoon(October–December) seasons of this year were 1, 6 and 2 respectively . One cyclone and five depressions formed in the monsoon season against the normal frequency of 6 to 7 per year . This year the frequency of systems during monsoon season is higher than that in 1994 and 1995 , when only 2 cyclones and 1 depression formed respectively.

The monthly distribution of cyclonic disturbances during the past 26 years (1971-1996) is given at the end of the Table 1(A).

The Table 1(B) gives the important features of cyclonic disturbances that formed during this year. Identification numbers are given to the systems of cyclone intensity only in accordance with the para 2.3 of the TCP-21 .

Tables (2 to 10) give the best track positions at 00,03,06,12, and 18 UTC along with the other Meteorological parameters of all the cyclones in the Bay of Bengal and the Arabian Sea.

Detailed account of all the systems are given in the following paragraphs. The locations of various stations referred to in this report are shown in fig. 2.

2. Detailed Description of Cyclonic Disturbances

2.1 Pre-Monsoon Season (March - May)

In the month of May, out of 77 cyclones that formed in the Bay of Bengal during the period 1881 to 1990 , 18 cyclones crossed Bangladesh coast , 28 crossed Indian coast , 25 crossed Myanmar coast and 6 died over the sea. In view of this, cyclones originating in the month of May have 60 percent probability of hitting Bangladesh / Myanmar coast.

During the pre- monsoon season one cyclone formed in the month of May and attained the intensity of SCS (H) . This system formed over south east Bay of Bengal and behaved as a normal type of cyclone of this month . Following the climatological track of this month it moved almost in a northerly direction and crossed Bangladesh coast.

2.1.1 Bay of Bengal Severe Cyclonic Storm With a Core of Hurricane Wind 15 to 20 May 1997. BOB 97 01 05 15 20

2.1.1.1 *The Life History of the Cyclone.*

A well marked low pressure area formed over southeast Bay of Bengal and adjoining south Andaman sea in the morning of 15 May , 1997. Moving northward it concentrated into a depression near Lat. 6.5° N and Long. 90.5° E at 0600 UTC. It was located near Lat. 7.0° N and Long. 90.5° E in the afternoon (0900 UTC) . Moving further northward it intensified into a cyclonic storm by

the morning of 16 May and was centred at 0300 UTC near Lat. 9.0° N and Long. 90.5°E . At this point it moved in a north-north – easterly direction up to the evening of 17 May and intensified further into a severe cyclonic storm with its centre at 0900 UTC near Lat. 13.5° N and Long. 91.5° . Later it changed its course towards north-north-westerly direction and moved fast at a speed of 08 kts. It was located at 0300 UTC of 18 May near Lat. 16.5° N and Long 90.5° E . During next 15 hours, it moved in a northerly direction and then it changed its course again into a north-easterly direction . At 0300 UTC of 19 May it was located near Lat. 20.3° N and Long. 91.2° E as observed by the Radar Khepupara. By 1200 UTC it came close to Chittagong coast and crossed near Sitakundu at 1430 UTC of 19 May . It weakened rapidly into a Depression at 1800 UTC and into a well marked low pressure area over Mizoram and neighbourhood by the morning of 20 May . The available observations show that the system hit Cox' Bazar and Chittagong coast and moved along the coast for two hours and finally crossed Chittagong –Feni coast.

2.1.1.2 MONITORING AND TRACKING.

As the system was beyond the range of Cyclone Detection Radar located along the east coast of India , the system was continuously monitored with the help of INSAT imagery up to the morning of 18 May and later with the help of Radar at Khepupara and INSAT imagery. CDR Calcutta also observed the system from 0600 UTC of 19 May. The Radar track as observed by CDR Calcutta and Khepupara is given in fig. 3 and 4 respectively.

2.1.1.3 FEATURES .

The cloud field in the ITCZ built up continuously and organised into a curved band pattern by 0500 UTC of 15 May when the intensity of the system was estimated as T-1.5 with centre near Lat. 6.5° N and Long. 90.5° E . Moving northward, it acquired the intensity of T-2.5 at 0400 UTC of 16 May with its centre near Lat. 9.2° N and Long. 91.0° E. The system intensified continuously in the next two days . Its intensity became T-3.5 at 0600 UTC of 17 May and by 0200 UTC of 18 May its intensity reached T-4.0 stage . Moving further northward it intensified into a T-4.5 stage at 1700 UTC of 18 May and by 0000 UTC of 19 May it acquired the peak intensity of T-5.0 . The formation of an asymetrical eye was seen in the northward portion of Central Dense Overcast (CDO) .

A few photographs of INSAT imagery are given in fig 5(a)to 5(h)

2.1.1.4 METEOROLOGICAL FEATURES AND WEATHER CAUSED

2.1.1.4.1 *PRESSURE AND WIND*

As the system attained the highest intensity T-5.0 the estimated central pressure was 964 hpa at 0900 UTC of 19 May, and the corresponding maximum sustained surface wind speed was estimated as 90 kts. The following stations recorded lowest pressure when the system was nearest to them.

Station	Lowest Pressure. (hPa)	Date/Time (UTC)
Chittagong	966.1	19 / 1200
Cox's Bazar	970.8	19 / 0900
Sita kundu	973.8	19 / 1200

The Coastal stations recorded the following maximum wind on 19 May.

Station	Maximum Wind Dir. / Speed (Kt.)	Date/Time (UTC)
Cox's Bazar	SW / 124	19 / 09
Sitakundu *	NE / 60	19/ 0900 (* Maximum Wind speed recorded 232 kmph).
Chittagong	NE / 90	19 / 1200
Chittagong (Ship Observation)	- / 210 kmph.	

Hourly observations from coastal stations of Bangladesh are given in fig. 6 (a & b).

2.1.1.4.2 *RAINFALL*

The cyclone caused heavy to very heavy rainfall in the coastal areas of Chittagong . Specific reports on rainfall amounts are not available.

2.1.1.4.3 SALIENT FEATURES OF THE CYCLONE

i. The eye of the cyclone was seen continuously from 0000 UTC of 19 May onward in INSAT imagery until the landfall. The rate of intensification in the cyclone stages was one T- number per day (fig. 7) .

ii. The system moved in an almost northerly direction in spite of the easterly upper air flow between 300 to 200 hpa. It appears that the system was steered by the resultant of mid-level south westerlies and upper –level easterlies.

iii. The speed of the system was 6 kt on 16 and 17 May and 10 kt there-after.

2.1.1.4.4 DAMAGE

The cyclone caused a huge damage to properties and loss of lives in Bangladesh .A brief account of which is given below:-

Districts Affected	10
People Killed	**155**
People Wounded	9,663
Families Affected	5.41,586
People Affected	28,35,472
Live Stock Killed	3118
Houses Damaged :	
Fully	1,12,160
Partially	99,557
Crops Damaged :	
Fully	19.173 acres of land
Partially	78,160 acres of land
Road damaged :	
Fully	53 Kms
Partially	162 Kms
Embankment damaged	6 Kms
Bridge & Culvert damaged	165
Religious & Educational Institutions damaged	1,480

2.2 Southwest Monsoon Season (June-September)

During the SW-monsoon season five depressions and one cyclone formed over the Bay of Bengal which is almost equal to the average frequency of 4 to 5 depressions during this season . No system formed over the Arabian sea. The formation of 6 systems in monsoon season have occurred after a gap of 11 years.

During the past few years , the formation of depressions / cyclones in the monsoon season has been below normal. In the years 1992-96 the number of depressions / cyclones was less than or equal to 3. This year the distribution of systems in the season has been very good in June, July and August. It was one system in June , one in July , three in August and one cyclone in September. Also, the life period of depressions that formed in the month of July and August was more than 3 days and their path was normal across plains of north India . As a result of this, the distribution of rainfall has been well distributed over most parts of the country .

The first depression formed in the last week of June and weakened over north Bihar by 30 June . The second system formed in the last week of July and weakened over Punjab and neighbourhood by 2 August . The next three depressions formed in the first , third and fourth week of August respectively.

2.2.1 BAY OF BENGAL DEPRESSION (June 26-30,1997)

2.2.1.1 *Brief History*

A well marked low pressure area formed over northwest Bay of Bengal in the early morning of 26 June and concentrated into a depression with centre at 0300 UTC of 26 June near Lat. 21.0° N and Long 89.5°E . Moving west- north-westward it concentrated into a deep depression near Sagar Island by the same evening and crossed west Bengal coast near Haldia the same night (around 2100 UTC). It was centred near Lat. 22.5° N and Long. 87.5° E at 0300 UTC of 27 June. Thereafter, it moved in a north-westerly direction up to the evening at 1200 UTC of 28 June when its centre was near Lat. 24.0°N and Long. 86.0°E. Later it moved in a northerly direction and was centered at 1200 UTC of 29 June near Muzaffarpur in Bihar . At this stage it moved in a northwesterly direction and weakened rapidly over east U.P. and neighbourhood by the evening of 30 June. A few relevant INSAT Imagery are given in fig 8(a) to 8(d).

2.2.1.2. WEATHER REALISED

Under the influence of this depression the south-west monsoon was vigorous to active along the west coast and central parts of the country . Wide spread rainfall with scattered heavy to very heavy falls occurred over Orissa, West Bengal and Bihar . Some of the Chief amounts are given below.

Station	Rainfall (Cm)	Date	Month
Cuttack(Orissa)	23	27	June
D.P.Ghat (WB)	26	28	"
Kheridwar (WB)	23	28	"
Rangagora (WB)	21	28	"
Kangsaboti Dam (WB)	21	28	"
Jamshedpur (Bihar)	25	28	"
Kursela (Bihar)	16	29	"
Sikandarpur(Bihar)	22	29	"
Patna (Bihar)	21	30	"
Koilwar (Bihar)	20	30	"

2.2.2 BAY OF BENGAL DEEP DEPRESSION (July 29- August 2, 1997)

2.2.2.1. *Brief History*

A well marked low pressure area formed in the morning of 29 July and concentrated into a depression at 0300 UTC with its centre near Lat. 21.0°N and Long. 89.0°E . Moving in a westerly direction it came close to north Orissa coast and intensified into a deep depression . Moving slowly west-north-west wards it

crossed north Orissa coast near Chandbali in the evening of July 30 . The system weakened into a depression close to Rourkela by the evening of 31 July. There-after moving in a north-westerly direction at a speed of 12 kt and traversing north-east M.P , south-west U.P. it was located in the morning at 0300 UTC of 2 August close to Mathura in west U.P. . It weakened into a well marked low pressure area over Haryana and adjoining Punjab during the night of 2 August. Fig 9 shows the speed of the system during the period of its life history. Some INSAT Imagery are given in Fig. 10 (a) to 10 (d).

2.2.2.2 WEATHER REALISED

Under the influence of this depression monsoon strengthened along the west coast and central parts of the country. It caused wide spread rainfall with scattered heavy to very heavy falls over Orissa, north M.P. , Rajasthan and Haryana . Some of the important amounts of rainfall are given below.

Station	Rainfall (Cm)	Date	Month
Nimapada (Orissa)	28	30	July
Paradeep (Orissa)	23	30	"
Sundargarh (Orissa)	20	30	"
Jenapur (Orissa)	17	30	"
Mandala (M.P.)	11	30	"
Maheswar (West M.P.)	14	1	August
Satna (East M.P.)	10	1	"
Rewari (Haryana)	11	2	"
Jalore (Rajsthan)	10	2	"
Nasirabad (Rajsthan)	10	2	"
Haridwar (U.P.)	12	3	"
Chandigarh	15	3	"
Jagadhari (Haryana)	16	3	"
Jagraon (Haryana)	16	3	"
Kasauli (Himachal)	16	3	"

2.2.3 BAY OF BENGAL DEEP DEPRESSION (August 4-8, 1997)

2.2.3.1 *Brief History*

A well marked low pressure area formed over north Bay on the morning of 4 August and concentrated into a depression at 0600 UTC of the same day. It was centered at 1200 UTC near Lat. 21.0° N and Long. 89.5°E. Moving in a north-westerly direction it intensified into a deep depression and lay centered at 0300 UTC of 5 August near Lat. 21.5°N and Long. 89.0°E. Moving in a north westerly direction it crossed near Sagar Island around noon of 5 August and was located at 1200 UTC close to Midnapore . Keeping its north – westerly track it intensified into a deep depression and was centered near Satna by the morning of 7 August . There after it changed its course to west- north – westerly direction and moved fast. It came close to Mount Abu in east Rajasthan by the evening of

7 August. It weakend into a well marked low pressure area by the morning of 8 August close to Bikaner in west Rajasthan.

Initially the system was detected and tracked with the help of INSAT imagery but afterwards it was well tracked with the help of surface observations and other conventional observations in addition to Satellite imagery. Fig. 11(a) to 11(d) show the different phases of the system.

2.2.3.2 WEATHER REALISED

Under its influence widespread rainfall with heavy to very heavy falls occurred all along the central parts of the country . Some of the important amount of rainfall are as below :

Station	Rainfall (Cm)	Date	Month
Thakur Munda, Orissa	33	5	August
Paradeep, Orissa	20	5	"
Mohanpur, Gangetic W.B.	11	6	"
Ranganjmods, East Rajasthan .	13	7	"
Khajuraho, West M.P.	12	7	"
Pali, West Rajasthan	18	8	"
Mount Abu, East Rajasthan	22	8	"

As per reports from the news papers about 7.5 lakhs people in 16 blocks of Midnapore districts were affected due to heavy rains . About 10,000 kachha houses collapsed and 15,000 houses damaged rendering 80,000 people homeless in Midnapore district . In Purulia district about 10,000 people were affected due to continuous heavy rains.

2.2.4 BAY OF BENGAL DEEP DEPRESSION (August 19-27, 1997)

2.2.4.1 *Brief History*

A low pressure area formed over north Bay on the evening of 16 August and became well marked in the morning of 18 August over north-west Bay off Orissa – west Bengal coast . It persisted over the same area till the evening of 19 August and it further intensified into a deep depression and crossed north Orissa coast between Paradeep and Chandbali around 0800 UTC and lay centered at 1200 UTC near Lat. 20.5° N and Long. 86.0° E. Moving west-north-westward , it was located near Lat. 21.0° N and Long. 84.5°E. Thereafter it moved in a north-westerly direction across north Madhya Pradesh and was located close to Jaipur in Rajasthan on the morning of 25 August . Later it moved in a north-north-westerly direction and was located near Lat. 31.0° N and Long. 74.0° E . It rapidly dissipated over Punjab and adjoining Pakistan by the evening of 27 August. A few INSAT pictures of the system are given in Fig. 12(a) to 12(j) showing the various aspects of the system.

2.2.4.2 Salient Features

1. The system caused tidal waves , over Digha on the night of 19 August. (Back cover)

2. Chandabali reported lowest pressure 990.6 hPa at 1000 UTC of 20 August. Paradeep reported lowest pressure 990.6 hPa at 0800 UTC and 1000 UTC .

3. Chandbali reported maximum surface wind southerly 35 kts at 1000 UTC of 20 August and Paradeep reported southerly 50 kts at 0900 UTC (Based on the observation of high wind speed recorder).

Under the influence of this system monsoon strengthened over the most parts of the country . Widespread rainfall with scattered heavy to very heavy occurred in the south-west sector of the system . Some of the significant amounts of rainfall are as below :

Station	Rainfall (Cm)	Date	Month
Puri , Orissa	20	20	August
Bhubaneswar, Orissa.	10	20	"
Bhubaneswar, Orissa	25	21	"
Nimapada, Orissa	24	21	"
Surada, Orissa	19	21	"
Malkapur, Vidarbha	23	22	"
Mana, East M.P.	11	22	"
Chhindwara (West MP.)	16	23	"
Durga Pwadi(Maharashtra)	52	23	"
Buldana, Vidarbha	23	23	"
Motala, Vidarbha	20	23	"
Haridwar, West U.P	17	24	"
Dungala , East Raj.	25	24	"
Chanasma, Gujarat	17	25	"
Ukai, Gujarat	15	25	"
Nagaur, West Raj.	14	26	"

2.2.4.3 DAMAGE REPORT

It is reported that huge damage of standing crops and houses occured in Digha. About 70,000 hectors of crops and 10,000 houses were destroyed. A touring officer visited the area and reported that a one Km stretch of road was washed away due to heavy rains (Fig. 13) . The economic loss has been reported around Rs. 40 crores. About four hundred fishermen were reported missing.

2.2.5 BAY OF BENGAL DEPRESSION (August 28-30, 1997)

2.2.5.1 *Life History*

In succession of deep depression 19-27 August, another depression formed over north-west Bay off Orissa coast on the morning of 28 August and was centred near Lat.19.5°N and Long. 87.0° E. Moving in a north-westerly direction it crossed Orissa coast close to Puri by 0600 UTC and was located at 1200 UTC near Lat.21.5° N and Long. 85.0°E . Moving further in a north-westerly direction it moved into Bihar by the morning of 30 August and was located close to Daltonganj at 0300 UTC . It weakened into a well marked low pressure area over east Uttar Pradesh and adjoining Bihar by the evening of 30 August . Fig. 14 (a) to 14(d) show the development of the system as observed in INSAT Imagery.

2.2.5.2 Weather Realised

Under its influence wide spread rainfall with heavy falls occurred over Orissa , Gangetic West Bengal , Bihar and parts of East Uttar Pradesh . Some of the chief amounts of rainfall are as below :

Station	Rainfall (Cm)	Date	Month
Panposh (Orissa)	12	29	August
Diamond Harbour(West Bengal)	11	29	"
Malda(West Bnegal)	21	30	"
Kursela (Bihar)	17	30	"
Balia(East U.P)	8	31	"

2.2.6 BAY OF BENGAL SEVERE CYCLONIC STORM (SEPTEMBER 23-27,1997)

BOB 97 02 09 23 27

2.2.6.1 *Brief History*:

Towards the end of monsoon season a depression formed over west central Bay of Bengal on 23 September with its centre at 0300 UTC near Lat. 15.5° N and Long. 82.5° E. It moved in a northerly direction and intensified into a deep depression by the same evening and into a cyclonic storm by the evening (0900 UTC) of 24 September when it was located close to the Indian coast of Andhra Pradesh about 75 km south east of Kakinada . At this point the system took northeasterly course and moved with a speed of 5 to 6 kts along the Andhra Pradesh coast and was located near Lat. 16.7° N and Long. 82.9° E at 1200 UTC. It was located near Lat. 17.3° N and Long. 83.7° E at 0300 UTC and near Lat. 18.5° N and Long. 85.0° E at 1200 UTC of 25 September.

Moving further in a north easterly direction at a speed 10 to 12 kts it intensified into a severe cyclonic storm and was located near Lat. 22.0° N and

Long. 91.0° E at 1800 UTC of 26 September. Thereafter it crossed Bangladesh coast near Hatia (41963) around 2100 UTC. It weakened into a cyclonic storm over land at 0300 UTC of 27 September and dissipated by the evening over north Bangladesh.

As per the Radar observations of Khepupara in Bangladesh,cyclone grazed Chittagong coast for some time and finally crossed Feni coast in early morning hours of 27 September.

2.2.6.2 MONITORING AND TRACKING

The system was initially detected with the help of INSAT imagery and coastal observations and later on 24 & 25 September , observations from CDR Visakhapatanam also helped in fixing the position of the system . CDR Khepupara tracked the system from 1800 UTC of 26 September of 1800 UTC when the system had come close to this station .

This is one of the rare Cyclones which came under the surveillance of all the Radars (except CDR Karaikal) as it moved along the east coast. These observations provided realistic estimates of the centre and intensity .

2.2.6.2.1. OBSERVATION FROM CDR MACHLIPATANAM

CDR Machilipatanam observed the system right from 1200 UTC of 22 September and continued to provide valuable observations up to 1200 UTC of 25 September. Centre of the system was estimated from 0300 UTC of 24 September. Some of the Radar pictures are given in fig. 15 (a) & 15 (b).

2.2.6.2.2 OBSERVATIONS FROM CDR VISAKHAPATANAM

The system was observed from 1800 UTC of 23 to 0300 UTC of 26 September . Some of the selected Radar pictures are given in fig. 16 (a) to 16 (d).

2.2.6.2.3 OBSERVATIONS FROM CDR PARADEEP

Radar at Paradeep observed this system from 0600 UTC of 25 September and continued up to 1200 UTC of 26 September . It estimated centre at 0900,1000, 2200 and 2300 UTC of 25 September and from 0000 UTC to 1100 UTC of 26 September with the help of spirals . Eye was seen from 0600 UTC to 0900 UTC of 26 September. Some of the important Radar pictures are given in fig. 17 (a) & 17 (b)

2.2.6.2.4 OBSERVATIONS FROM CDR CALCUTTA

Radar at Calcutta observed the system from 0600 UTC of 25 September to 0000 UTC of 27 September. Centre of the system was estimated with the help of spiral fitment technique. Some of the important Radar fixes are given in fig. 18 (a) to 18 (f).

Thereafter the system was observed by CDR Khepupara . The report is awaited.

The track of the system as observed by the above radars is given in Fig.19.

2.2.6.3 SIGNIFICANT FEATURES OF THIS CYCLONE

i). The system formed close to the south Andhra Pradesh coast and moved along the east coast and maintained its intensity as cyclonic storm up to 26 September and severe cyclonic storm till the time of crossing the coast. There is no parallel of this system in the history of cyclones in the month of September.

ii) Wide spread rain with heavy falls occurred in the coastal regions of Andhra Pradesh , Orissa ,West Bengal and Bangladesh during its life period.

iii) The shortest distance from the Indian coast was 60 Km. from the Andhra Pradesh coast on 24 September evening.

iv) Eye was also seen clearly .

v) High wind speed recorder at Visakhapatanam recorded average wind of 25 kt gusting to 38 kt during the morning of (0030 UTC to 0300 UTC of 25 September) . The lowest pressure recorded at the station was 981.0 hPa at 0300 UTC of 25 September.

A few INSAT Imagery showing the various phases of the cyclone are given in Fig. 20 (a) to 20 (h).

2.2.6.4 WEATHER REALISED

Under its influence there was widespread rainfall with heavy to very heavy falls over coastal Andhra Pradesh, Orissa and Gangetic West Bengal. Some of the chief amounts of rainfall were :

Station	Rainfall (Cm)	Date	Month
Bapatla	21	24	September
Avanigadda	20	24	"
Tenali	15	24	"
Amlapuram	14	24	"
Repali	13	24	"
Machilipatnam	13	24	"
Ongole	12	24	"
Yerraguntapalem	12	24	"
Kakinada	40	25	"
Koderu	18	25	"
Tuni	17	25	"
Peddapuram	17	25	"
Chodavaram	16	25	"
Rajamundry	12	25	"

2.2.6.5 **DAMAGE**

1. Loss of Human lives	**32 (District wise: Guntur 14, Visakhapatnam 2, East Godavari 7, West Godavari 1, Krishna and Prakasham 4)**
2. Houses damaged	**1470**
3. Cattle Loss	**326**
4. Breaches to Tanks	**39**

2.3 POST-MONSOON SEASON (OCT- DEC)

On an average 3 to 4 cyclonic storms form over north Indian Ocean during the period 1 October to 31 December. During this period of 1997 cyclonic activity over the north Indian Ocean was at the minimum. This year one cyclone ' LINDA ' Which originated over north-west Pacific in the begining of November moved northwestward and emerged into the Bay of Bengal. It weakened over west central Bay of Bengal and finally died over the sea. No other cyclonic system formed over the Bay of Bengal. One depression formed over the Arabian Sea during the same month and moving north-westward, it also died over the sea. Thus there was very little cyclonic activity over the Bay of Bengal and Arabian Sea . There is no such parallel in the past record of cyclones (1891 to 1996). In the history of cyclones, there is only one year, i.e., 1961 , in which only two cyclonic systems, including one land depression had formed during the month of October and there was no activity in the remaining period of November and December.

Inspite of the little cyclonic activity over the Bay of Bengal and Arabian sea, excess rain occurred over the major parts of India . Area weighted estimate of rain over the country was 18 cm against the normal of 12 cm. A series of western disturbances moved across the northern parts of India and caused frequent rains over the country. The month of December had been excessively cold over northern parts of India .

2.3.1 BAY OF BENGAL CYCLONIC STORM (NOVEMBER 04-09 , 1997)

BOB 97 03 11 04 09

2.3.1.1 *Brief History*

The cyclone **'LINDA'** which formed over south west pacific near Lat. 7.5° N and Long. 113.0° E at 0000 UTC of November 1 moved northwestward into Gulf of Thailand by the evening of 3 November when it was centred near Lat. 10.5° N and Long. 101.0°E. It emerged into Andaman Sea as a cyclonic storm at 0000 UTC of 4 November and was centred near Lat. 12.5°N and Long. 98.0°E at 0300 UTC. Moving in a northwesterly direction it was located at 0300 UTC of 5 November near Lat.14.0° N Long. 95.0° E. At this point it moved in a westerly direction up to morning of 7 November when it was centred near Lat.15.5° N and Long. 91.5° E . Thereafter, the system remained practically stationary up to the morning of 9 November . At 0300 UTC of 9 November it was centred near Lat.15.0°N and Long. 90.5°E as deep depression. Fig. 21 (a) & (b) show the flow pattern at 200 hPa. It started weakening on the morning of 9 November and became a depression in the afternoon and a well marked low over sea by the evening.

2.3.1.2 MONITORING AND TRACKING

The system was mainly monitored with the help of INSAT imagery. Observations of Bay Islands also helped in fixing the centre of the system.

2.3.1.3 IMPORTANT FEATURES

1) The system caused huge damage over Thailand on 3 November when it was a Severe Cyclonic Storm.

2) As the system moved into the Bay of Bengal , strong southwesterly to westsouthwesterly winds prevailing in the upper levels all along the east coast and strong vertical wind shear did not allow convection to grow in the system .

3) INSAT imagery showed the development of CDO) pattern with pronounced outflow streaming out unilaterally northeastwards. This pattern indicated that there would be very little further development of the system (Fig. 22 (a) to 22(d)).

4) Some of the INSAT imagery (Fig . 22(e) & 22 (f)) showed shearing of clouds over the system .

2.3.1.4 WEATHER REALISED

As the system did not develop due to the prevailing strong vertical wind shear in the region , it weakened over the central Bay of Bengal and did not cause any damage except strong winds over the northern Bay Islands.

No cyclonic system could form over the Bay of Bengal in the rest of November and December due to strong vertical wind shear over the south Bay of Bengal . The sub-tropical ridge line at 200 hPa was hovering around Latitude 10.0°N during this period.

2.3.2 ARABIAN SEA DEEP DEPRESSION (NOVEMBER 10 –13, 1997)

A well marked low pressure persisted over South East Arabian Sea on the morning of 10 November and intensified into a depression by the mid-night (1800 UTC) and was located near Lat. 11.0°N and Long 69.0° E . Moving in a northwesterly direction it intensified into a deep depression with centre near Lat. 11.5° N and Long. 68.0° E at 0300 UTC of 11 November . It continued to move in a northwesterly direction and by the morning (0300 UTC) of 12 November it was centered near Lat. 13.5° N and Long. 66.0° E. Thereafter it moved in a WNW-ly direction and was centered at 0300 UTC of 13 November near Lat. 14.5° N and Long. 63.5° E . By the afternoon (0900 UTC) the system weakened into a depression and then to a low pressure area by the same evening. The system as observed in INSAT imagery is given in Fig. 23 (a) to 23 (d).

Since the system died over the sea no effect was noticed over the coastal areas of south peninsula.

3. DYNAMICAL ASPECTS.

3.1 VERTICAL WIND SHEAR

It is known that the development of a disturbance is favoured when the vertical wind shear is small in the lower level . This year there was very little cyclonic activity over the Bay of Bengal and Arabian Sea during the month of October , November and December . One of the reasons was the presence of strong vertical wind shear prevailing over this region. Whenever a cyclonic system formed in the lower level it could not develop into a cyclone due to the presence of a strong vertical wind shear between 850 and 200 hPa as shown in fig. 24 .

3.2 TRACK PREDICTION MODELS

Storm track prediction is made operationally by RSMC New Delhi by utilizing several models based on climatology, persistence and the combination of climatology and persistence (CLIPER). These models were run for all the cyclonic disturbances (depression stage onward). The track prediction was also

made on the basis of Analogue Techniques. Mean forecast position errors on the basis of climatology, persistence and CLIPER models for depression and cyclones are given in Table 11. Mean forecast position errors for the depression and cyclones based on Analogue and RSMC Model are given in Table 12 . The forecast skill relative to CLIPER and RSMC Model for depression / cyclones is given in Table 13.

The forecast skill relative to CLIPER model is expressed as percentage and calculated by using the formula given below :

$$\text{Forecast skill} = \frac{\text{CLIPER (PE)} - \text{OM (PE)}}{\text{CLIPER (PE)}} \times 100$$

CLIPER (PE) = Position errors based on CLIPER Model .
OM (PE) = Position errors based on other models such as persistence, climatology, Analogue etc.

The data reveals the following facts :

a). In general the forecast position errors increased with time, particularly beyond 24 hours.

b). The 24 hours forecast errors based on CLIPER Model for depressions were less than the errors based on Analogue Model but slightly higher than the errors based on RSMC Model . In the case of cyclone the 24 hours forecast based on CLIPER Model were almost equal to the errors based on Analogue, but less than the errors based on the RSMC Model.

c). In the case of cyclones the average of 24 hours forecast errors (km) based on Analogue , CLIPER and RSMC were 138, 198 & 238 and in the case of depressions 202 , 182 & 154 respectively. This indicates that the errors based on different models were almost comparable and they were between 100 to 250 km.

d). The results of movement of cyclone prediction indicate the following points :

1. The forecast direction and intensification of the cyclone were in agreement with the observed behaviour .

2. In general, the predicted movement of cyclone was less displaced from the observed.

e). The average of forecast position errors in the case of systems of this year were slightly higher than the last year (1996). However a slight improvement is noticed in the case of the errors based on the RSMC Models from last year.

3.3 THE LIMITED AREA FORECAST MODEL (LAM) OF RSMC , NEW DELHI

The limited area forecast model adopted from Florida State University , U.S.A. is also being run by R.S.M.C. New Delhi on an experimental basis. The details of the models were given in the R.S.M.C. report of the year 1993.

3.3.1 RESULTS FROM MODEL FOR CYCLONES- 1997

The Limited Area model used by RSMC was run for two depressions and two cyclones of 1997. Fig 26 shows the observed and 24 hour forecast position (based on RSMC Model) of monsoon depressions / cyclonic storm. Some of the initial and predicted vorticity fields at 850 hPa are given in fig. 27(a), (b)&(c). Table 12 gives the 24 hours model forecast error for depression and cyclone along with the forecast error based on Analogue and CLIPER. The average 24 hr forecast error for the cyclone were between 154 and 322 kms. The 24 hr forecast error in respect of the other depressions were between 140 and 167 kms.

4. DISSEMINATION OF WARNINGS

Cyclone warnings were issued and disseminated to the general public, central and state Government officials and other user organizations in India through high priority telegrams, T/P, Telephone and Telex. The electronic and print media were also used extensively for this purpose.

Particularly , timely cyclone warnings issued to the public and the State Governments of Andhra Pradesh, Orissa and West Bengal in connection with the cyclones of May and September were helpful in minimizing the loss of life and public property to a great extent . The services provided by India Meteorological Department were appreciated by the high ranking officials of state Government. Cyclone warnings in different local languages were communicated directly by India Meteorological Department's (IMD) Cyclone Warning Centres to the affected coastal populations through the satellite based communication system known as the Cyclone Warning Dissemination System (CWDS).

The direction of movement of the system particularly recurvature was predicted well by the RSMC Model. However, the displacement of the system was less than the actual. The position of the vortex in the LAM analysis field was between 100 and 200 kms of its position in the conventional analysis on most of the occasions.

5. CO-OPERATION AMONG PANEL COUNTRIES

As in the previous years, the Regional Specialized Meteorological Centre (RSMC) New Delhi, issued 49 (Forty nine) Tropical Cyclone Advisories this year also to all the member countries of WMO/ESCAP Panel on Tropical Cyclones during the cyclone period at the six hourly interval and 3 (three) special Weather Tropical Outlook. Besides this, Tropical Weather Outlooks for the north Indian Ocean were issued daily at 0600 UTC as a routine to the member countries of the panel.

Cloud Motion Vectors based on 0000 UTC and 1200 UTC observations were regularly disseminated over GTS for the area covering the Bay of Bengal, the Arabian Sea and the Indian Ocean up to 30° S . 0000 UTC IR full frame satellite picture is transmitted on Radio Facsimile for international use.

Bangladesh Meteorological Department has provided some valuable information on upper wind data and radar observations from the coastal cyclone detection radars (CDR) in connection with the system of 16-20 May 1997. These were very useful in finalizing the track and the intensity of the system at the time of crossing the Bangladesh coast on May 19.

6. CONCLUDING REMARKS.

Like the earlier years, this year has also witnessed a below normal cyclonic activity over the north Indian Ocean as nine cyclonic disturbances formed over this region against the average frequency of 13 to 14 and only three out of them have attained the intensity of a cyclone. Significantly this year there has been little cyclonic activity over the Bay of Bengal and the Arabian Sea during the peak months of October , November and December . The months of October and December were free from any cyclonic activity which is a rare event for this region. The cyclone that formed in the month of September close to the coast of Andhra Pradesh made an unusual track by moving along the east coast of India.

The formation of cyclonic disturbances during the monsoon season (June to September) has been normal . The track of these disturbances was close to normal and has been useful in giving widespread rainfall over the major part of the country.

In view of the above, the year 1997, may be called as the year of low cyclonic activity. Only two systems attained the intensity of a cyclone during this year and crossed the south east coast of Bangladesh. As the remaining stretch of the entire coast was free from cyclone, no severe damage of property or loss of life occurred during the year 1997.

TABLES

TABLE-1A

Monthly distribution of cyclonic disturbances (depressions and cyclones) over North Indian Ocean (The Bay of Bengal and Arabian Sea) during 1997.

System	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
BAY OF BENGAL													
Depression	...	...	...	...	...	1	1	3	...	...	...	...	5
Cyclonic storm	...	...	...	...	...	...	...	...	...	...	1	...	1
Severe cyclonic storm	...	...	...	...	...	...	...	...	1	...	...	...	1
Severe cyclonic Storm with a Core of Hurricane winds	...	...	...	...	1	...	...	...	...	...	...	...	1
Land Depression	...	...	...	...	...	...	...	...	...	...	...	...	...
ARABIAN SEA													
Depression	...	...	...	...	...	...	...	...	...	...	1	...	1
Cyclonic Storm	...	...	...	...	...	...	...	...	...	...	...	...	...
Severe cyclonic storm	...	...	...	...	...	...	...	...	...	...	...	...	...
Severe cyclonic Storm with a Core of Hurricane winds	...	...	...	...	...	...	...	...	...	...	...	...	...
TOTAL(North Indian Ocean)	...	...	...	...	1	1	1	3	1	...	2	...	9
No of cyclonic Sys. During 1971-96	3	0	1	5	25	36	25	47	36	54	60	22	314

TABLE-1B

S.NO.	Cyclonic Disturbance	Peak Intensity T. No.	MSSW (Kt)	Duration Time(UTC) / Date	Place and time of crossing the coast	Loss (human) life	Peak stor surge height (m
O1	Bay of Bengal Severe Cyclonic Storm with a core of hurricane winds (15-20 May 1997) (BOB 97 01 05 1520)	5.O	9O	0300/16 to 143O/19 May	Crossed Bangladesh coast near Sitakundu at 1430 UTC of 19 June 1997	155	
O2	Bay of Bengal Deep Depression 26-29 June 1997.	2.O	3O	0300/26 to 1800/29 June	Crossed West Bengal coast near Digha around OO UTC of 27 June 1997.		
O3	Bay of Bengal Deep Depression 29July-2 August 1997.	2.O	35	0300/29 to 0600/02 August	Crossed near Chandbali around 1OOO UTC of 3o July 1997		
O4	Bay of Bengal Deep Depression O4-O8 August 1997.	2.O		0600/04 to 1800/07 August	Crossed West Bengal coast near Sagar Island on 5th A/N.		
O5	Bay of Bengal Deep Depression 19-27 August 1997.	2.O	3O	0300/19 to 0300/27 August	Crossed north Orissa coast near Chandbali around 0800 UTC of 20 June 1997.	4	
O6	Bay of Bengal Depression,28-30 August 1997	1.5	25	0300/28 to 1200/30 August	Crossed Orissa coast around 0600 UTC of 28-Aug-97 between Puri- Paradip)		
O7	Bay of Bengal Severe cyclonic Storm 23-27 September 1997. (BOB 97 O2 O9 23 27)	3.5	55	0300/24 to 0000/27 September	Crossed Bangladesh coast near Hatia about 21OO UTC of 26 Sep. 1997		
O8	Bay of Bengal Cyclonic Storm (LINDA) O4-O9 November 1997. BOB 97 03 11 04 09)	2.5	35	0300/04 to 0000/09 November	Weakened over sea.		
O9	Arabian Sea Depression 10-13 November,1997	2	3O	1500/10 to 0600/13	Weakened over sea.		

MSSW Maximum Sustained Surface Wind

TABLE-2

BEST TRACK OF SCS (H) FROM 15-20 MAY 1997
BOB 97 01 05 15 20

Date May	Time UTC	Lat. Deg.N	Long Deg.E	T.No.	E.M.S. wind kt	E.C.P hPa	Δ P hPa	Grade
15	06	6.5	90.5	1.5	25	1000	4	D
	09	7.0	90.5	1.5	25	1000	4	D
	12	7.5	90.5	2.0	30	1000	4	DD
	18	8.0	90.5	2.0	30	1002	5	DD
16	00	8.5	90.5	2.0	30	1002	6	DD
	03	9.0	90.5	2.5	35	1001	7	CS
	06	9.2	90.5	2.5	35	1001	7	CS
	09	9.5	90.5	2.5	35	1001	7	CS
	12	10.0	91.0	2.5	35	999	7	CS
	18	10.5	91.3	2.5	35	999	7	CS
17	00	11.0	91.4	2.5	35	998	8	CS
	03	12.0	91.5	2.5	35	998	8	CS
	06	13.0	91.5	3.0	45	992	12	CS
	09	13.5	91.5	3.5	55	986	16	SCS
	12	14.0	91.0	3.5	55	986	16	SCS
	18	15.0	91.0	3.5	55	986	16	SCS
18	00	16.0	91.0	3.5	55	986	16	SCS
	03	16.5	90.5	4.0	65	980	22	SCS(H)
	06	17.0	90.5	4.0	65	980	22	SCS(H)
	09	17.5	90.5	4.0	65	980	22	SCS(H)
	12	18.0	90.5	4.0	65	980	22	SCS(H)
	18	19.3	90.3	4.5	77	974	30	SCS(H)
19	00	20.0	90.8	5.0	90	968	42	SCS(H)
	03	20.3	91.2	5.0	90	964	42	SCS(H)
	06	20.3	91.3	5.0	90	964	42	SCS(H)
	09	21.6	91.5	5.0	90	964	42	SCS(H)
	12	22.1	91.8	5.0	90	964	42	SCS(H)
		Crossed near Sitakundu at 1430 UTC						
	18	weakened	into a land	depression	over	Mizoram &	Myanmar	
20	00	weakened	into low	pressure	area over	Myanmar		

EMS Estimated Maximum Sustained Winds
ECP Estimated Central Pressure
△ P Pressure Defect

TABLE-3

BEST TRACK OF DEEP DEPRESSION FROM 26-30 JUNE , 1997

DATE JUNE	TIME UTC	Lat deg.N	Long deg.E	T.NO.	E.MAX wind kt	E.C.P. hPa	Δ P hPa	GRADE
26	00	NW BAY						WML
	03	21.0	89.5	1.5	25	990	4	D
	06	21.0	89.0	1.5	25	990	4	D
	12	21.5	88.5	2.0	30	986	5	DD
	18	21.5	88.5	2.0	30	986	6	DD
							6	
27	00	22.0	88.0	2.0	30	985	...	DD
	crossed	west	Bengal	coast	near	Digha	around	00UTC
	27 June	1997						
	03	22.5	87.5	...	OVER	LAND	...	DD
	06	22.5	87.0	...	OVER	LAND	...	DD
	12	23.0	86.5	...	OVER	LAND	...	DD
	18	23.0	86.0	...	OVER	LAND	...	DD
				...				
28	00	23.0	86.0	...	OVER	LAND	...	DD
	03	23.5	86.0	...	OVER	LAND	...	DD
	06	24.0	85.5	...	OVER	LAND	...	DD
	12	24.0	86.0	...	OVER	LAND	...	DD
	18	24.0	86.0	...	OVER	LAND	...	DD
29	00	24.5	85.5	...	OVER	LAND	...	DD
	03	24.5	85.5	...	OVER	LAND	...	DD
	06	25.0	85.5	...	OVER	LAND	...	DD
	12	25.5	85.5	...	OVER	LAND	...	DD
	18	26.0	85.0	...	OVER	LAND	...	D
30 JUN	00	----	----	...	OVER	LAND	...	WML

TABLE-4

BEST TRACK OF DEEP DEPRESSION FROM 29 JULY TO 2ND AUGUST 1997

DATE JULY	TIME UTC	LAT. Deg.N	LONG. Deg.E	T.NO.	E.Max wind kt	E.C.P. hPa	Δ P hPa	GRADE
July 29	03	21.0	89.0	1.5	25	1006	4	D
	06	21.0	89.0	1.5	25	1006	4	D
	12	21.0	87.5	1.5	25	1006	4	D
	18	21.0	87.5	1.5	25	1006	4	D
30	00	21.0	87.5	1.5	25	1004	6	D
	03	21.0	87.5	2.0	30	1002	6	DD
	06	21.0	87.0	2.0	30	1002	6	DD
	crossed	near	Chandbali	around		1000UTC		
	12	21.5	86.5	...	...	...	...	DD
	18	21.5	86.5	...	...	...	...	DD
31	00	21.5	86.5	...	...	...	...	DD
	03	22.0	86.0	...	...	...	...	DD
	06	22.0	86.0	...	...	...	...	DD
	12	22.5	85.0	...	...	...	...	DD
	18	23.0	83.0	...	...	...	...	DD
Aug.01	00	24.0	82.0	...	...	...	...	DD
	03	24.5	80.5	...	...	...	...	DD
	06	25.0	79.0	...	...	...	...	DD
	12	26.0	78.5	...	...	...	...	DD
02	00	26.5	78.0	...	...	...	...	DD
	03	27.5	77.5	...	...	...	...	DD
	06	28.0	77.0	...	...	...	...	D
	09	----	----	...	...	...	...	WML

TABLE-5

BEST TRACK OF DEEP DEPRESSION FROM 04-08 AUGUST 1997

DATE AUGUST,97	TIME UTC	LAT. DEG.N	LONG. DEG.E	T.NO.	E.MAX wind kt	E.C.P. hPa	Δ P hPa	GRADE
04	06	20.0	91.0	1.5	25	988	4	D
	09	21.5	90.0	1.5	25	990	4	D
	12	21.0	89.5	1.5	25	990	4	D
	18	21.5	89.5	1.5	25	990	4	D
05	00	21.5	89.0	1.5	25	988	...	D
	03	22.0	88.0	2.0	30	896	...	DD
	06	22.5	88.0	...	OVER	LAND	...	DD
	crossed W. Bengal coast near Sagar Island around 0600 UTC							
	09	22.5	88.0	...	OVER	LAND	...	DD
	12	22.5	87.5	...	OVER	LAND	...	DD
	18	23.0	85.0	...	OVER	LAND	...	DD
05	00	23.5	84.0	...	OVER	LAND	...	DD
	03	23.5	83.8	...	OVER	LAND	...	DD
	06	24.0	83.0	...	OVER	LAND	...	DD
	09	24.0	82.5	...	OVER	LAND	...	DD
	12	24.0	82.0	...	OVER	LAND	...	DD
	18	24.0	81.5	...	OVER	LAND	...	DD
05	00	24.0	81.5	...	OVER	LAND	...	DD
	03	25.5	78.5	...	OVER	LAND	...	DD
	06	25.0	78.5	...	OVER	LAND	...	D
	09	25.5	76.5	...	OVER	LAND	...	D
	12	26.0	76.0	...	OVER	LAND	...	D
	18	26.5	74.0	...	OVER	LAND	...	D
05	00	...	...	...	...	...	...	WML

TABLE-6

BEST TRACK OF DEEP DEPRESSION FROM 19-27 AUGUST 1997

DATE AUGUST	TIME UTC	LAT DEG. N	LONG. DEG. E	T.NO.	E.MAX wind kt	E.C.P. hPa	Δ P hPa	GRADE
19	12	NW	Bay					WML
20	03	20.5	87.5	1.5	25	992	4	D
	06	20.5	87.0	2.0	30	990	6	DD
	crossed	near	Chandbali	around	0800 UTC			
	12	20.5	86.5	OVER	LAND	...	...	DD
	18	21.0	85.5	OVER	LAND	...	...	DD
21	00	21.0	85.0	OVER	LAND	...	...	DD
	03	21.0	84.5	OVER	LAND	...	...	DD
	06	21.0	84.0	OVER	LAND	...	...	DD
	12	21.0	83.0	OVER	LAND	...	...	DD
	18	21.5	82.0	OVER	LAND	...	...	DD
22	00	21.5	81.0	OVER	LAND	...	...	DD
	03	21.5	81.0	OVER	LAND	...	...	DD
	06	21.5	80.5	OVER	LAND	...	...	DD
	12	22.0	79.5	OVER	LAND	...	...	DD
	18	22.5	79.0	OVER	LAND	...	...	DD
23	00	23.0	78.5	OVER	LAND	...	...	DD
	03	23.0	78.0	OVER	LAND	...	...	DD
	06	23.0	77.5	OVER	LAND	...	...	DD
	12	23.5	77.0	OVER	LAND	...	...	DD
	18	24.0	77.0	OVER	LAND	...	...	DD
24	00	24.5	77.0	OVER	LAND	...	...	DD
	03	24.5	76.5	OVER	LAND	...	...	DD
	06	24.5	76.5	OVER	LAND	...	...	DD
	12	25.0	76.0	OVER	LAND	...	...	DD
	18	25.5	75.5	OVER	LAND	...	...	DD
25	00	26.0	75.0	OVER	LAND	...	...	DD
	03	26.0	75.0	OVER	LAND	...	...	DD
	06	26.0	75.0	OVER	LAND	...	...	DD
	12	26.5	74.5	OVER	LAND	...	...	DD
	18	27.0	74.5	OVER	LAND	...	...	DD
26	00	27.0	74.0	OVER	LAND	...	...	DD
	03	27.0	74.0	OVER	LAND	...	...	DD
	06	27.0	74.0	OVER	LAND	...	...	DD
	12	27.5	74.0	OVER	LAND	...	...	DD
	18	29.0	74.0	OVER	LAND	...	...	D
27	03	31.0	74.0	OVER	LAND	...	...	D
	06	31.0	74.0	OVER	LAND	...	...	D
	12	WML	OVER	PUNJAB	AND	ADJ.	PAKISTAN	

TABLE-7

BEST TRACK OF DEPRESSION FROM 28-30 AUGUST 1997

DATE AUGUST	TIME IN UTC	LAT DEG. N	LONG DEG. E	T.NO.	E.MAX wind kt	E.C.P. hPa	Δ P hPa	GRADE
27	12	...	...	1.0	20	994	...	WML
28	03	19.5	87.0	1.5	25	994	4	D
	06	19.5	86.0	1.5	25	994	4	D
	CROSSED	ORISSA	COAST	AROUND	0600UTC	OF	28TH	AUGUST
	09	20.5	85.5	...	...	...	...	D
	12	21.5	85.0	OVER	LAND	...	..	D
	18	22.0	84.5	OVER	LAND	...	...	D
29	00	22.5	84.5	OVER	LAND	...	...	d
	03	23.0	84.0	OVER	LAND	...	...	D
	09	23.0	84.0	OVER	LAND	...	...	D
	12	23.5	84.0	OVER	LAND	...	...	D
	18	23.5	84.0	OVER	LAND	...	...	D
30	00	24.0	83.0	OVER	LAND	...	...	D
	03	24.0	83.5	OVER	LAND	...	...	D
	06	24.0	83.5	OVER	LAND	...	...	D
	12	WML	OVER	EAST U P	AND	ADJ.	BIHAR	

TABLE-8

BEST TRACK OF BAY OF BENGAL SEVERE CYCLONIC STORM FROM 23-27 SEPTEMBER 1997 BOB 97 02 09 23 27

DATE SEPT	TIME UTC	LAT DEG. N	LONG DEG. E	T.NO.	EST.MAX wind kt	E.C.P hPa	Δ P hPa	GRADE
23	03	15.5	82.5	1.5	25	1000	6	D
	06	16.0	82.5	1.5	25	1000	6	D
	09	16.0	82.5	1.5	25	1000	6	D
	12	16.0	82.5	2.0	30	998	6	DD
	18	16.0	82.5	2.0	30	998	6	DD
24	00	16.5	82.5	2.0	30	998	6	DD
	03	16.5	82.5	2.0	30	998	6	DD
	06	16.5	82.5	2.0	30	998	6	DD
	09	16.5	82.7	2.5	35	996	8	CS
	12	16.7	82.9	2.5	35	996	8	CS
	18	16.7	82.9	2.5	35	996	8	CS
25	00	17.3	83.6	2.5	35	994	8	CS
	03	17.3	83.7	2.5	35	994	8	CS
	06	17.7	84.0	2.5	35	994	8	CS
	09	18.0	84.5	2.5	35	994	8	CS
	12	18.0	85.0	2.5	35	994	8	CS
	18	19.5	87.0	2.5	35	994	8	CS
26	00	19.5	87.5	2.5	35	994	8	CS
	03	20.0	87.5	2.5	35	994	8	CS
	06	20.5	88.5	2.5	40	992	8	CS
	09	21.0	88.5	3.0	45	990	10	CS
	12	21.5	89.5	3.0	45	988	12	CS
	18	22.0	91.0	3.5	55	984	16	SCS
27	00	23.0	91.5	...	OVER	LAND	...	CS
	03	23.5	92.5	...	OVER	LAND	...	CS
	06	24.0	92.5	...	OVER	LAND	..	DD
	12	24.0	93.0	...	OVER	LAND	...	D

LOW MOVE PRESSURE IN AREA EASTERLY OVER DIRECTION NORTH EASTERN STATE AND

TABLE-9

BEST TRACK OF BAY OF BENGAL CYCLONIC STORM FROM 04 -09 NOVEMBER 1997 BOB 97 03 11 04 09

DATE NOVEMBER	TIME UTC	LAT DEG. N	LONG DEG. E	T.NO.	E.MAX wind kt	E.C.P. hPa	Δ P hPa	GRADE
04	03	12.5	98.0	2.5	35	1006	8	CS
	06	13.0	97.2	2.5	35	1006	8	CS
	09	13.0	97.0	2.5	35	1004	8	CS
	12	13.5	96.5	2.5	35	1004	8	CS
	18	14.0	96.0	2.5	35	1004	8	CS
05	00	14.0	95.0	2.5	35	1004	8	CS
	03	14.0	95.0	2.5	35	1004	8	CS
	06	14.0	95.0	2.5	35	1004	8	CS
	12	14.5	94.0	2.5	35	1004	8	CS
	18	14.5	94.0	2.5	35	1004	8	CS
06	00	14.5	93.5	2.5	35	1004	8	CS
	03	15.0	93.5	2.5	35	1004	8	CS
	06	15.0	93.0	2.5	35	1004	8	CS
	09	15.0	92.0	2.5	35	1004	8	CS
	12	15.0	92.0	2.5	35	1004	8	CS
	18	15.2	92.2	2.5	35	1004	8	CS
07	00	15.5	92.2	2.5	35	1004	8	CS
	03	15.5	91.5	2.5	35	1004	8	CS
	06	15.5	91.5	2.5	35	1004	8	CS
	09	15.5	91.5	2.5	35	1004	8	CS
	12	15.5	91.5	2.5	35	1004	8	CS
	18	15.5	91.5	2.5	35	1004	8	CS
08	00	15.5	91.5	2.5	35	1004	8	CS
	03	15.5	91.0	2.5	35	1006	8	CS
	06	15.5	90.5	2.5	35	1006	8	CS
	09	15.5	90.5	2.5	35	1006	7	CS
	12	15.5	90.5	2.5	35	1005	7	CS
	18	15.5	90.5	2.5	35	1005	7	CS
09	00	15.5	90.5	2.5	35	1005	5	CS
	03	15.5	90.0	2.0	30	1007	5	DD
	06	15.5	90.0	2.0	30	1007	5	DD
	09	15.5	90.0	1.5	30	1007	5	D
	12	weakened	rapidly	into a	WML	over	the	sea.

TABLE-10

BEST TRACK OF ARABIAN SEA DEEP DEPRESSION FROM 10 - 13 NOVEMBER 1997

DATE NOVEMBER	TIME UTC	LAT DEG.N	LONG DEG. E	T.NO	E.MAX wind kt	E.C.P hPa	Δ P hPa	GRADE
10	18	11.0	69.0	1.5	25	1006	4	D
11	00	11.0	69.0	1.5	25	1007	5	D
	03	11.5	68.0	2.0	30	1007	5	DD
	06	12.0	66.0	2.0	30	1007	5	DD
	12	13.0	65.5	2.0	30	1005	5	DD
	18	13.0	65.5	2.0	30	1005	5	DD
12	00	13.0	65.5	2.0	30	1005	5	DD
	03	13.5	66.0	2.0	30	1005	5	DD
	06	14.0	66.5	2.0	30	1005	5	DD
	12	14.0	64.5	2.0	30	1005	5	DD
	18	14.5	64.5	2.0	30	1005	5	DD
13	00	14.5	63.5	2.0	30	1005	5	DD
	03	14.5	63.5	2.0	30	1005	5	DD
	06	14.5	63.0	2.0	30	1005	5	DD
	09	15.0	63.0	1.5	25	1006	4	D
	weakend	into	WML	over	same	area		

TABLE-11

FORECAST POSITION ERRORS FOR DEEP DEPRESSION / TROPICAL CYCLONES IN THE BAY OF BENGAL AND THE ARABIAN SEA IN 1997 BASED ON CLIMATOLOGY , PERSISTANCE AND CLIPER MODELS.

DEPRESSION	12-HOURS			24-HOURS			36-HOURS			48-HOURS		
	P	C	CL	P	C	CL	P	C	CL	P	C	CL
26-29 June	119	93	96	162	148	136	248	156	195	574	326	446
29 Jul-2 Aug	133	125	128	55	86	59	198	92	162	519	329	453
04-08 Aug.	210	161	144	201	213	259	314	416	252	579	656	667
19-27 Aug.	138	253	115	451	115	211	603	238	151	724	334	467
10-13 Nov.	89	65	69	226	123	244	....	....	....	...	...	....
AVERAGE	138	139	110	219	137	182	341	226	190	599	411	508

Tropical Cyclones

16-20May.	87	58	57	166	129	72	236	183	114	504	251	217
23-27 Sept.	60	330	199	162	648	338	...	...	...	...	...	....
04-09 Nov	147	148	66	169	342	184	272	470	262	...	...	...
AVERAGE.97	98	179	107	166	373	198	254	326	188	504	251	217
AVERAGE.96	97	142	93	169	223	155	310	273	273	586	484	435

P- Persistance
C - Climatology
CL- Cliper

TABLE-12

Forecast position errors for individual depressions / tropical cyclones over the Bay of Bengal and the Arabian sea in 1997 based on analogue , CLIPER and RSMC forecast models

Depressions	FORECAST ERRORS (Km)						
	ANALOGUE			CLIPER			RSMC
	12-HR	24-HR	36-HR	12-HR	24-HR	36-HR	24-HR
26-29 June	121	152	160	96	136	195	140
29Jul-2 August	135	237	----	128	59	162	....
04-08 August	49	182	----	144	259	252	....
19-27 August	86	143	----	115	211	151	167
10-13 November	134	297	319	69	244	---	....
Average for 97	105	202	240	110	182	190	154
Tropical cyclones							
16-20 May	47	46	145	57	72	114	322
23-27 September	118	229	321	199	338	----	154
04-09 November	81	140	271	66	184	262	....
Average for 97	82	138	246	107	198	188	238
Average for ,96	62	98	164	93	157	273	261

TABLE-13

FORECAST SKILL (%) OF OTHER MODEL WITH RESPECT TO CLIPER FOR DEPRESSIONS / TROPICAL CYCLONES IN THE BAY OF BENGAL AND THE ARABIAN SEA 1997

DEPRESSIONS	CLIPER VS PERSISTANCE				CLIPER VS CLIMATOLOGY				CLIPER VS ANALOGUE			CLIPER VS RSMC
	12	24	36	48	12	24	36	48	12	24	36	24
26-29 June	-24	-19	-29	-29	+03	-09	+20	+27	-26	-12	+18	-03
29Jly-2 Aug.	-04	+07	-22	-15	+02	-46	+43	+27	-05	-456	...	...
04-08 Aug.	-67	-22	-25	+13	-12	+18	-65	+02	+66	+30	...	...
19-27 Aug.	-20	-114	-299	-55	-120	+45	-58	+28	+25	-32	...	+21
10-13 Nov.	-29	+07	...	...	+06	+49	...	...	-94	-22	...	...
Average	-28	-28	-94	-22	-24	+11	-15	+21	-07	-86	+18	+09
Tropical Cyclones												
16-20 May	-53	-130	-107	-132	-02	-79	-60	-14	+18	+36	-01	-347
23-27 Sept.	+01	+52	...	...	- 66	-92	...	...	+41	+32	...	+54
04-09 Nov.	-123	+08	-04	...	-124	-86	-79	...	-23	+24	-03	...
Average	-58	-23	-56	-123	-64	-86	-70	-14	+12	+31	-02	-147
G. Average	-40	-30	-81	-44	-39	-25	-33	+14	+00	-42	+05	+24

+ : Positive skill includes other Model forecast is better than CLIPER.
- : Negative skill includes the CLIPER forecast is better than other Models.

FIGURES

LIST OF FIGURES

Fig.12 Satellite imagery :-

(a) 0600 UTC August 19 (VIS) b) 0600 UTC August 21 (VIS)

c) 0600 UTC August 22 (VIS) d) 0900 UTC August 22 (VIS)

e) 0900 UTC August 23 (VIS) f) 0600 UTC August 24 (VIS)

g) 0039 UTC August 25 (VIS) h) 0600 UTC August 25 (VIS)

i) 0300 UTC August 26 (VIS) j) 0900 UTC August 26 (VIS)

Fig. 13(a&b) Photographs of damages at Digha by Deep Depression.

Fig. 14 Satellite imagery:-

a) 0300 UTC August 28 (VIS) b) 0900 UTC August 28 (VIS)

c) 0600 UTC August 29 (VIS) d) 0600 UTC August 30 (VIS)

Fig. 15 Machilipatnam radar picture:-

a) 1200 UTC September 24 b) 1600 UTC September 24

Fig.16 Visakhapatnam radar picture:-

a) 2100 UTC September 24 b) 0100 UTC September 25

c) 0300 UTC September 25 d) 0700 UTC September 25

Fig.17 Paradeep radar picture:-

a) 1759 UTC September 25 b) 0009 UTC September 26

Fig.18 Calcutta radar picture:-

a) 0002 UTC September 26 b) 0248 UTC September 26

c) 0548 UTC September 26 d) 0848 UTC September 26

e) 0849 UTC September 26 f) 1123 UTC September 26

Fig.19 Track of Cyclonic (23-27 Sept) observed by :-

(a) CDR Calcutta and Paradeep (b) CDR Chennai and Visakhapatnam

Fig.20 Satellite imagery:-

a) 0300 UTC September 23 (VIS) b) 0900 UTC September 23 (VIS)

c) 0300 UTC September 24 (VIS) d) 0900 UTC September 24 (VIS)

e) 0300 UTC September 25 (VIS) f) 0900 UTC September 25 (VIS)

g) 0300 UTC September 26 (VIS) h) 0900 UTC September 26 (VIS)

Fig. 21 Analysis of 200 hpa wind chart of 8th November :-

a) 0000 UTC b) 1200 UTC

Fig. 22 Satellite imagery:-

a) 0600 UTC November 3 (VIS) b) 0300 UTC November 4 (VIS)

c) 0600 UTC November 4 (VIS) d) 0600 UTC November 5 (VIS)

e) 0600 UTC November 8 (VIS) f) 0600 UTC November 9 (VIS)

Fig. 23 Satellite imagery:-

a) 1800 UTC November 9 (IR) b) 0600 UTC November 10 (VIS)

c) 2100 UTC November 11 (IR) d) 0000 UTC November 12 (IR)

Fig. 24 (a) Vertical wind shear between 850 hpa and 200 hpa from 10 Oct to 30 November 97.

Fig. 24 (b) Vertical wind shear between 850 hpa and 200 hpa from 10 Oct to 30 November 97.

Fig. 25 Forecast skill relative to CLIPER and other models.

Fig. 26 Observed and 24 hours forecast position (RSMC Model) for Monsoon Depressions and Cyclonic Storms.

Fig. 27(a) Initial and predicted 24 hrs and 48 hrs forecast fields of vorticity at 850 hpa for the cyclone (May 16-20, 1997)

Fig. 27(b) Initial and predicted 24 hrs and 48 hrs forecast fields of vorticity at 850 hpa for the Depression (August 19-27, 1997)

Fig. 27(c) Initial and predicted 24 hrs and 48 hrs forecast fields of vorticity at 850 hpa for the cyclone (Sept 23-27, 1997)

15-19 May 1997

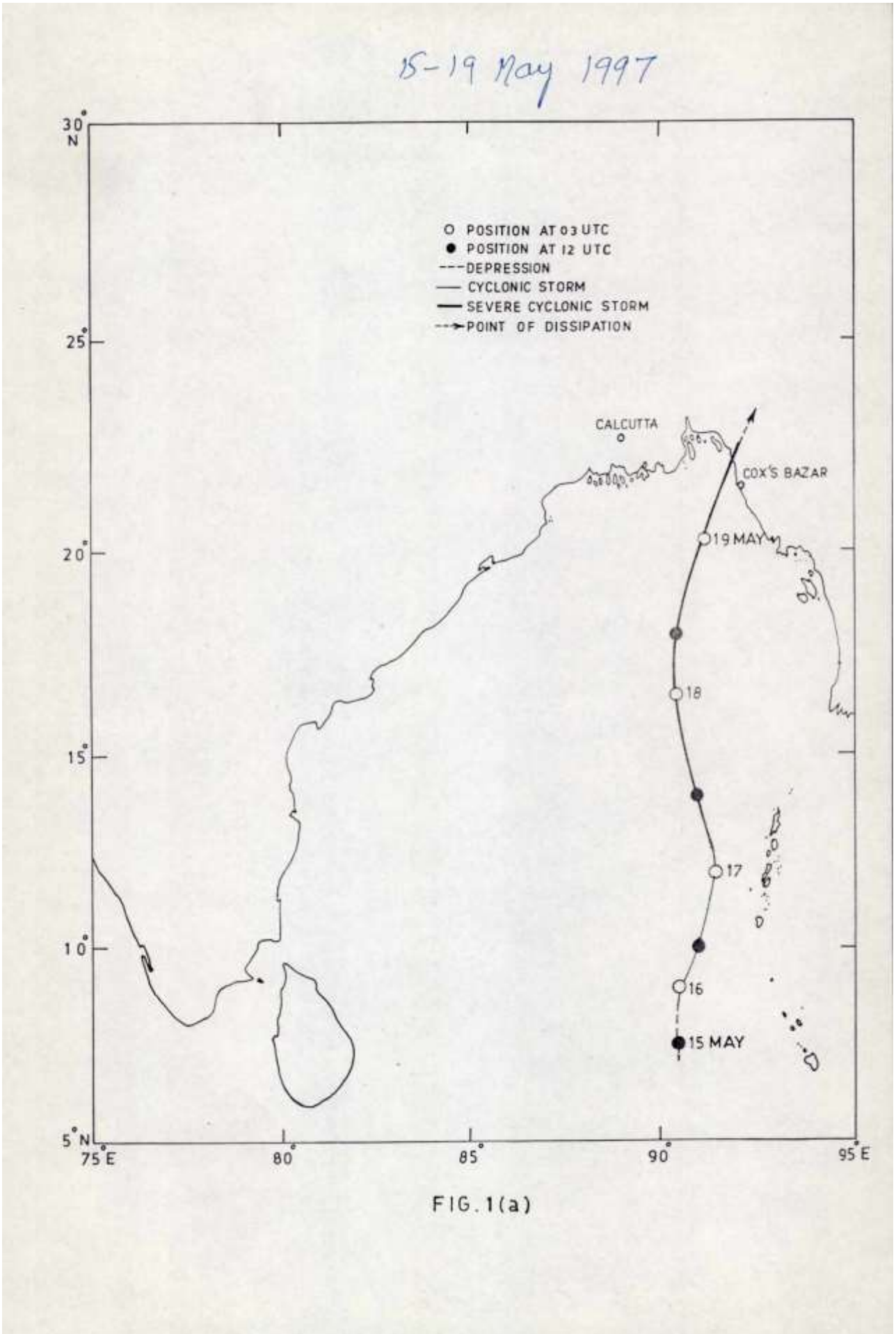


FIG. 1(a)

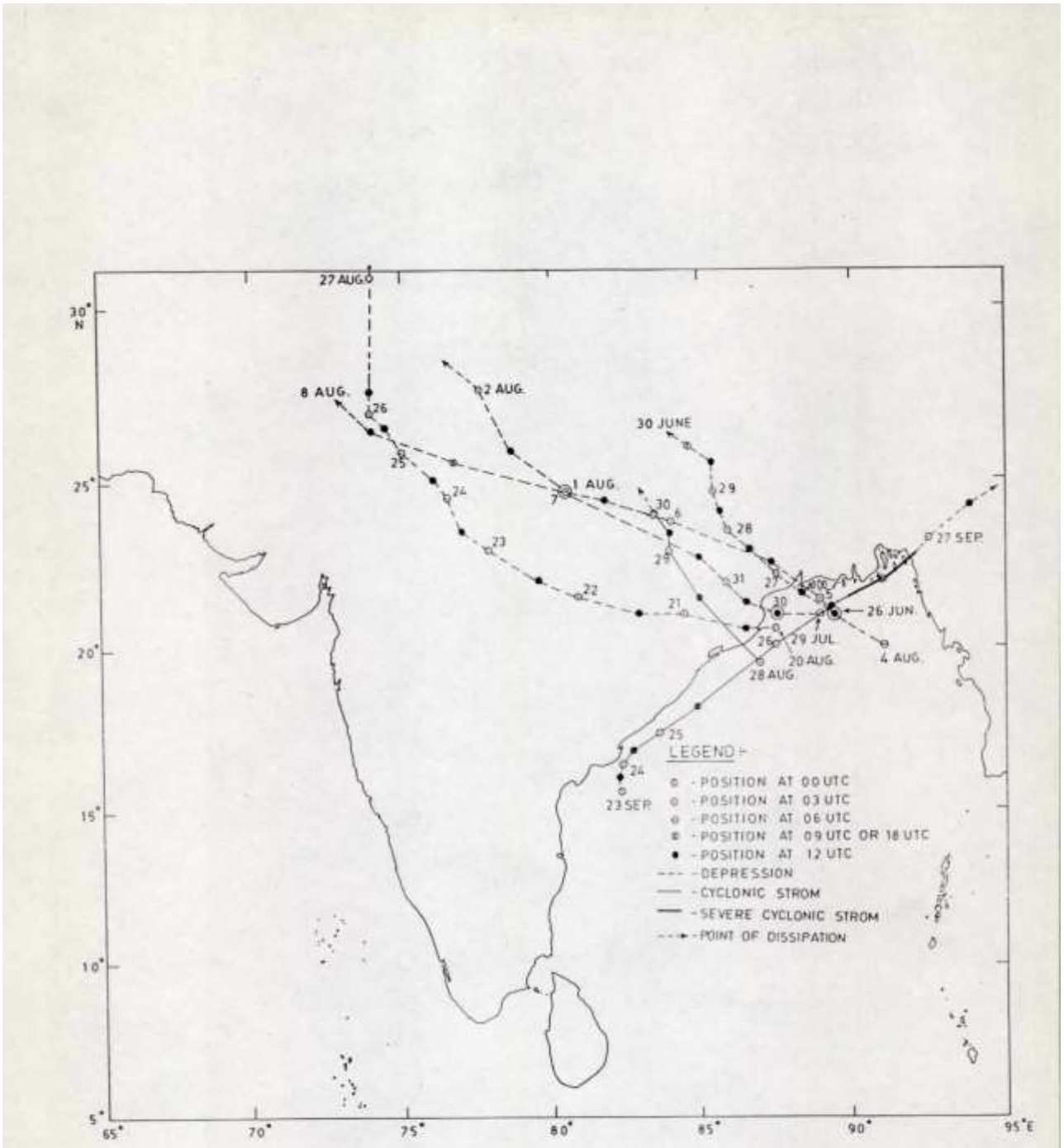

27 AUG.
8 AUG.
12 AUG.
30 JUNE
1 AUG.
27 SEP.
26 JUN.
29 JUL.
20 AUG.
28 AUG.
4 AUG.
23 SEP.
LEGEND :-
- POSITION AT 00 UTC
- POSITION AT 03 UTC
- POSITION AT 06 UTC
- POSITION AT 09 UTC OR 18 UTC
- POSITION AT 12 UTC
- DEPRESSION
- CYCLONIC STROM
- SEVERE CYCLONIC STROM
- POINT OF DISSIPATION
30° N
25°
20°
15°
10°
5°
65°
70°
75°
80°
85°
90°
95° E

FIG. 1(b)

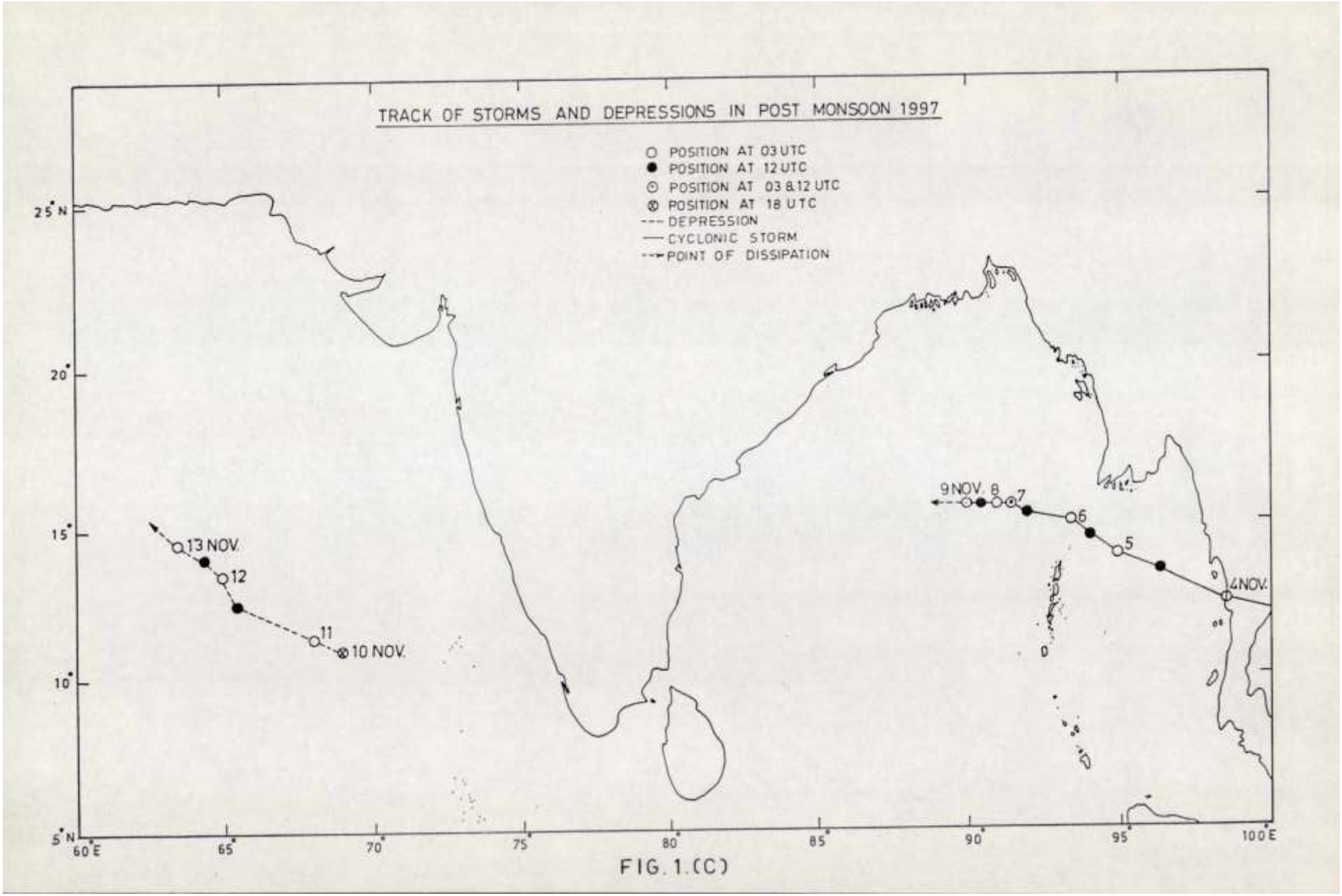

TRACK OF STORMS AND DEPRESSIONS IN POST MONSOON 1997
POSITION AT 03 UTC
POSITION AT 12 UTC
POSITION AT 03 & 12 UTC
POSITION AT 18 UTC
DEPRESSION
CYCLONIC STORM
POINT OF DISSIPATION
25° N
20°
15°
10°
5° N
60° E
65°
70°
75°
80°
85°
90°
95°
100° E
13 NOV.
12
11
10 NOV.
9 NOV.
8
7
6
5
4 NOV.

FIG. 1.(C)

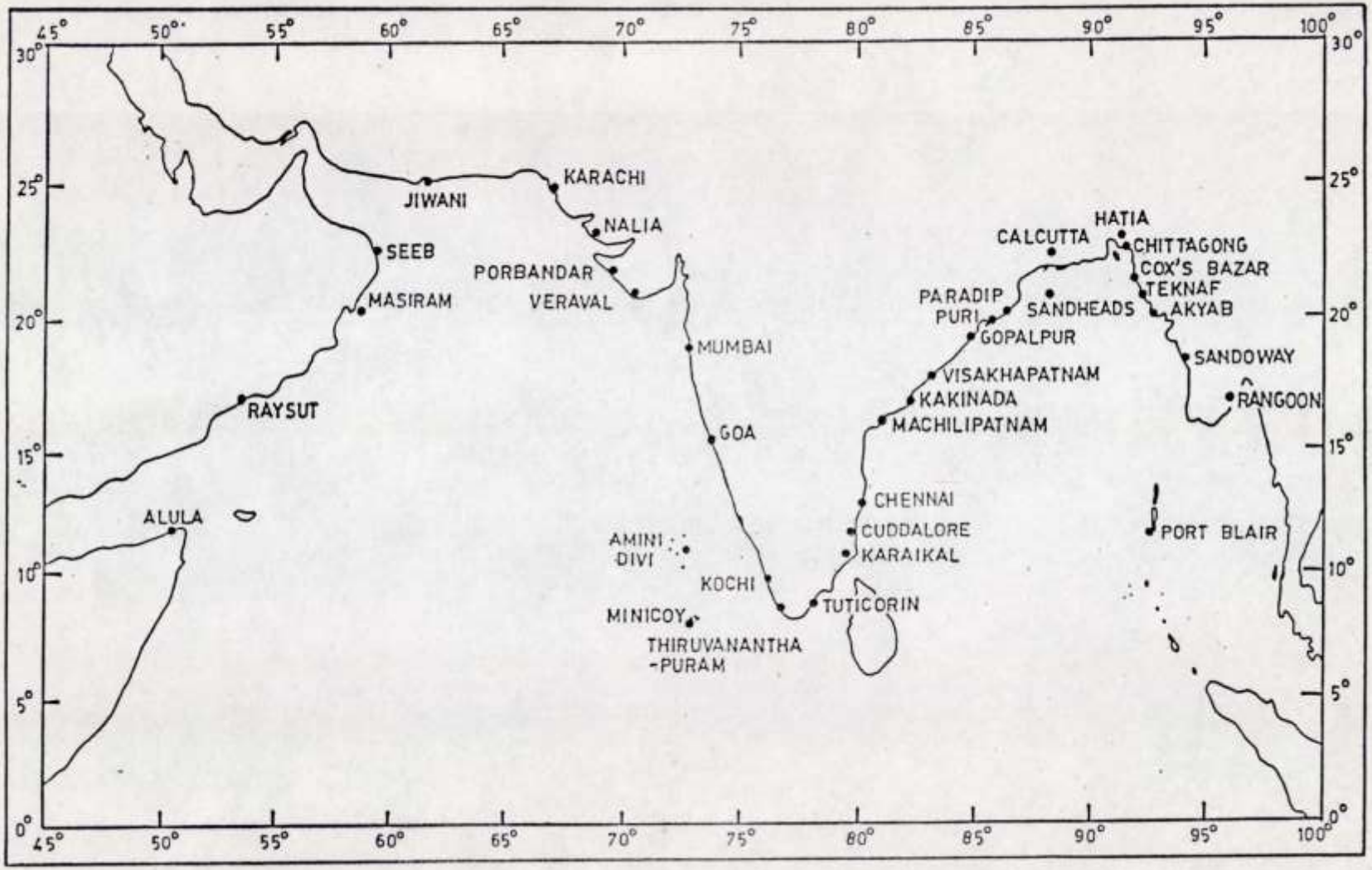
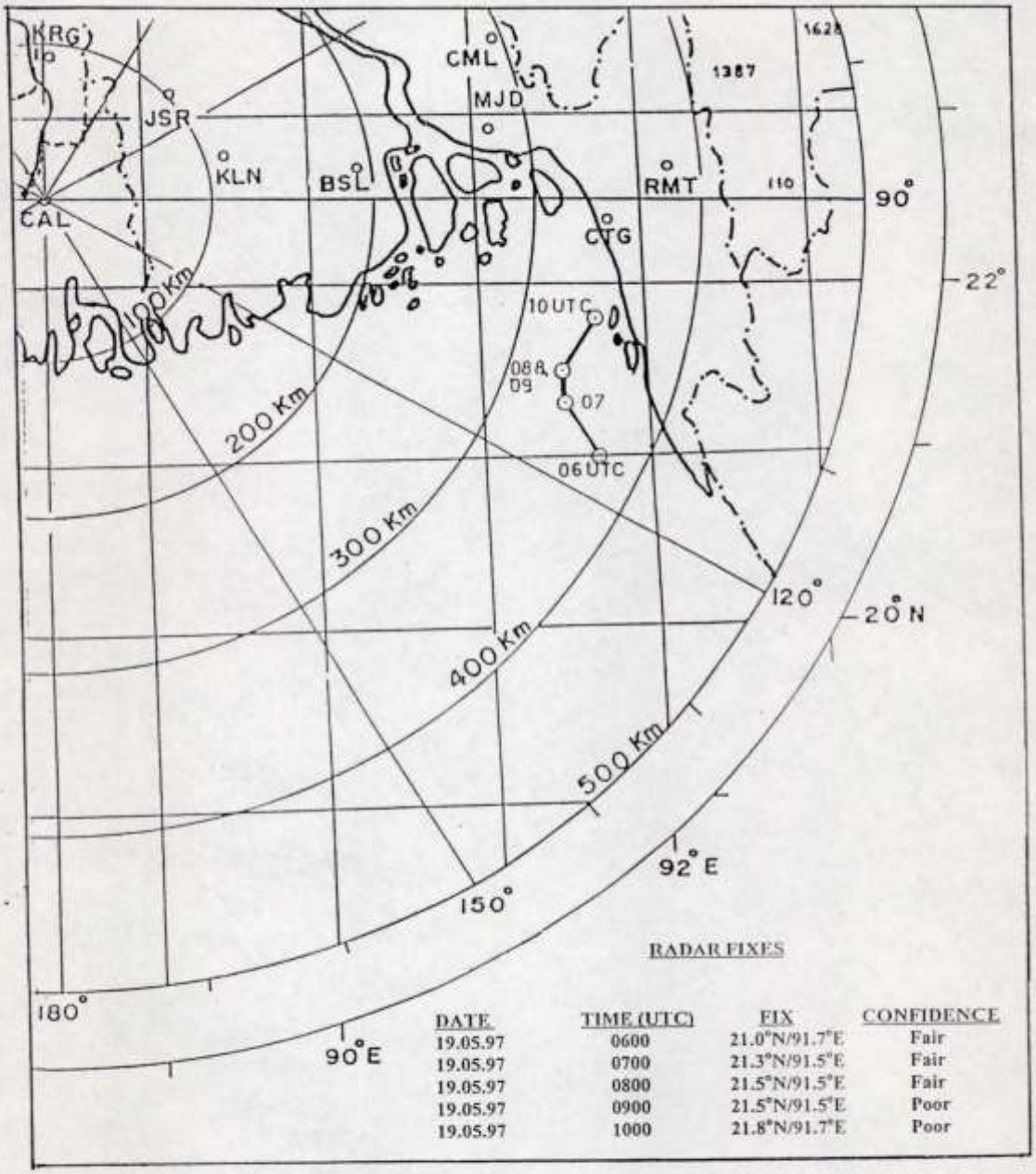

45°
50°
55°
60°
65°
70°
75°
80°
85°
90°
95°
100°
30°
25°
20°
15°
10°
5°
0°
KARACHI
JIWANI
NALIA
SEEB
PORBANDAR
MASIRAM
VERAVAL
MUMBAI
RAYSUT
GOA
ALULA
AMINI
DIVI
KOCHI
MINICOY
THIRUVANANTHA
-PURAM
TUTICORIN
CHENNAI
CUDDALORE
KARAIKAL
MACHILIPATNAM
KAKINADA
VISAKHAPATNAM
GOPALPUR
PARADIP
PURI
CALCUTTA
HATIA
SANDHEADS
CHITTAGONG
COX'S BAZAR
TEKNAF
AKYAB
SANDOWAY
RANGOON
PORT BLAIR

FIG. 2



DATE	TIME (UTC)	FIX	CONFIDENCE
19.05.97	0600	21.0°N/91.7°E	Fair
19.05.97	0700	21.3°N/91.5°E	Fair
19.05.97	0800	21.5°N/91.5°E	Fair
19.05.97	0900	21.5°N/91.5°E	Poor
19.05.97	1000	21.8°N/91.7°E	Poor

RADARSCOPE OBSERvATIONS
CDR CALCUTTA

500 Km.

RADAR FIX AND TRACK OF BAY SEVERE CYCLONIC STORM DATE 19.05.97.

FIG. 3

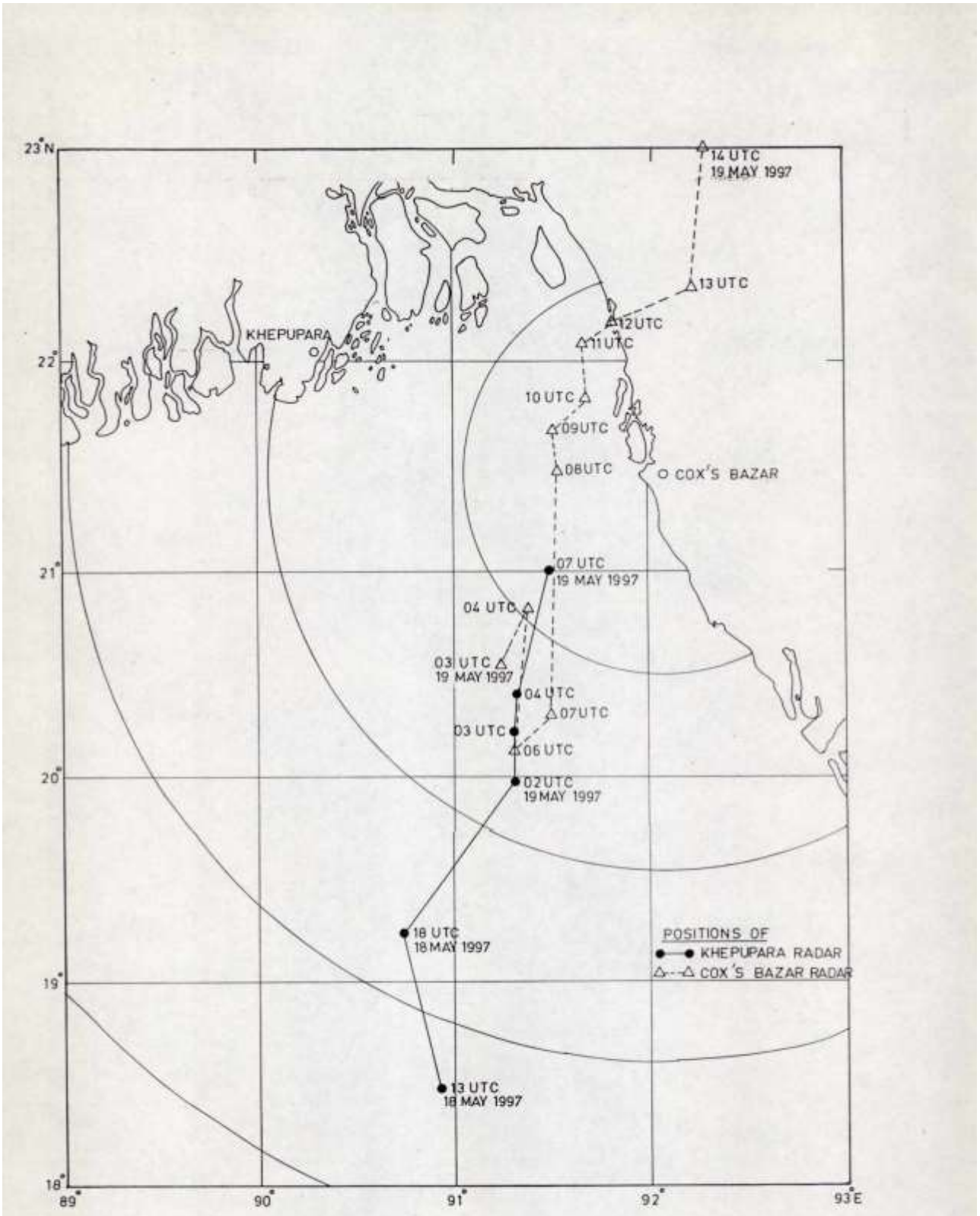
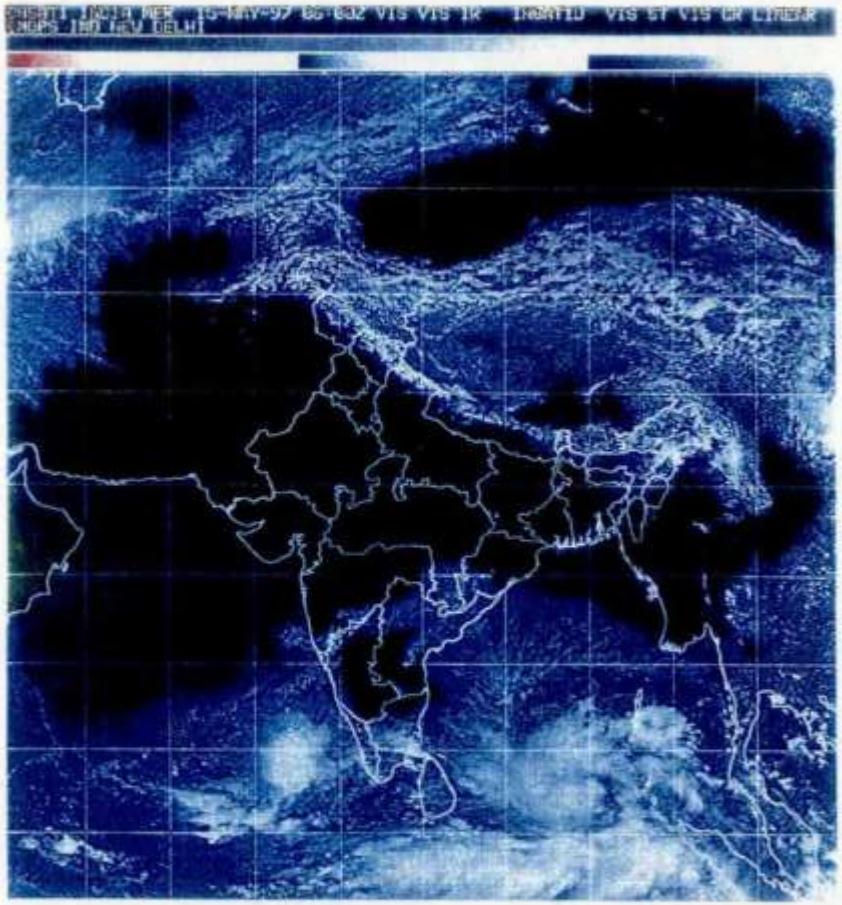
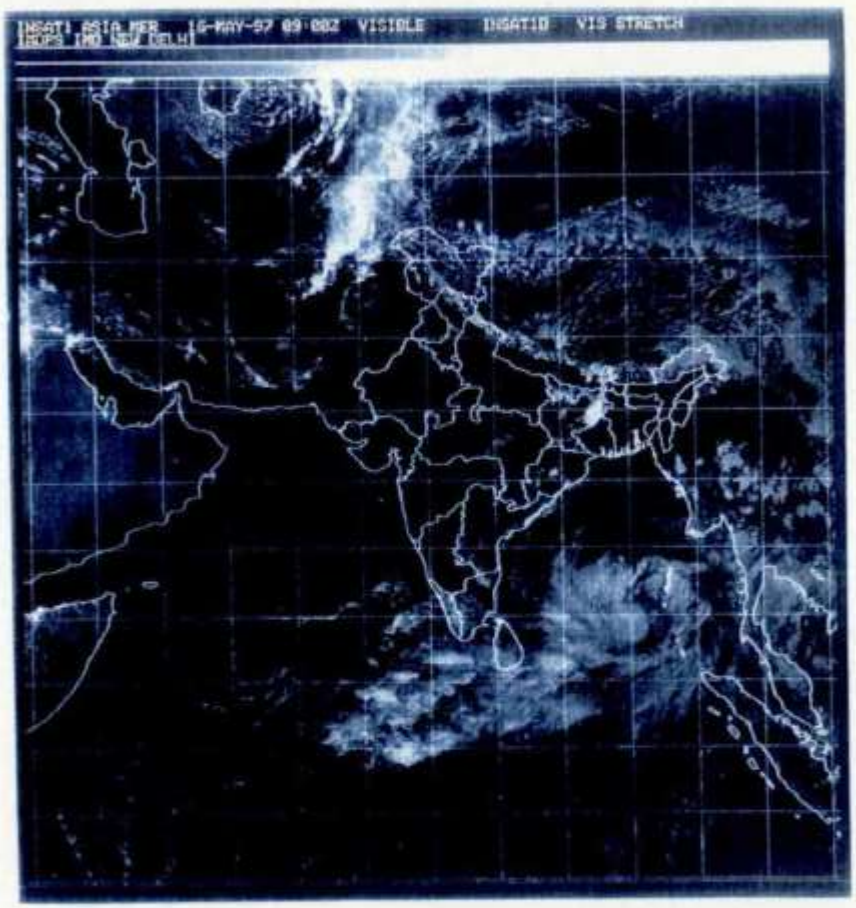

23°N
22°
21°
20°
19°
18°
89°
90°
91°
92°
93°E
14 UTC
19 MAY 1997
13 UTC
12 UTC
11 UTC
10 UTC
09 UTC
08 UTC
KHEPUPARA
COX'S BAZAR
07 UTC
19 MAY 1997
04 UTC
03 UTC
19 MAY 1997
04 UTC
07 UTC
03 UTC
06 UTC
02 UTC
19 MAY 1997
18 UTC
18 MAY 1997
13 UTC
18 MAY 1997
POSITIONS OF
KHEPUPARA RADAR
COX'S BAZAR RADAR

FIG. 4

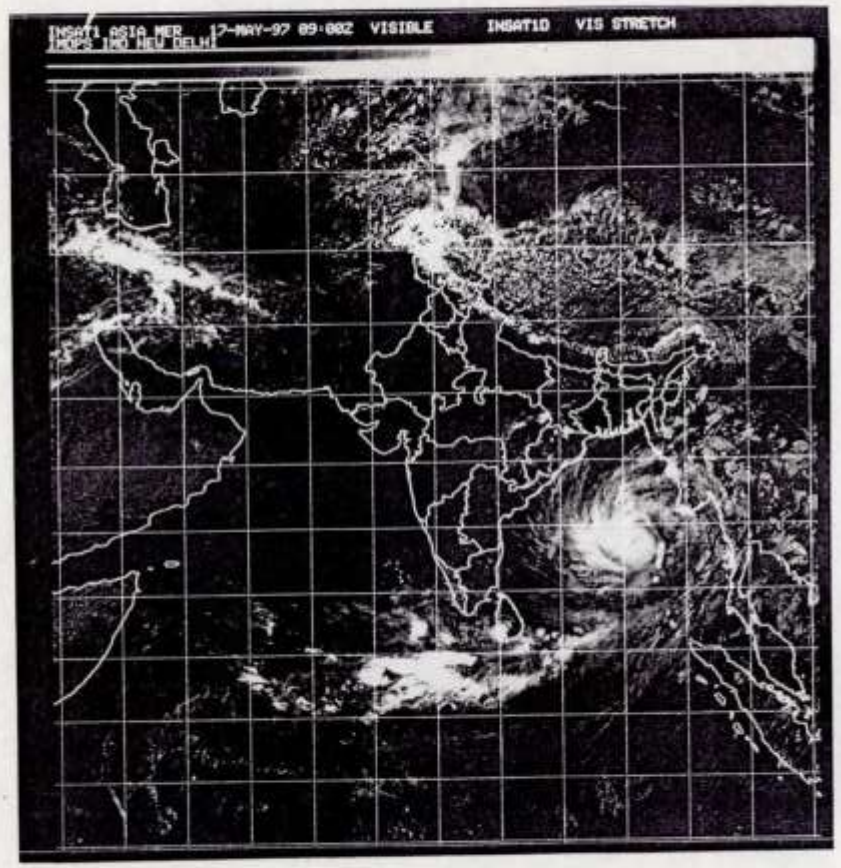


(a)

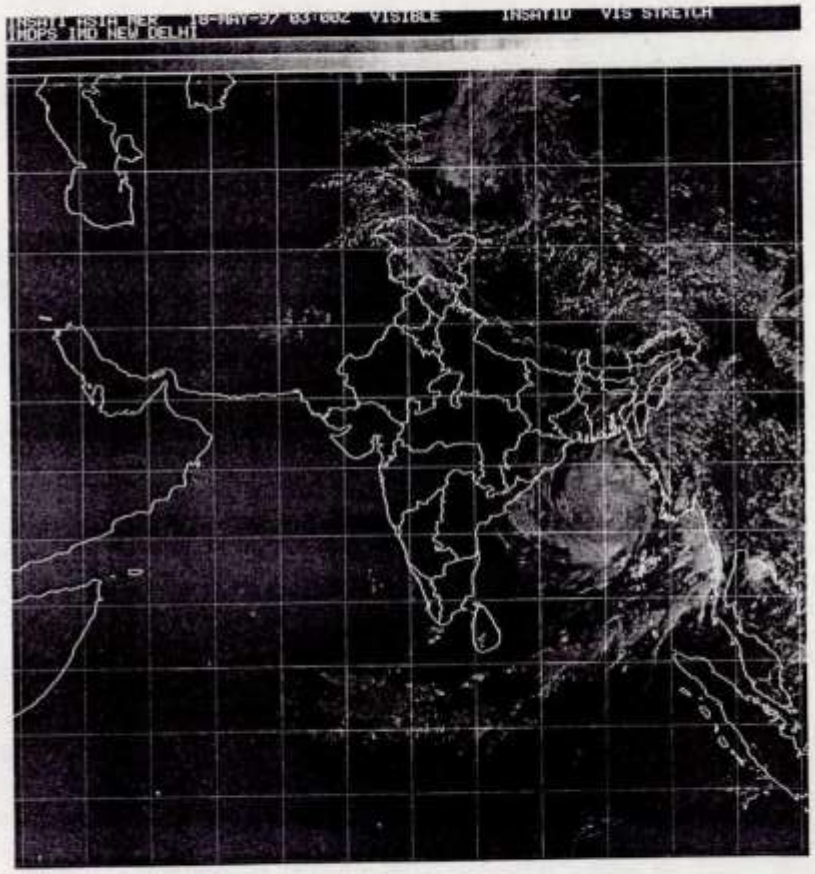


(b)

FIG. 5

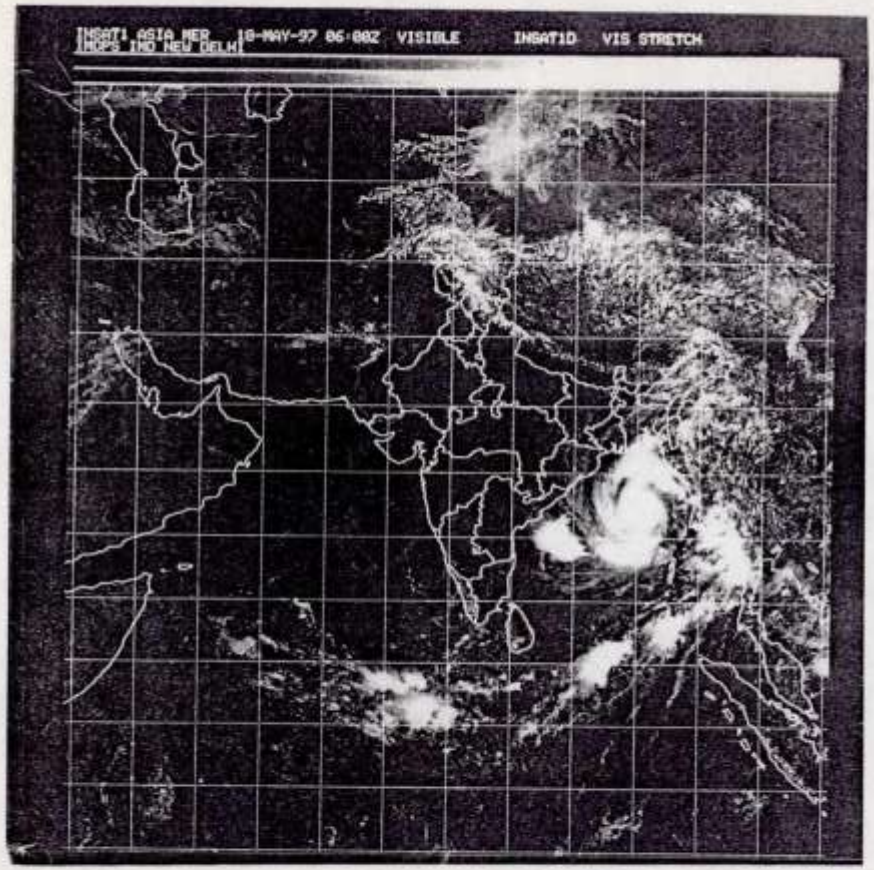

INSAT1 ASIA MER 17-MAY-97 09:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(c)

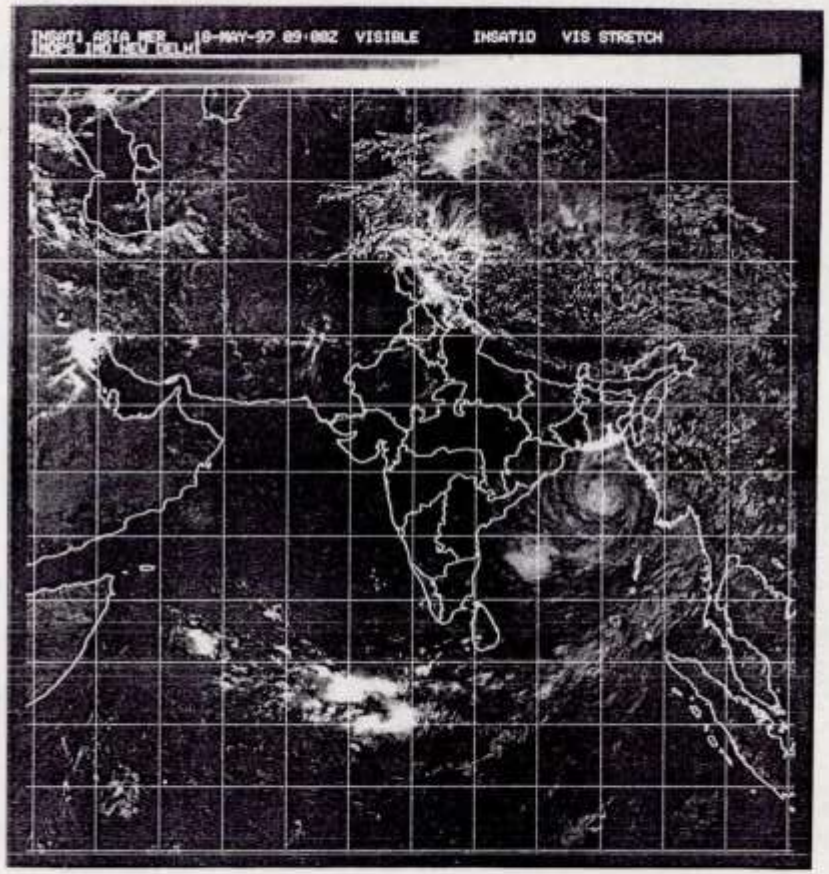

INSAT1 ASIA MER 18-MAY-97 03:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(d)

FIG. 5

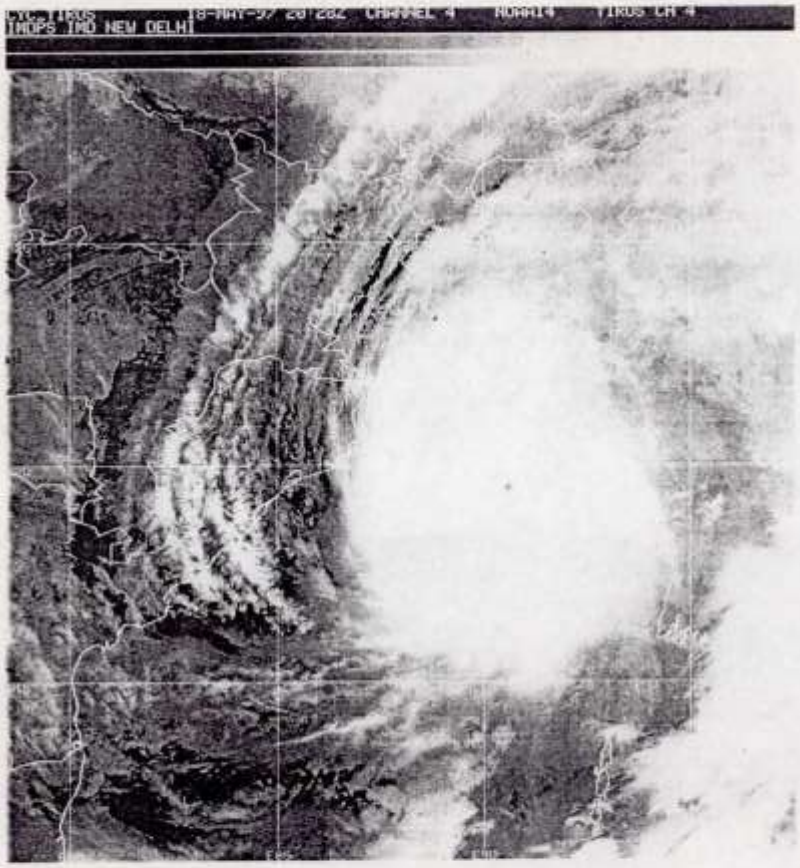

INSAT1 ASIA MER 10-MAY-97 06:00Z VISIBLE INSAT1D VIS STRETCH
INCOIS IND NEW DELHI

(e)

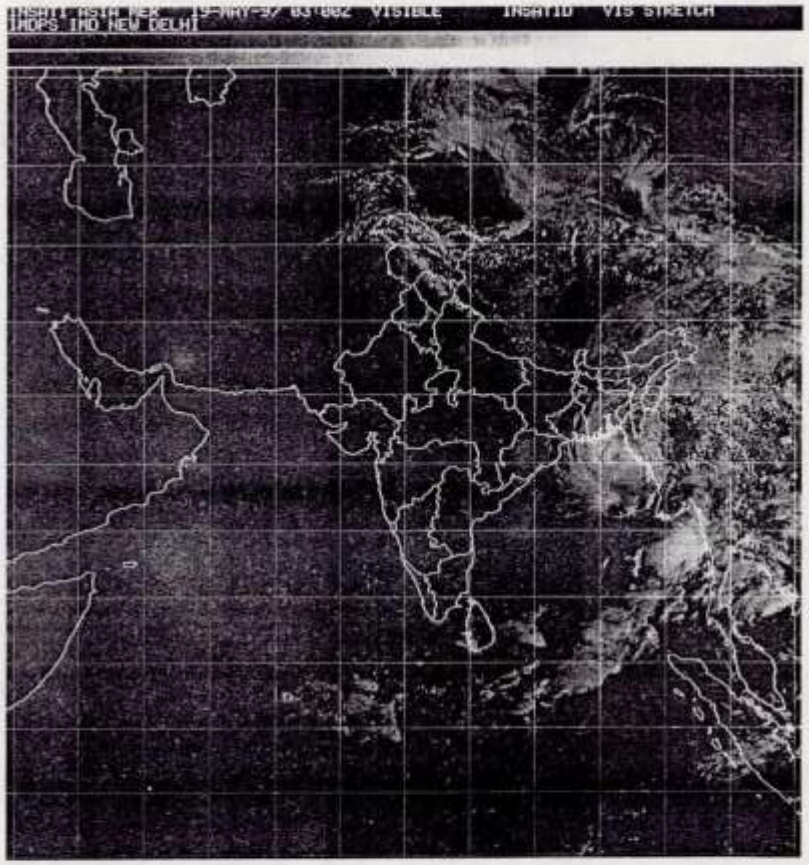

INSAT1 ASIA MER 10-MAY-97 09:00Z VISIBLE INSAT1D VIS STRETCH
INCOIS IND NEW DELHI

(f)

FIG. 5



(g)



(h)

FIG. 5

18 MAY 1997

SPECIAL OBSERVATION

STN \ UTC	00	03	06	09	12	15	18	21
DHAKA 41923								
SYLHET 41891								
COX'S BAZAR 41992								
BHOLA 41951								
SANDWIP 41964								
HATIYA 41963								
PATUAKHALI 41960								
KHULNA 41947								
BARISAL 41950								
SATKHIRA 41946								
CHITTAGONG 41978								
TEKNAF 41998								
SITAKUNDA 41965								

FIG. 6(a)

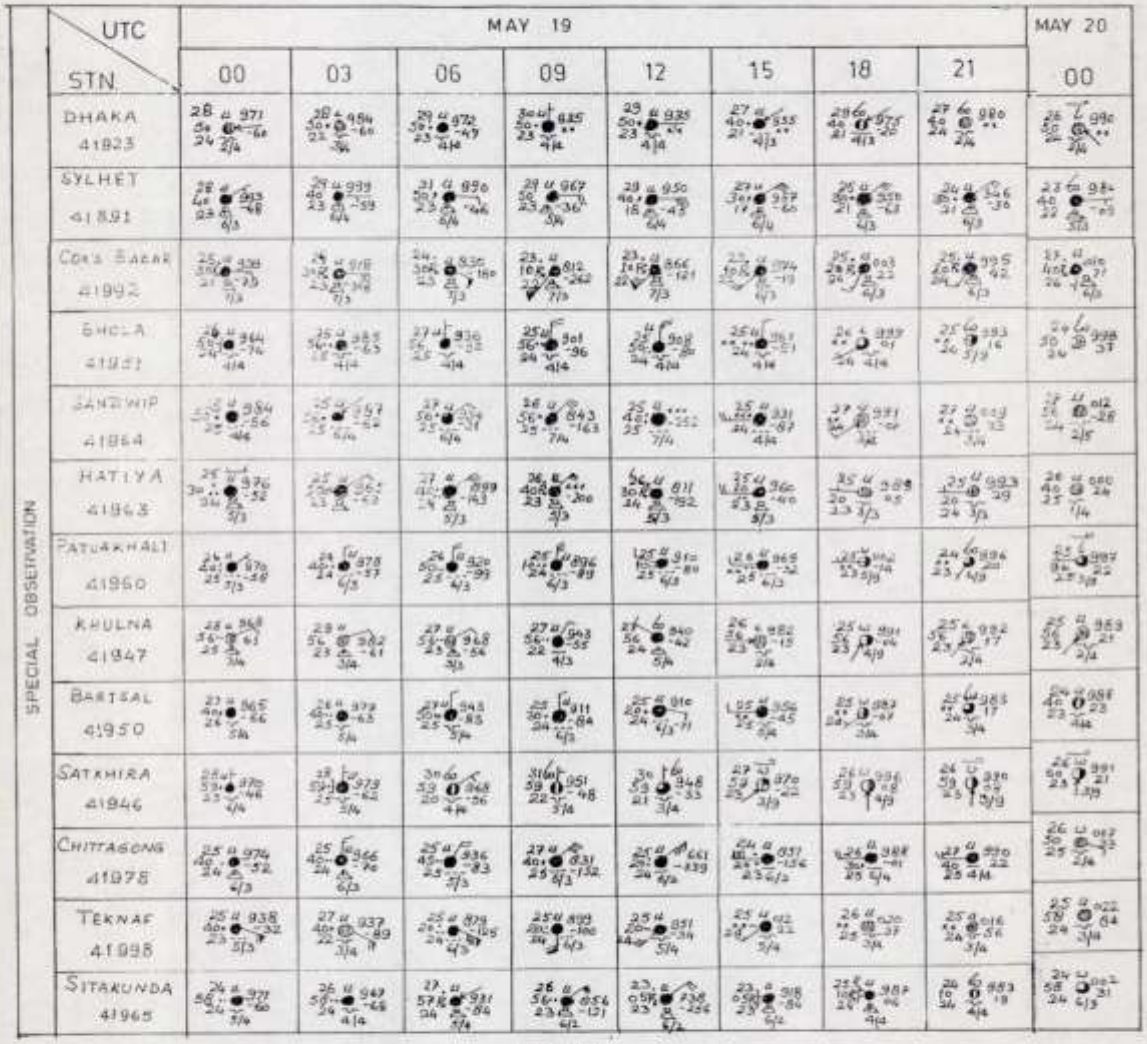

SPECIAL OBSERVATION
UTC
STN.
MAY 19
MAY 20
00
03
06
09
12
15
18
21
00
DHAKA
41823
SYLHET
41891
COX'S BAZAR
41992
BHOLA
41951
SANDWIP
41864
HATIYA
41963
PATUAKHALI
41950
KHULNA
41947
BARISAL
41950
SATKHIRA
41946
CHITTAGONG
41978
TEKNAF
41998
SITAKUNDA
41965

FIG. 6 (b)

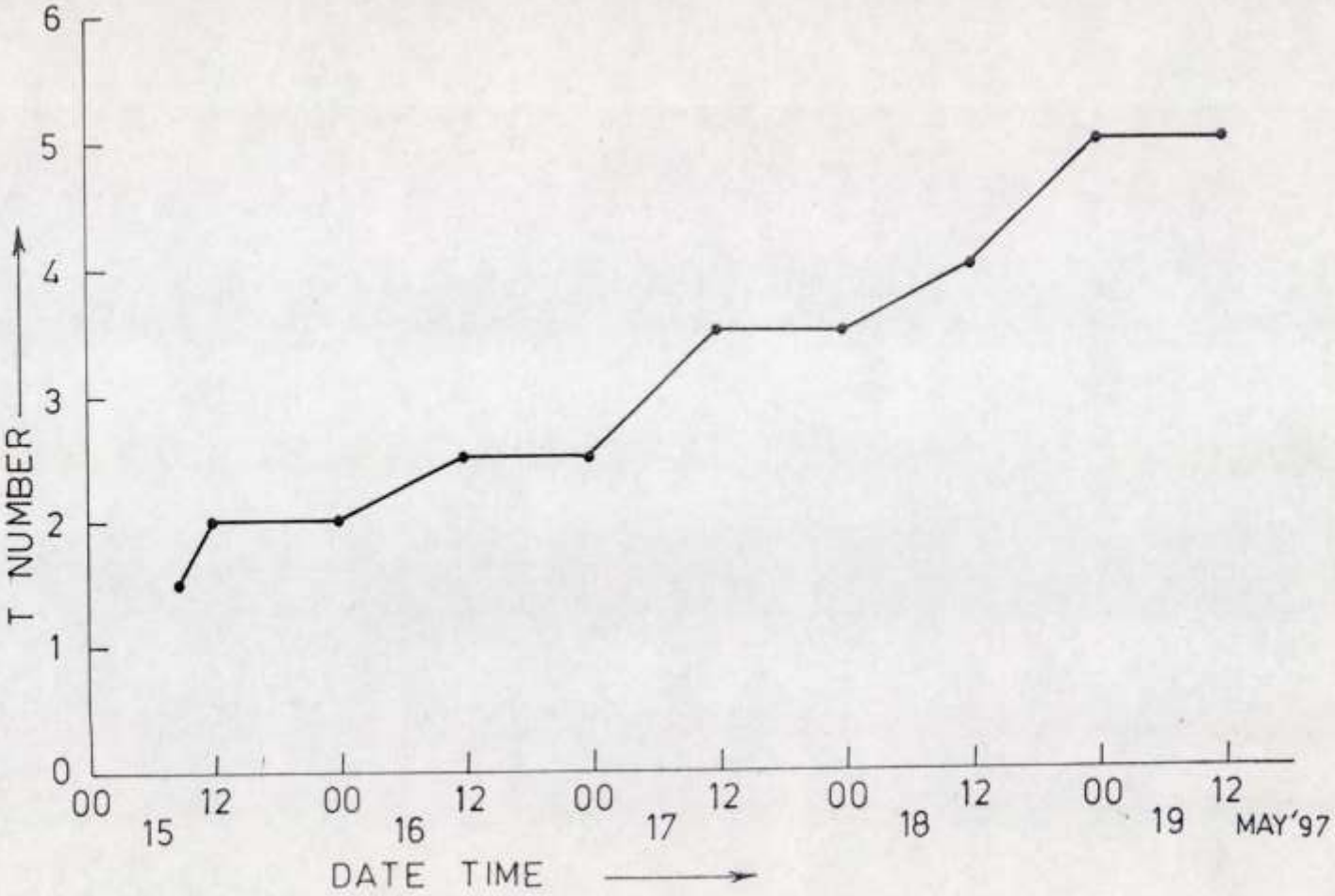
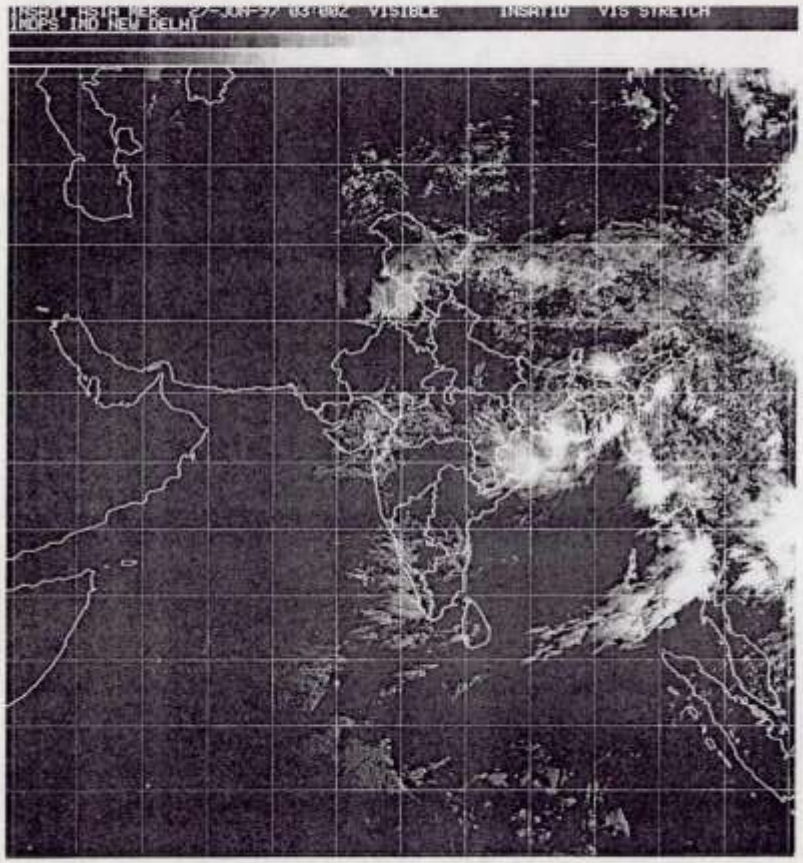
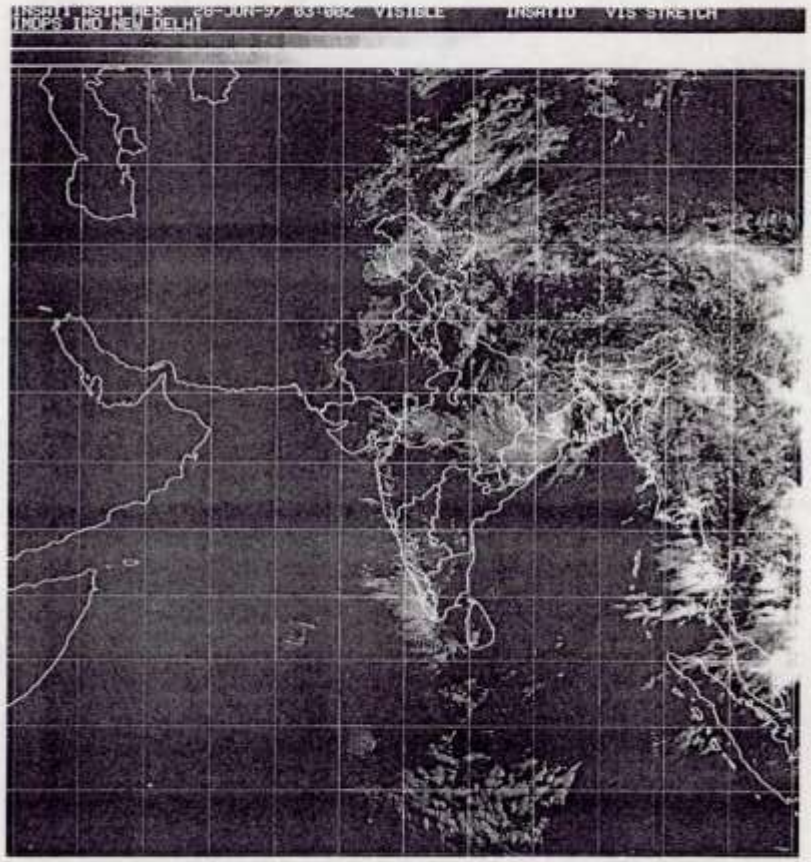

6
5
4
3
2
1
0
T NUMBER
00
12
00
12
00
12
00
12
00
12
15
16
17
18
19
MAY'97
DATE TIME

FIG. 7.

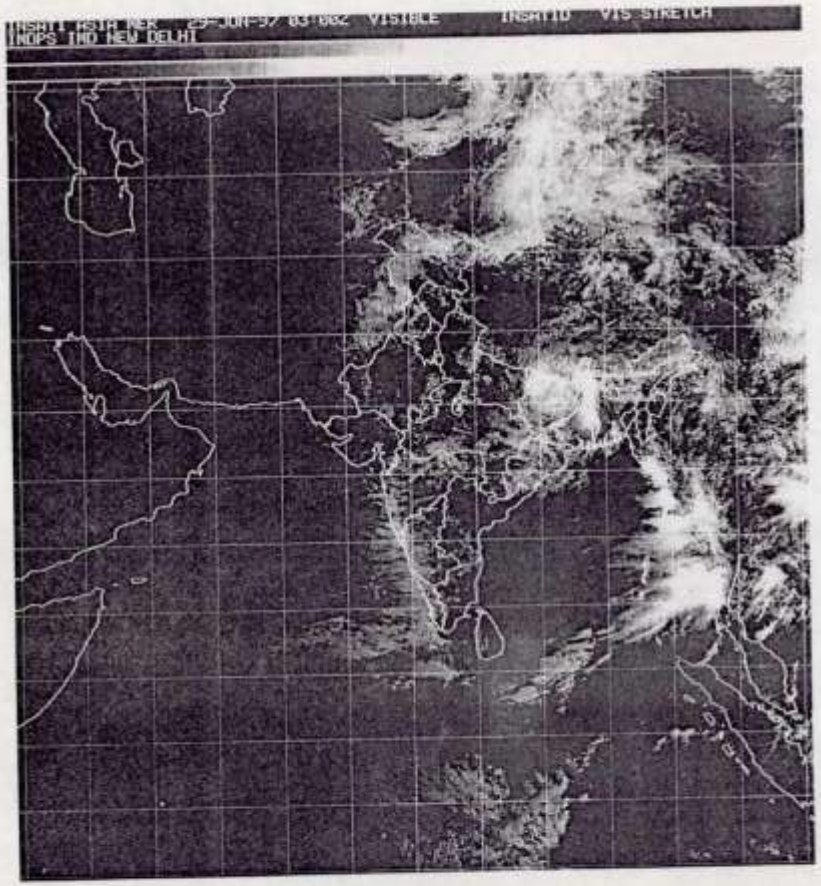


(a)

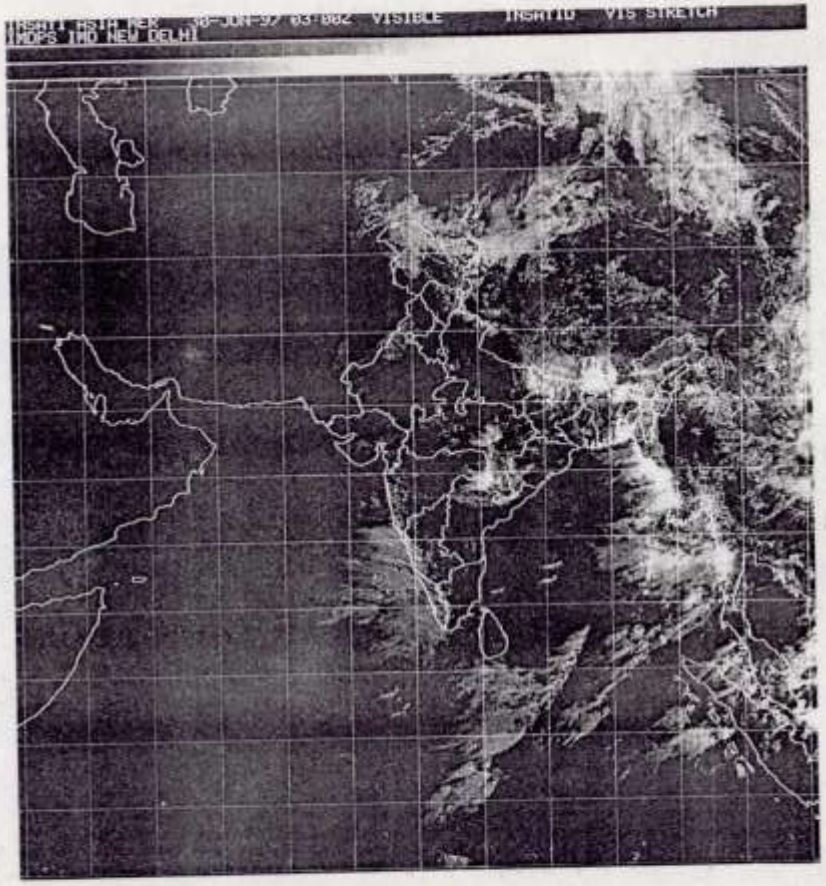


(b)

FIG. 8


INSAT1 HSTR NEK 29-JUN-97 03:00Z VISIBLE INSAT1D VIS STRETCH
INDPS IMD NEW DELHI

(c)


INSAT1 HSTR NEK 30-JUN-97 03:00Z VISIBLE INSAT1D VIS STRETCH
INDPS IMD NEW DELHI

(d)

FIG. 8

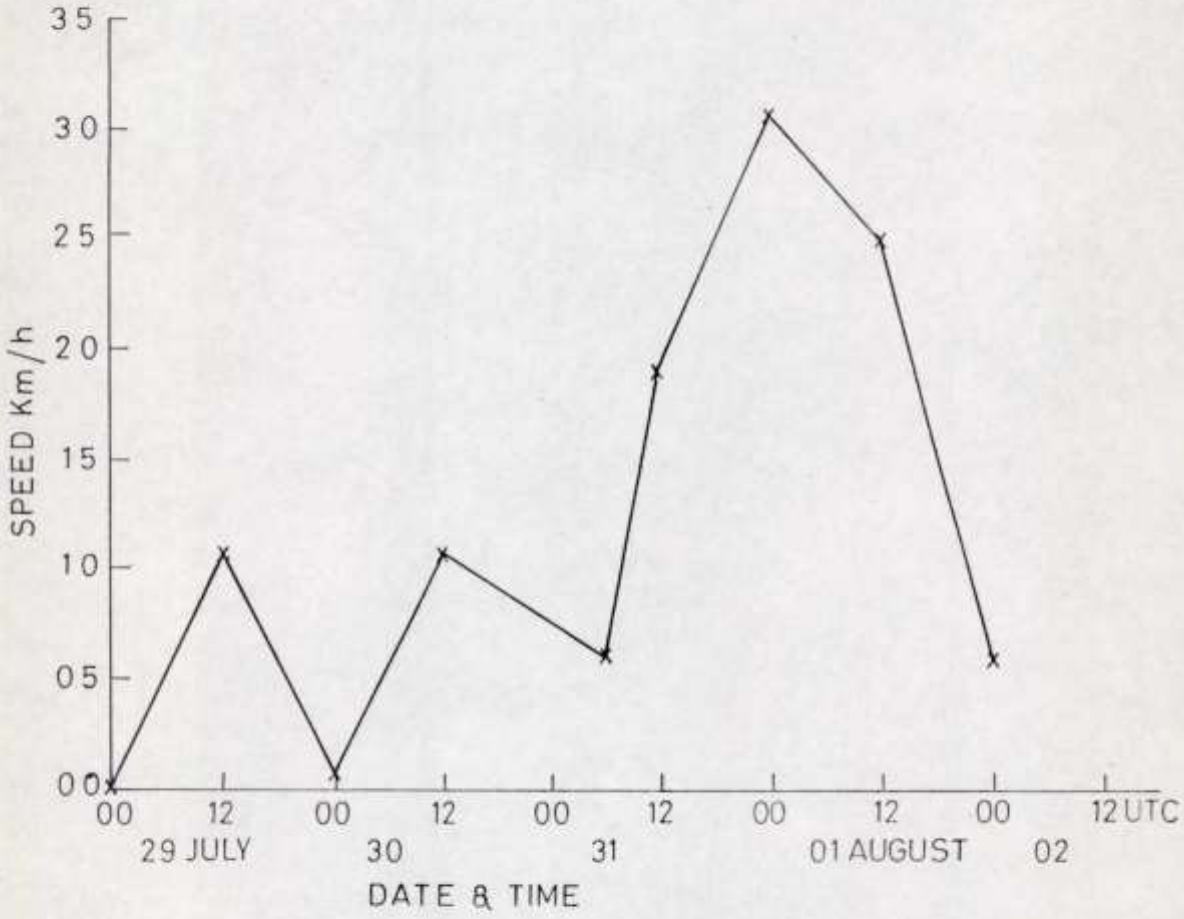
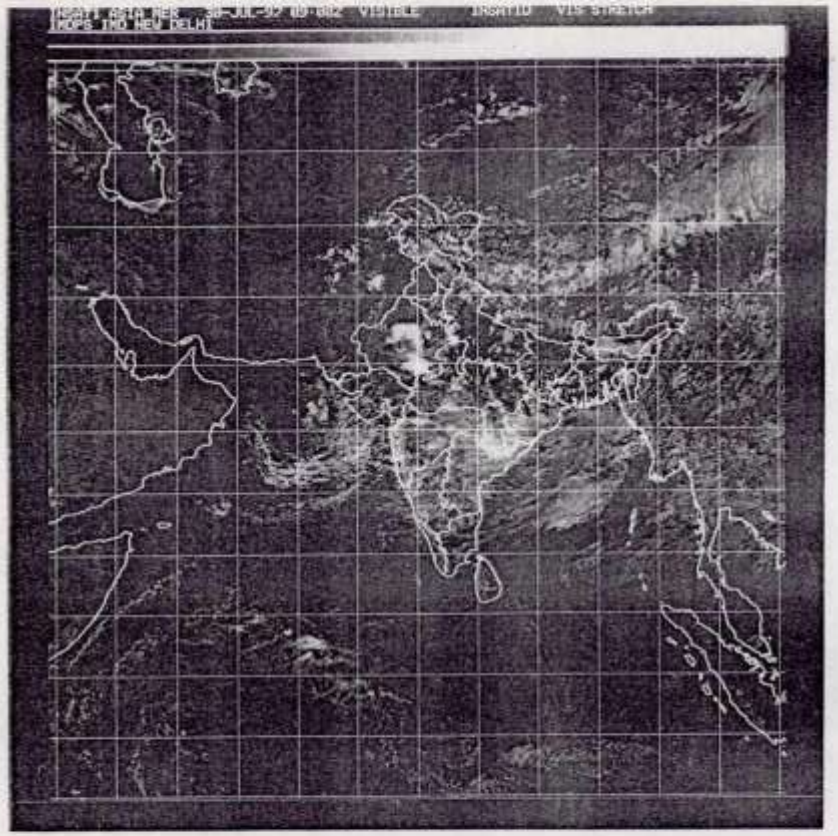
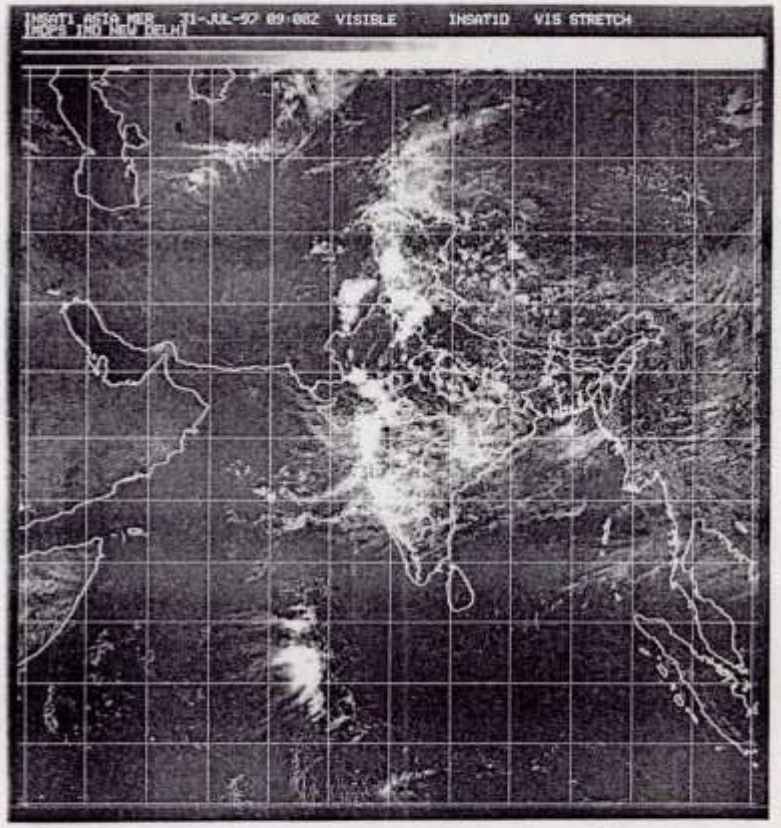

35
30
25
20
15
10
05
00
SPEED Km/h
00
12
00
12
00
12
00
12
00
12 UTC
29 JULY
30
31
01 AUGUST
02
DATE & TIME

FIG. 9


INSAT1 ASTA MER 31-JUL-92 09:00Z VISIBLE INSAT1D VIS STRETCH
MOPS IND NEW DELHI

(a)

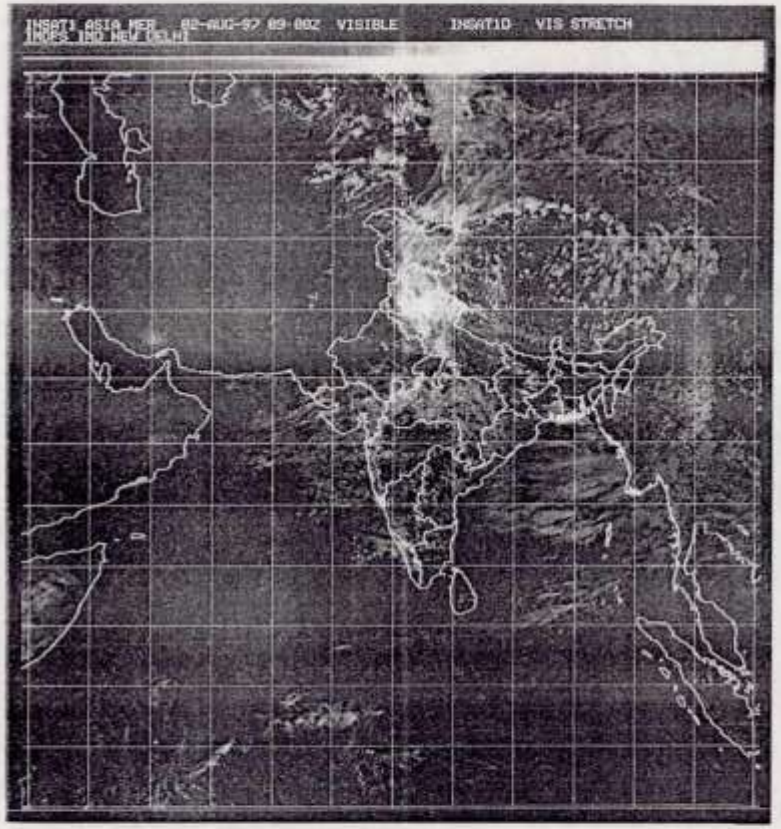

INSAT1 ASTA MER 31-JUL-92 09:00Z VISIBLE INSAT1D VIS STRETCH
MOPS IND NEW DELHI

(b)

FIG. 10

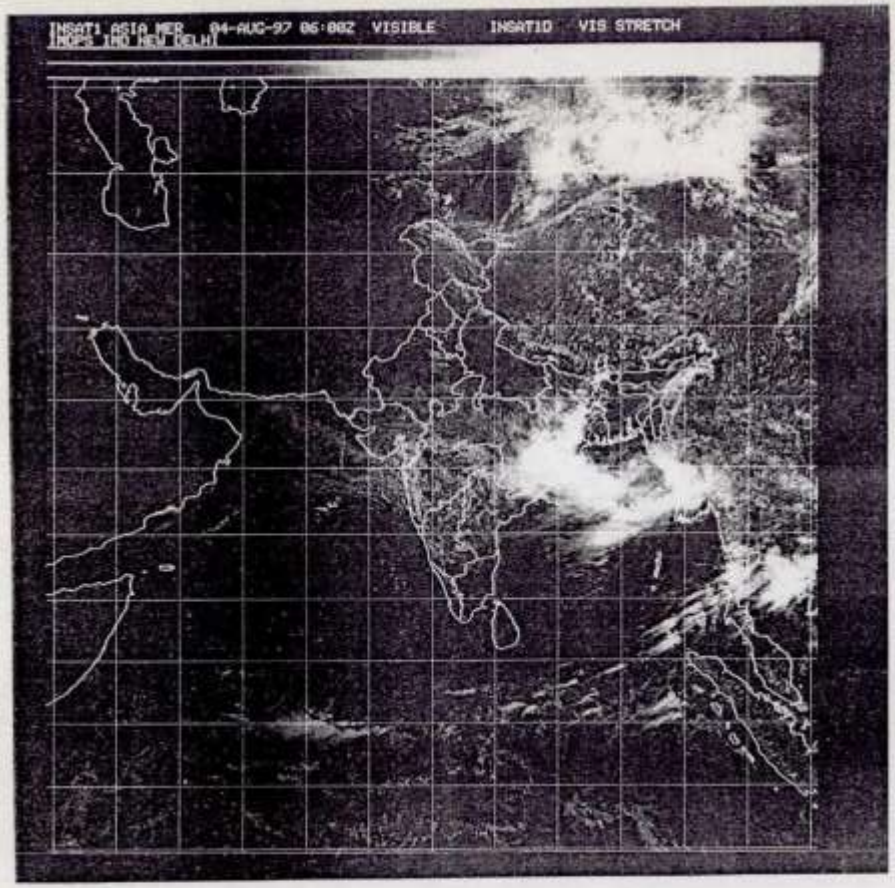

INSAT1 ASIA MER 01-AUG-97 06:00Z VISIBLE INSAT1D VIS STRETCH
INDES IND NEW DELHI

(c)

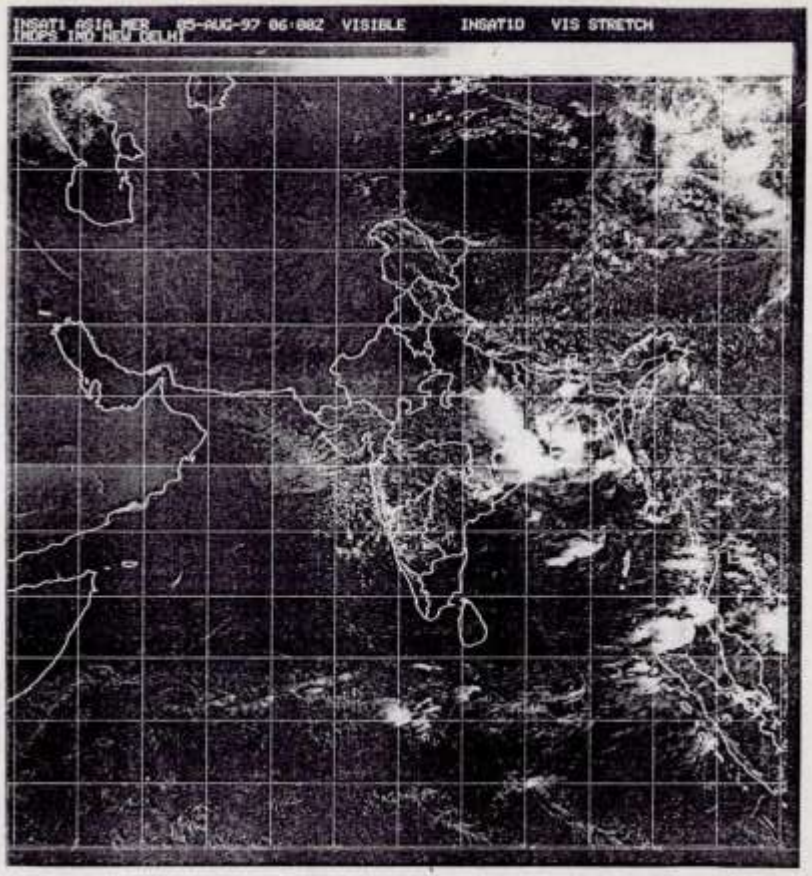

INSAT1 ASIA MER 02-AUG-97 09:00Z VISIBLE INSAT1D VIS STRETCH
INDES IND NEW DELHI

(d)

FIG. 10


INSAT1 ASIA MER 04-AUG-97 06:00Z VISIBLE INGAT1D VIS STRETCH
INDRS IMD NEW DELHI

(a)


INSAT1 ASIA MER 05-AUG-97 06:00Z VISIBLE INGAT1D VIS STRETCH
INDRS IMD NEW DELHI

(b)

FIG. 11

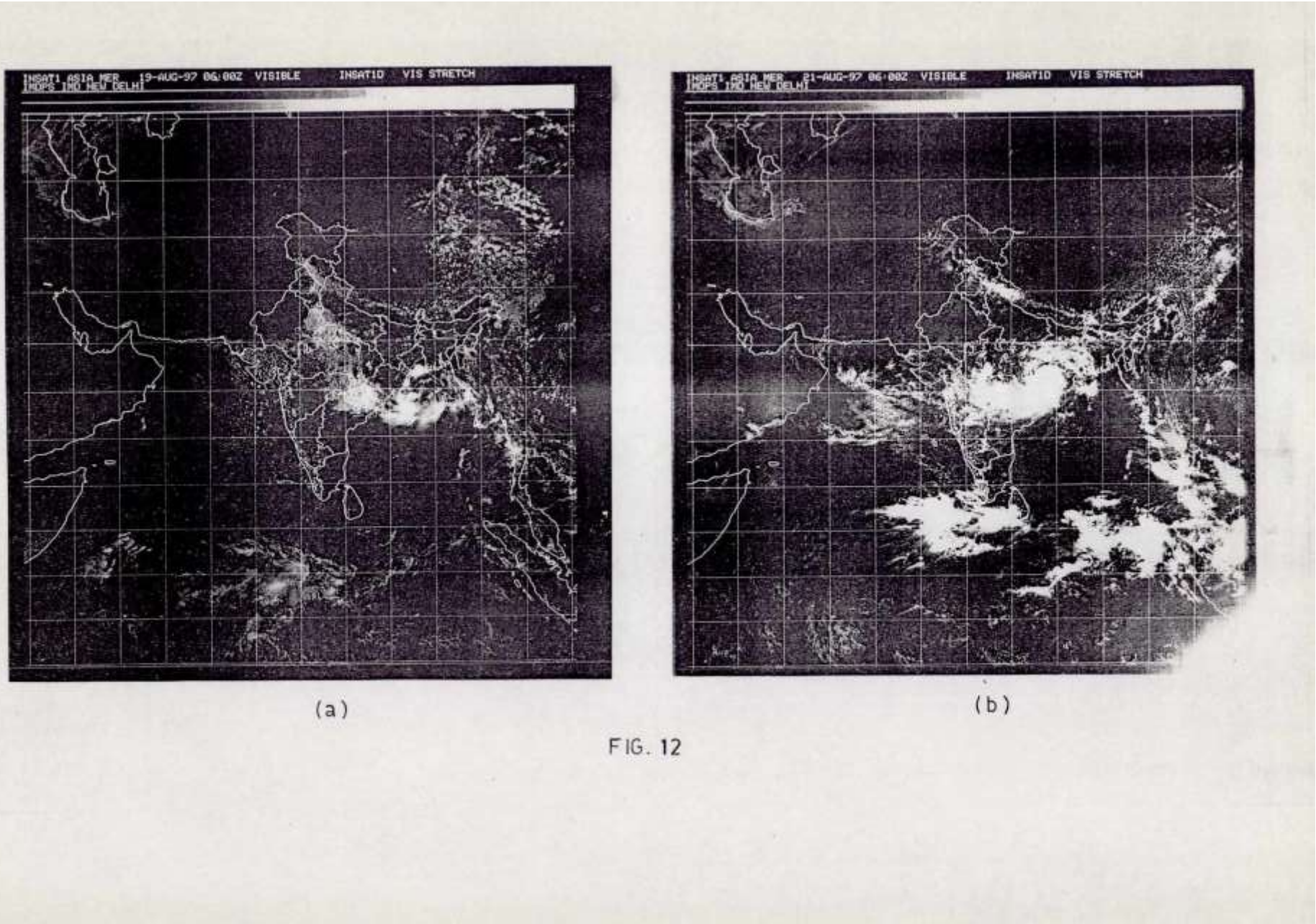

INSAT1 ASIA MER 06-AUG-97 06:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(c)


INSAT1 ASIA MER 07-AUG-97 06:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

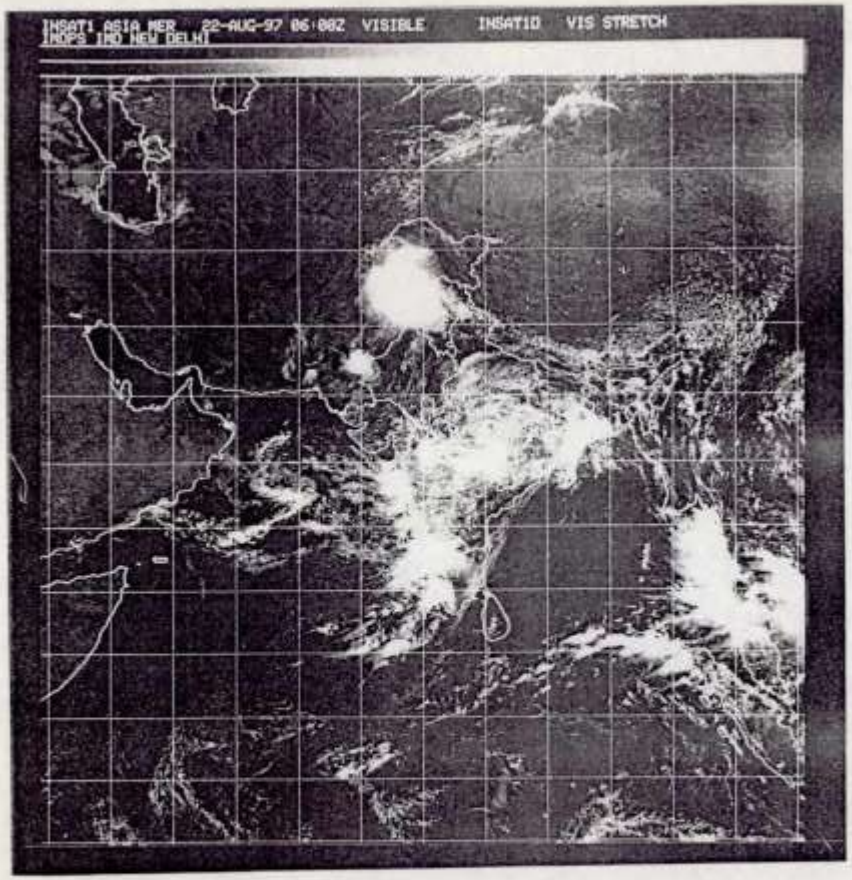
(d)

FIG. 11


INSAT1 ASIA MER 19-AUG-97 06:00Z VISIBLE INSATID VIS STRETCH
IMDPS IMD NEW DELHI
INSAT1 ASIA MER 21-AUG-97 06:00Z VISIBLE INSATID VIS STRETCH
IMDPS IMD NEW DELHI

(a) (b)

FIG. 12


INSAT1 ASIA MER 22-AUG-97 06:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(c)

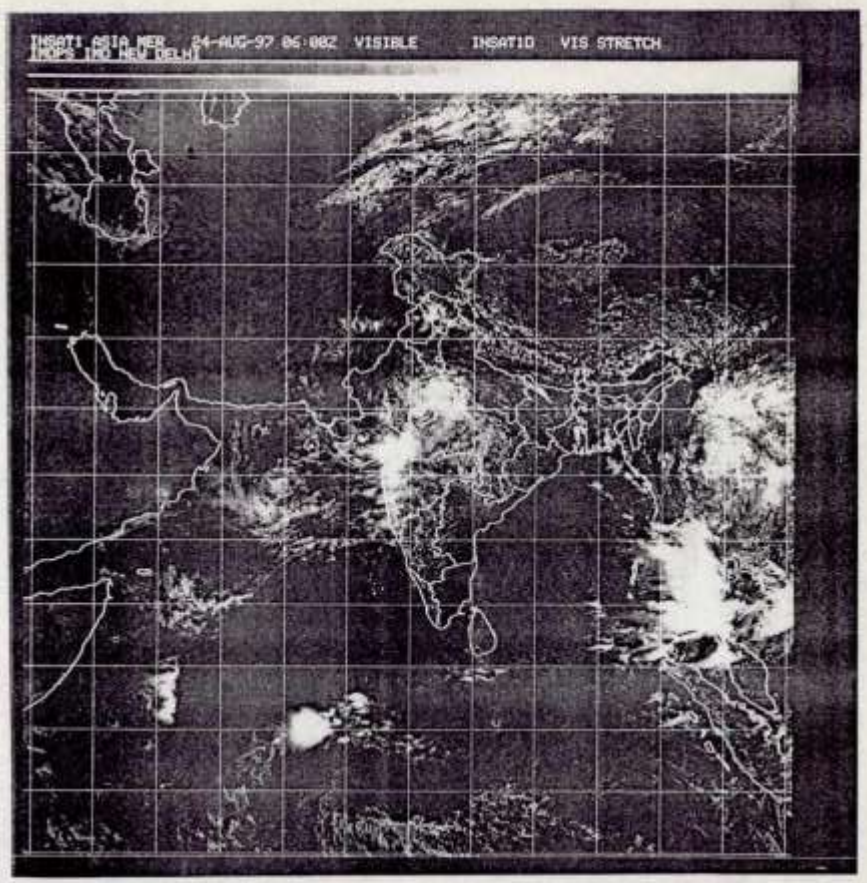

INSAT1 ASIA MER 22-AUG-97 09:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(d)

FIG. 12

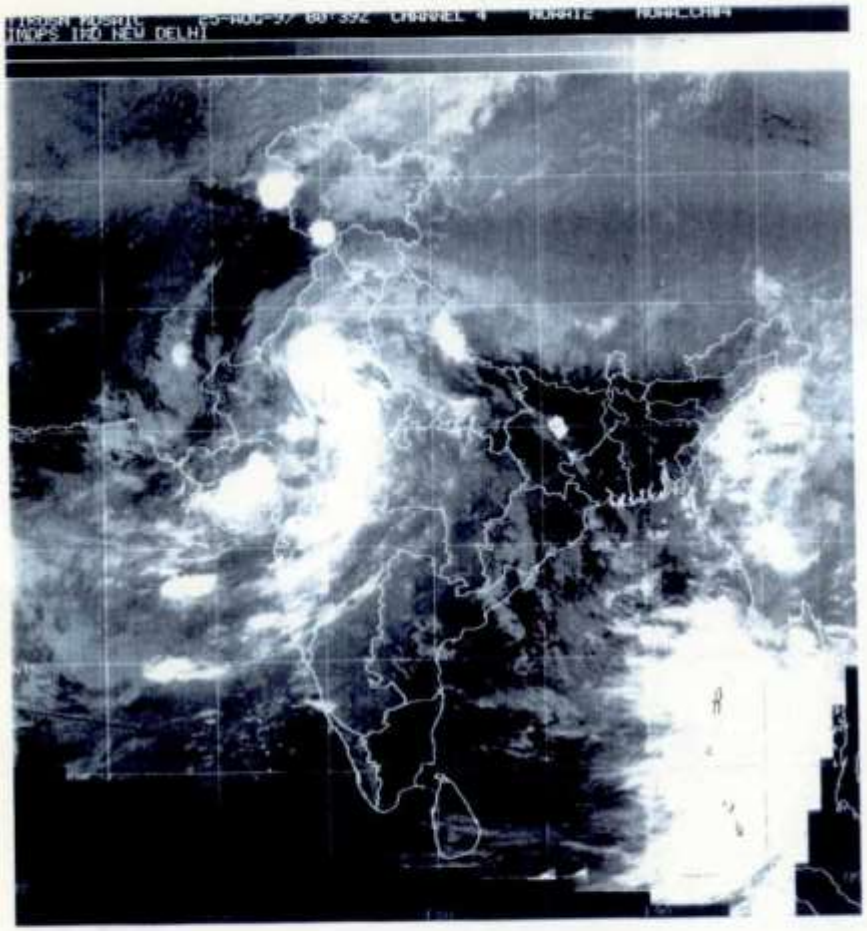

INSAT1 ASIA MER 23-AUG-97 09:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(e)


INSAT1 ASIA MER 24-AUG-97 06:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(f)

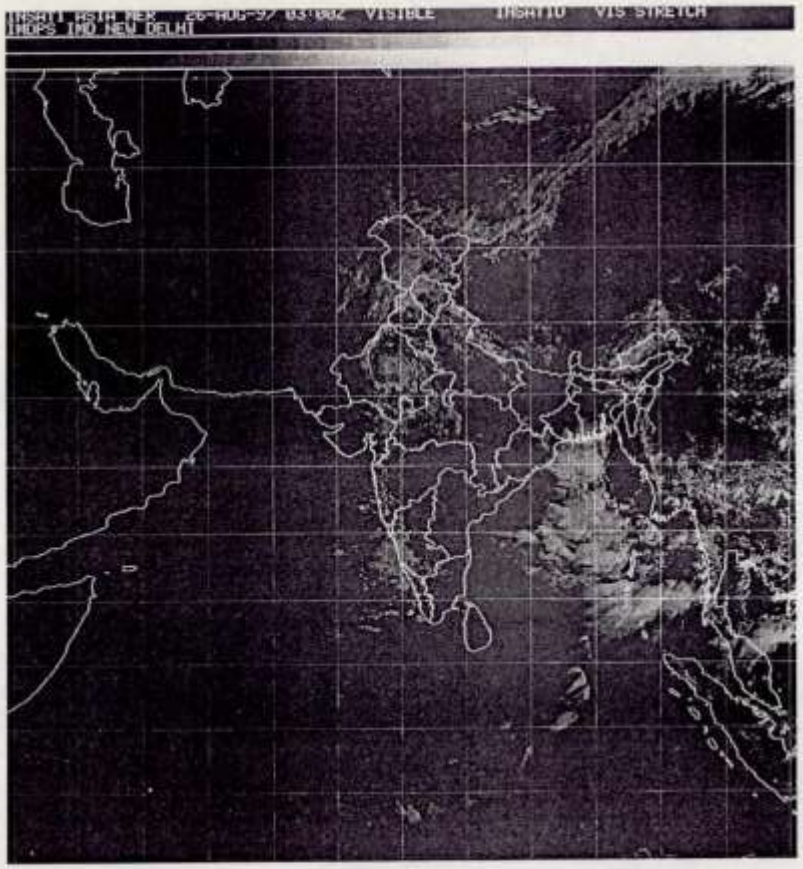
FIG. 12



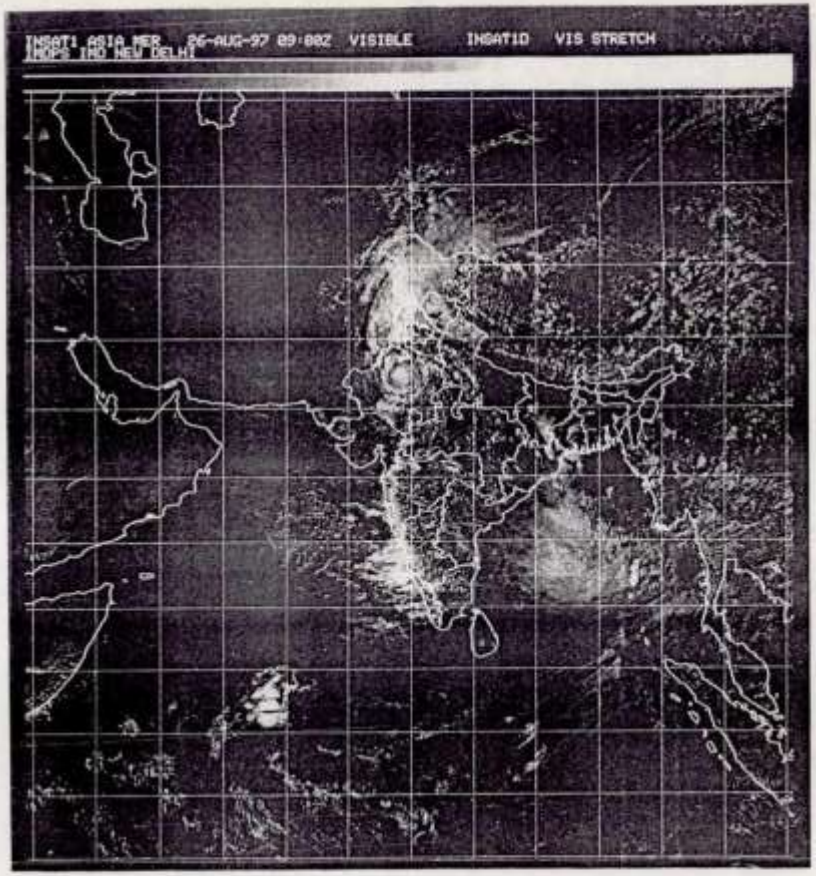
(g)

(h)

FIG. 12

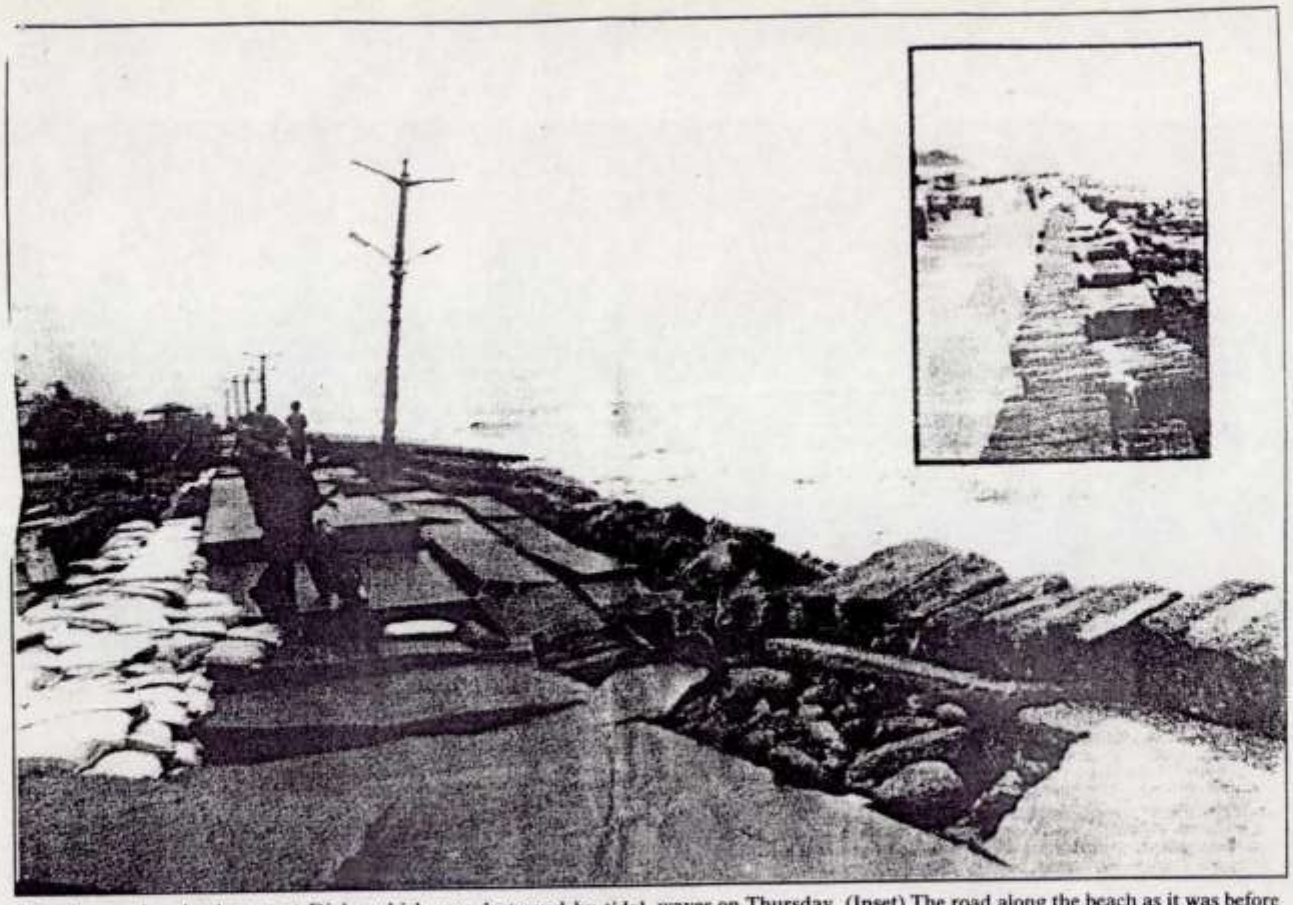

INSAT1 ASIA MER 26-AUG-97 03:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(i)


INSAT1 ASIA MER 26-AUG-97 09:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(j)

FIG. 12

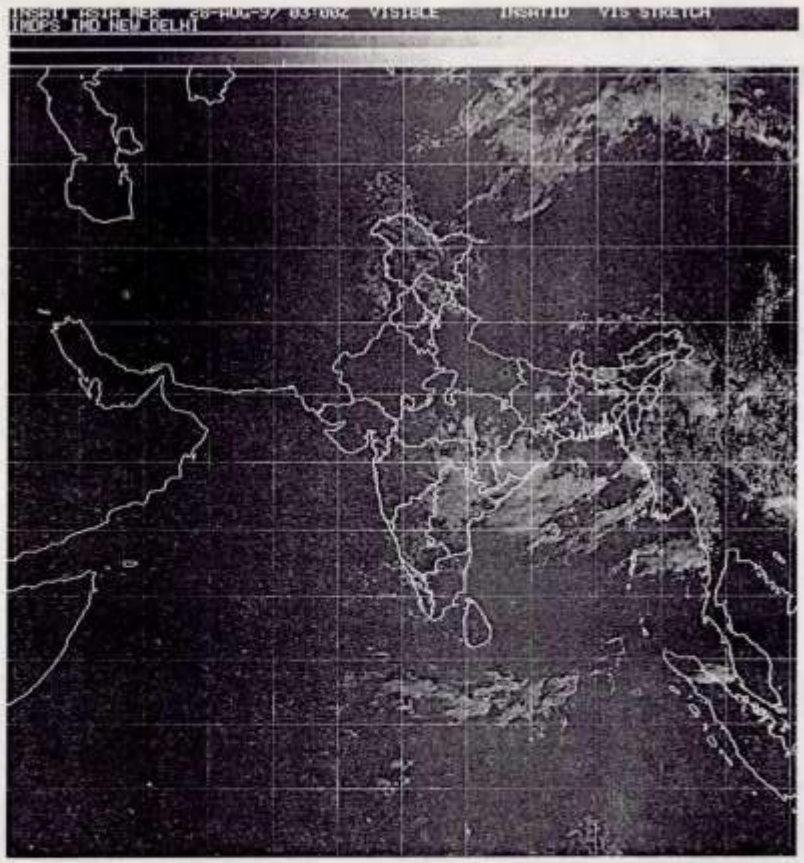


The damaged embankment at Digha which was destroyed by tidal waves on Thursday. (Inset) The road along the beach as it was before the damage.

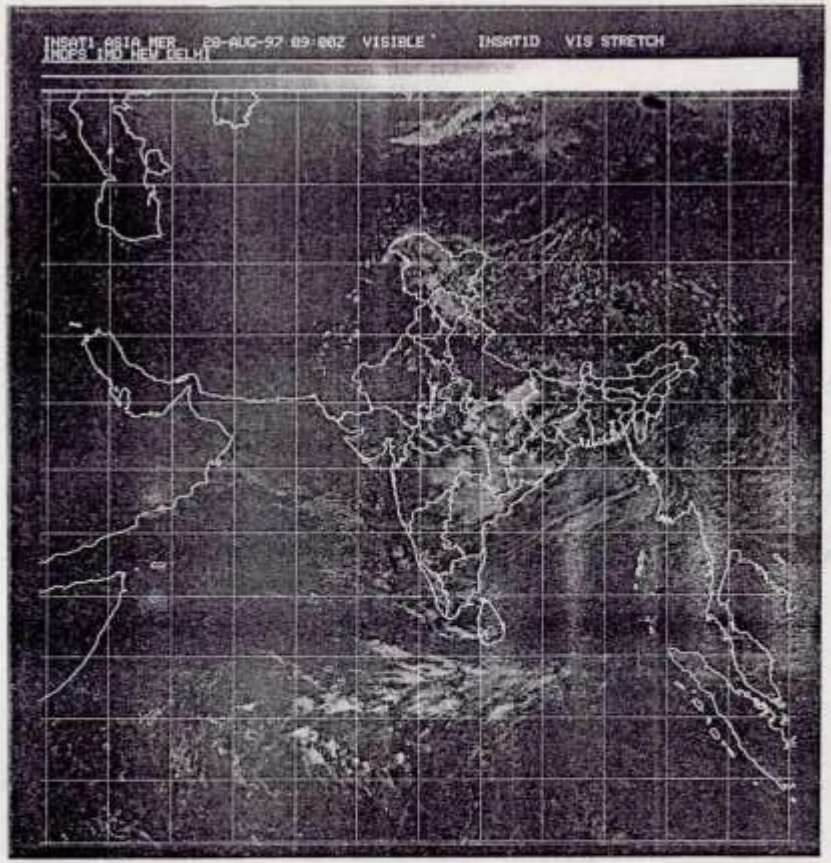
FIG. 13 (a)

A portion of the concrete pathway, along Digha beach, wrecked by tidal waves.

FIG. 13 (b)


INSAT1 ASIA MER 28-AUG-97 03:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(a)


INSAT1 ASIA MER 28-AUG-97 09:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(b)

FIG. 14

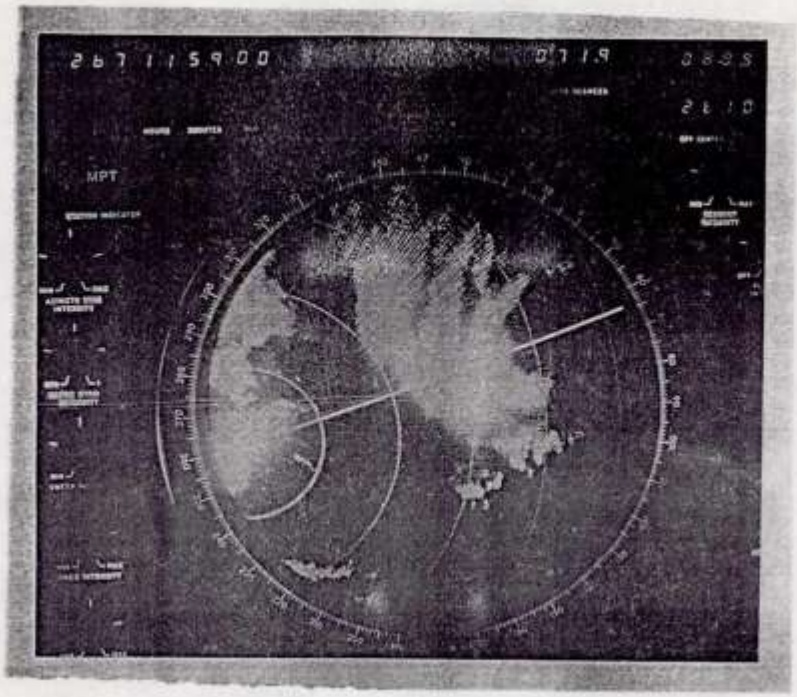

INSAT1 ASIA MER 29-AUG-97 06:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(c)

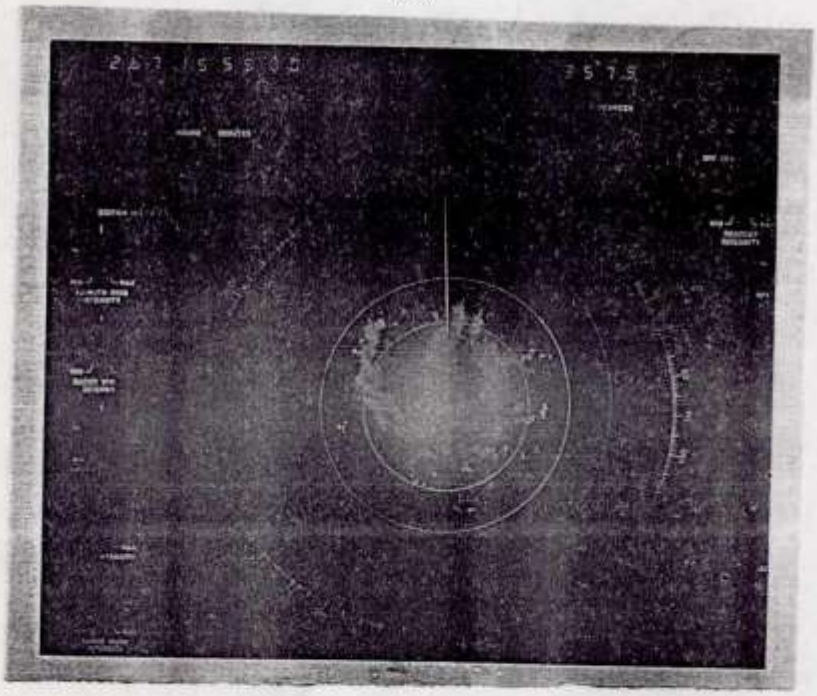

INSAT1 ASIA MER 30-AUG-97 06:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(d)

FIG. 14

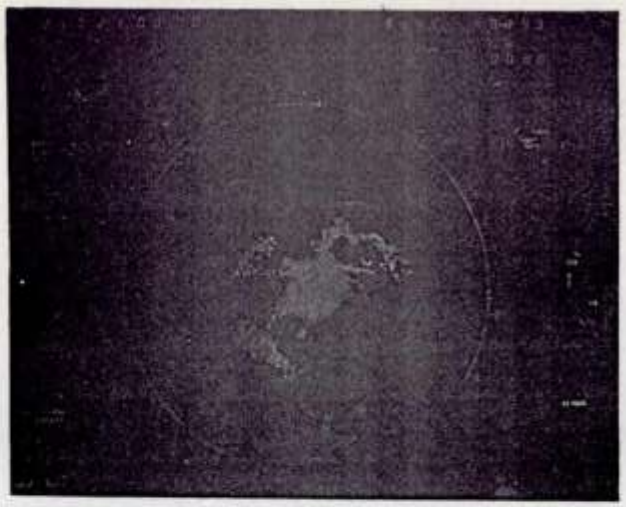


(a)

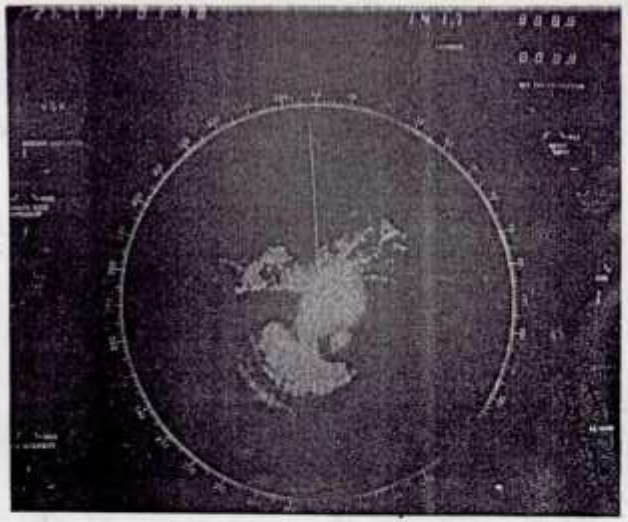


(b)

FIG. 15

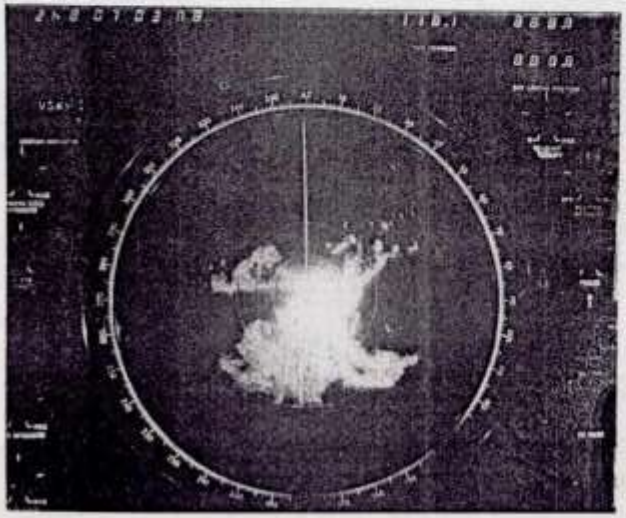


(a)



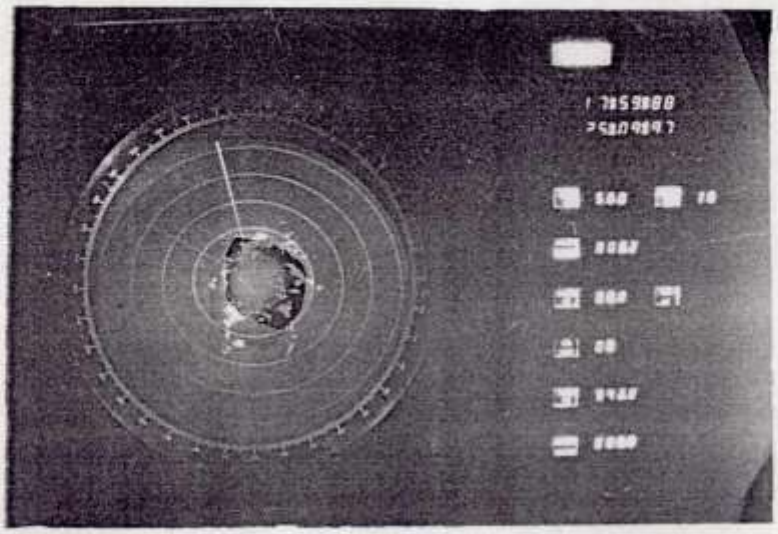
(b)

(c)

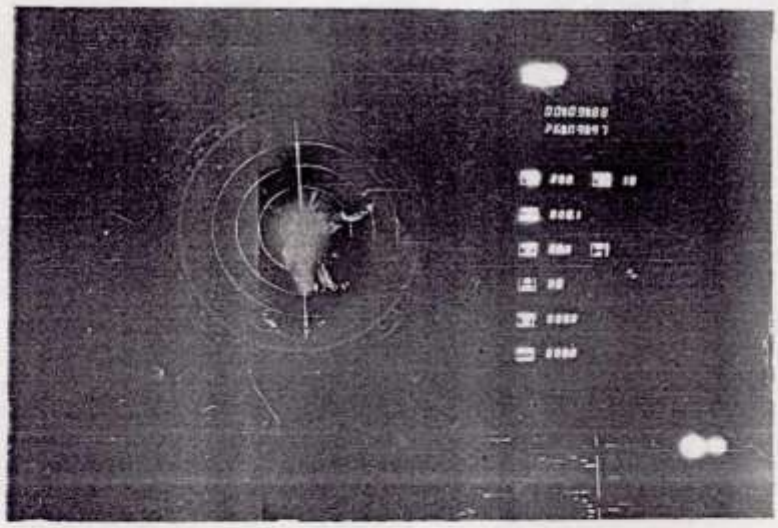


(d)

FIG. 16



(a)



(b)

FIG. 17

(a)

DATE	TIME HR.:MIN.	RANGE (KM.)	REMARKS
26.09.97	00:02	500	PPI LOG

(b)

DATE	TIME HR.:MIN.	RANGE (KM)	REMARKS
26.09.97	02:48	500	PPI LOG

(c)

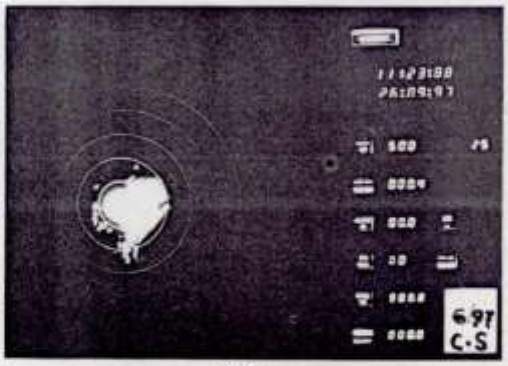
DATE	TIME HR.:MIN.	RANGE (KM)	REMARKS
26.09.97	05:48	500	PPI LOG

(d)

DATE	TIME HR.:MIN.	RANGE (KM)	REMARKS
26.09.97	08:48	500	PPI LOG

(e)

DATE	TIME HR.:MIN.	RANGE (KM)	REMARKS
26.09.97	08:49	400	PPI LOG



(f)

DATE	TIME HR.:MIN.	RANGE (KM)	REMARKS
26.09.97	II:23	500	PPI LOG

FIG. 18

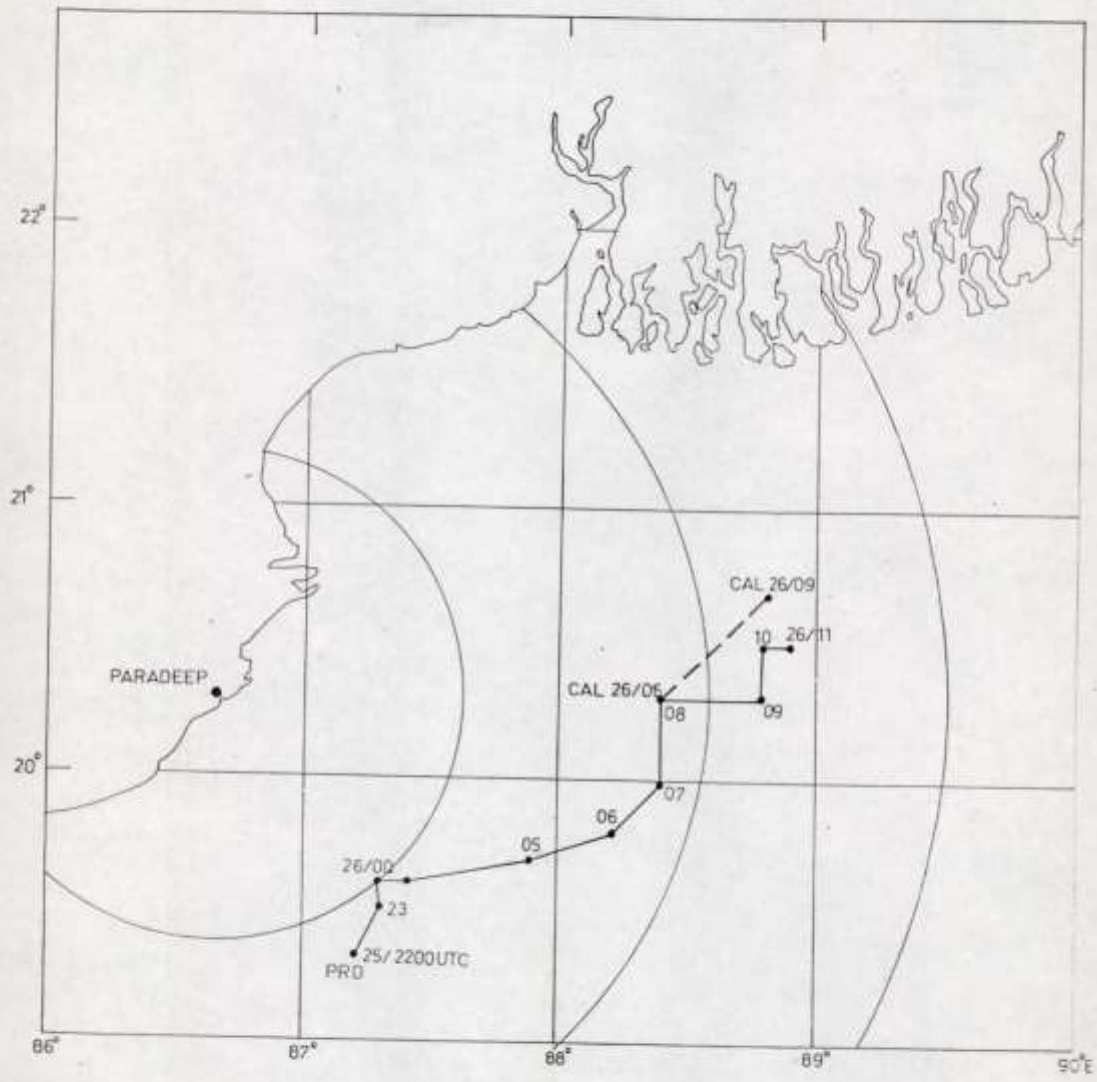

22°
21°
20°
86°
87°
88°
89°
90°E
PARADEEP
CAL 26/09
10
26/11
CAL 26/05
08
09
07
06
05
26/00
23
25/2200UTC
PRD

FIG 19(a)

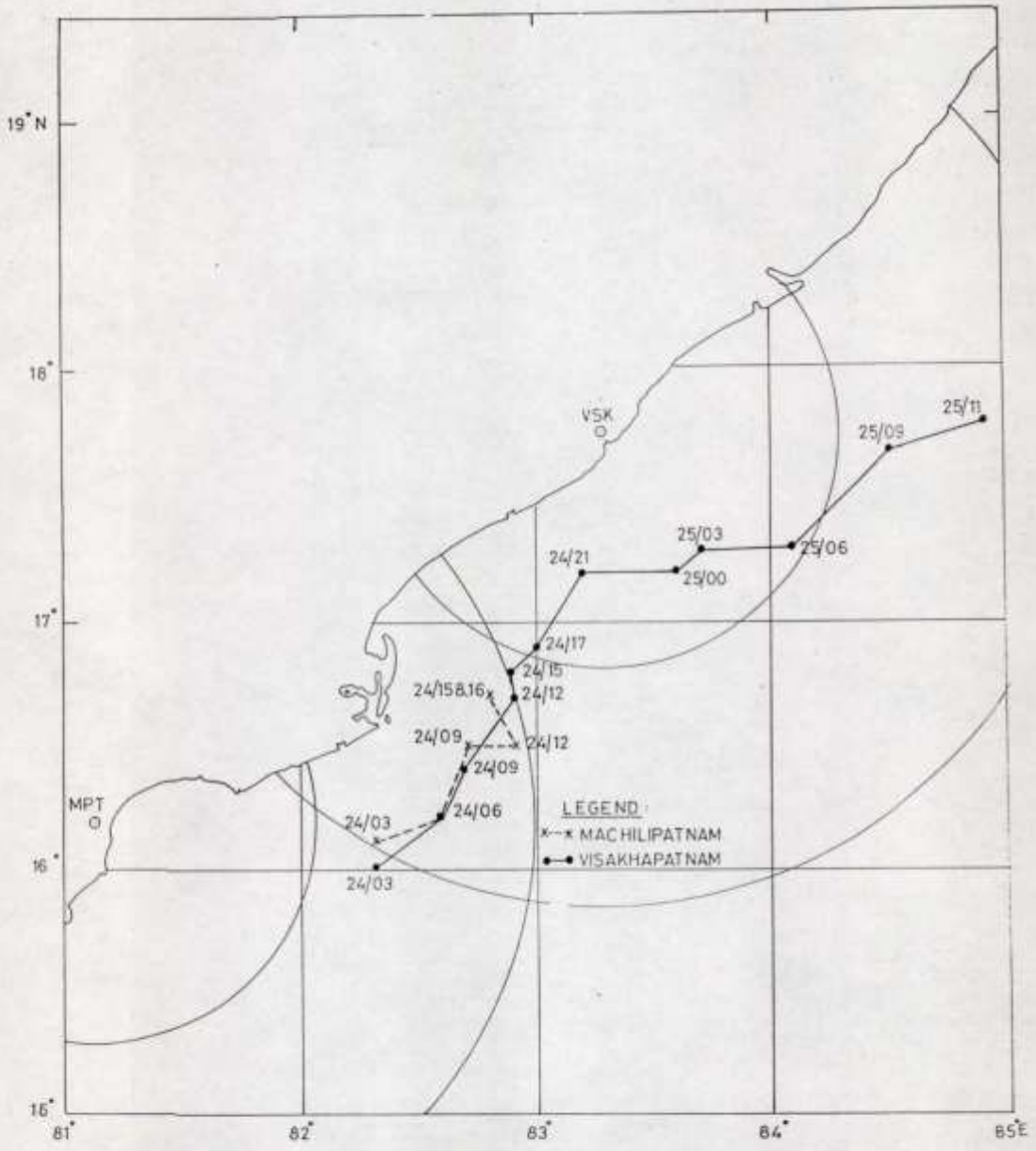
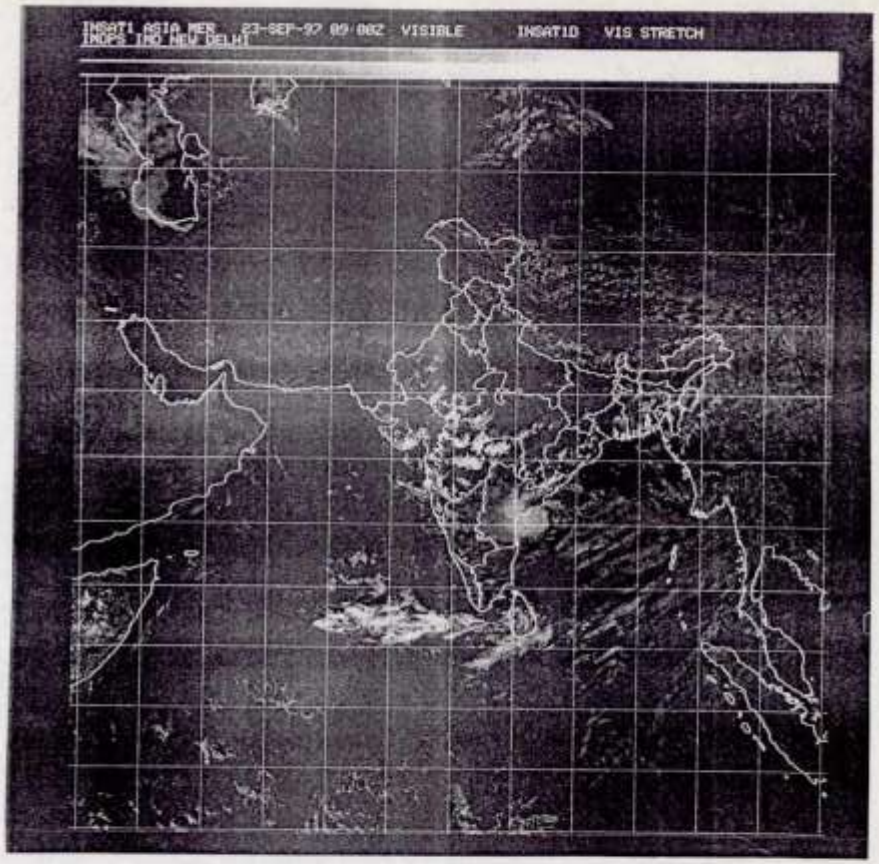

19°N
18°
17°
16°
15°
81°
82°
83°
84°
85°E
VSK
MPT
25/11
25/09
25/06
25/03
25/00
24/21
24/17
24/15
24/12
24/158.16
24/09
24/12
24/09
24/06
24/03
24/03
LEGEND
MACHILIPATNAM
VISAKHAPATNAM

FIG 19(b)


INSAT1 ASIA MER 23-SEP-97 03/00Z VISIBLE INSAT1D VIS STRETCH
INDPS IMD NEW DELHI

(a)

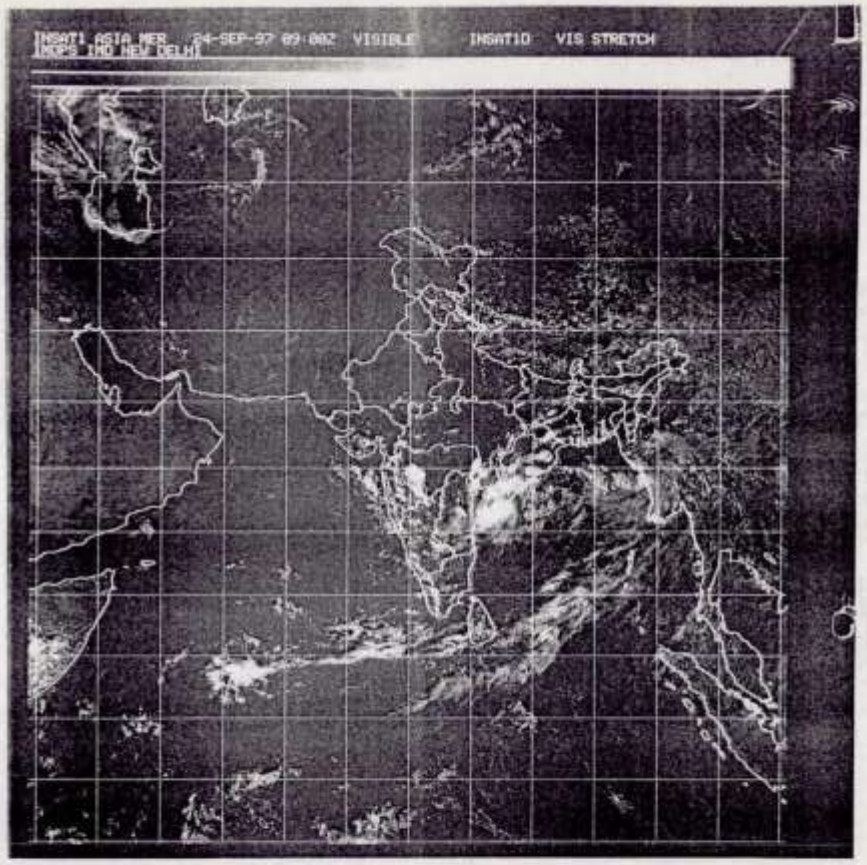

INSAT1 ASIA MER 23-SEP-97 09/00Z VISIBLE INSAT1D VIS STRETCH
INDPS IMD NEW DELHI

(b)

FIG. 20

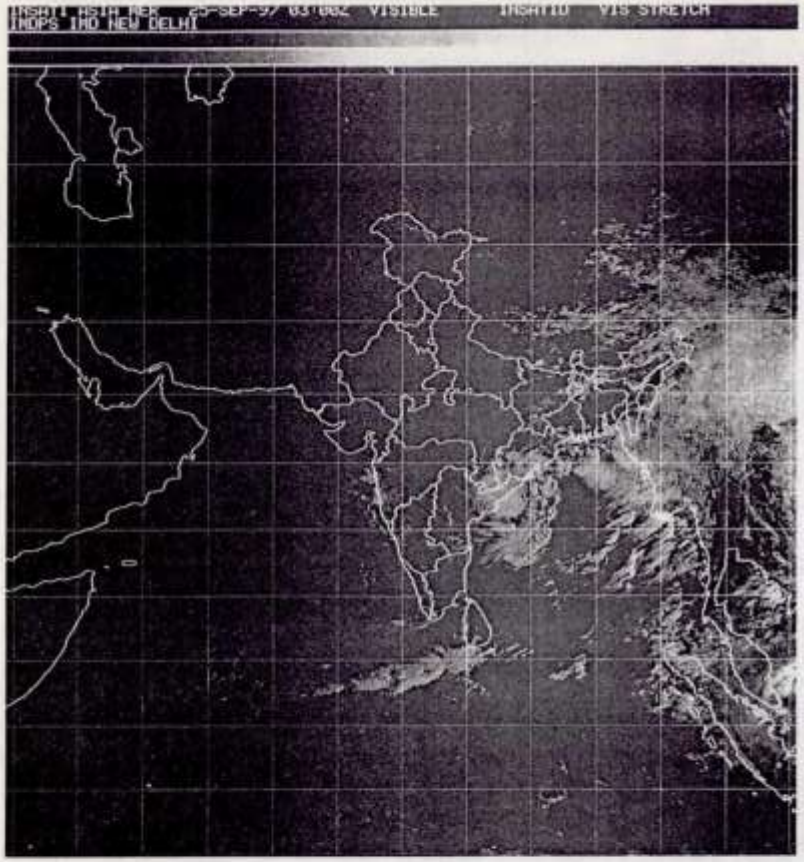

INSAT1 ASIA MER 24-SEP-97 03:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(c)

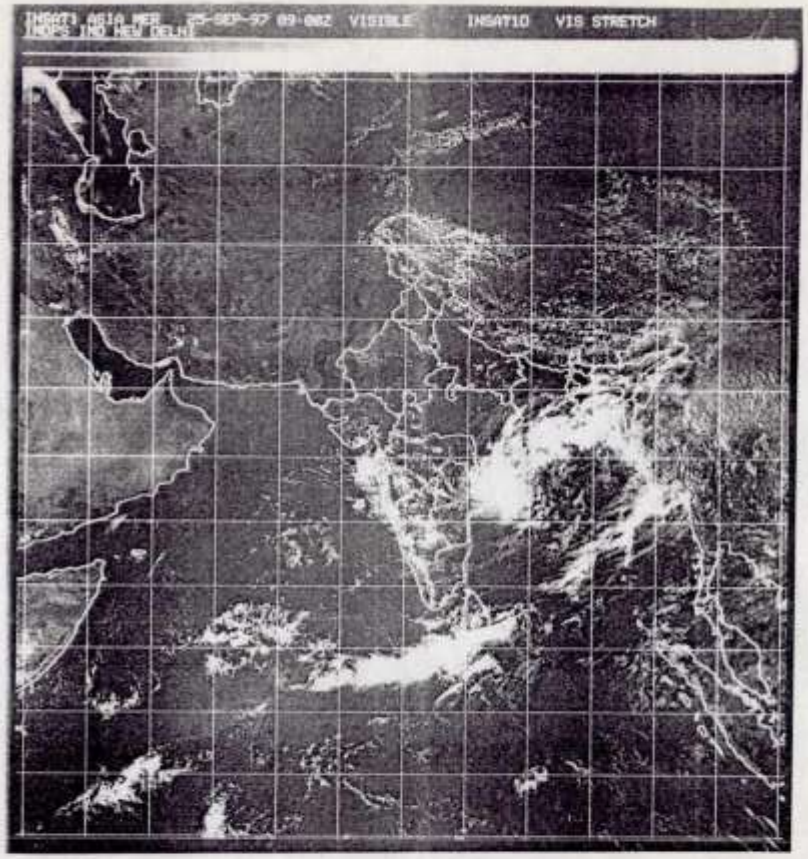

INSAT1 ASIA MER 24-SEP-97 09:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(d)

FIG. 20

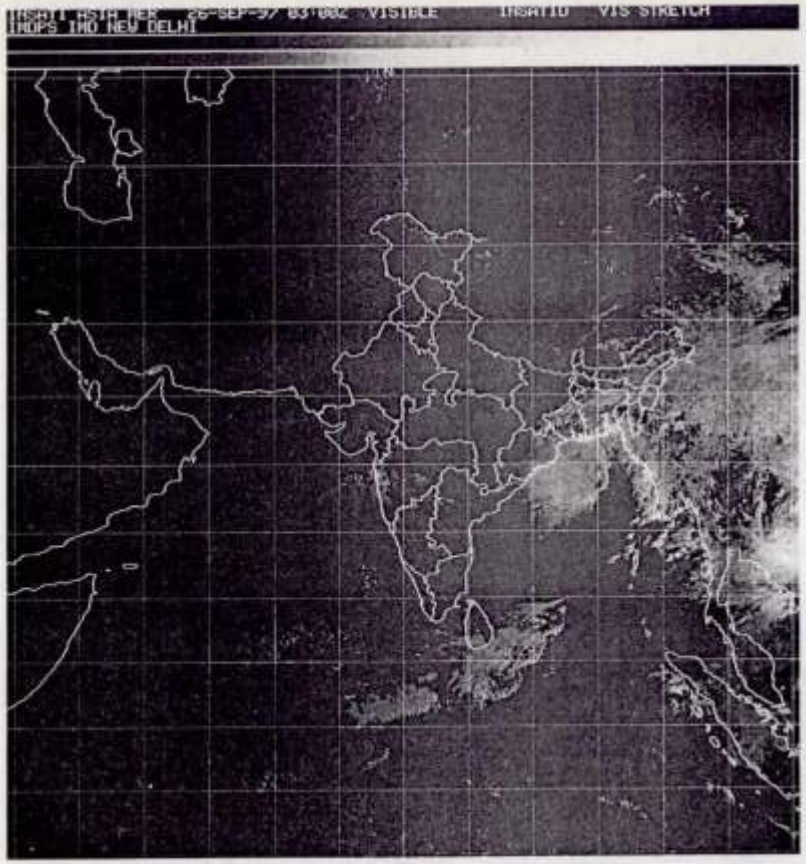

INDPS IND NEW DELHI
VISIBLE
INSAT1D
VIS STRETCH

(e)

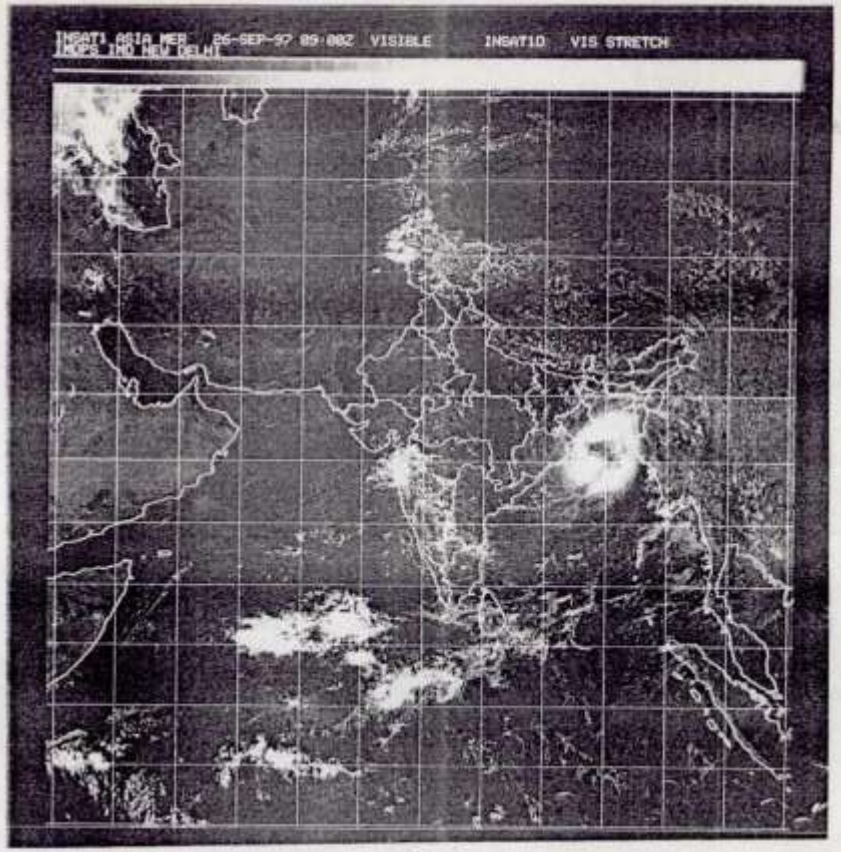

INDPS IND NEW DELHI
VISIBLE
INSAT1D
VIS STRETCH

(f)

FIG. 20


INSAT1 ASIA MER 26-SEP-97 03:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(g)


INSAT1 ASIA MER 26-SEP-97 09:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(h)

FIG. 20

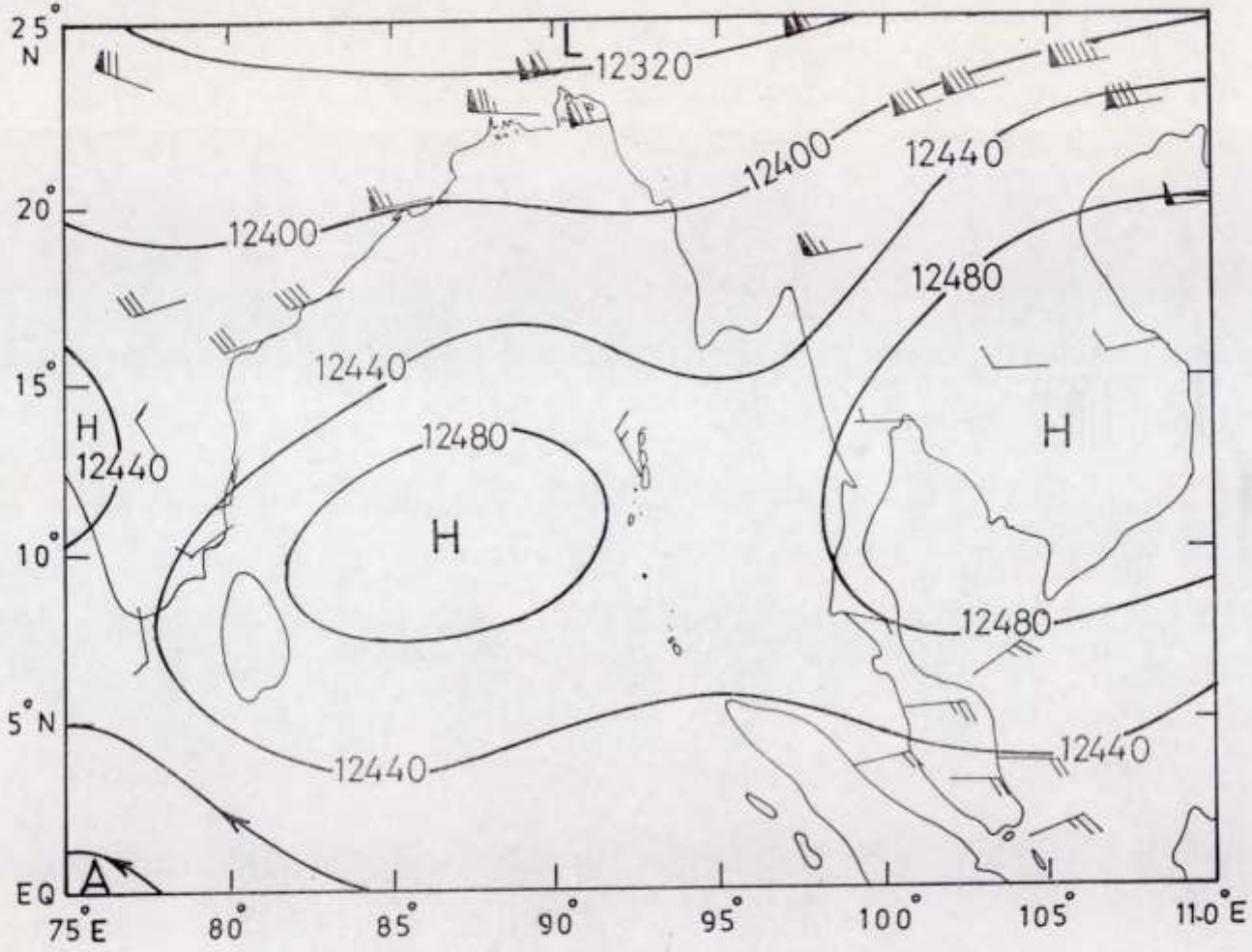

25° N
20°
15°
10°
5° N
EQ
75° E
80°
85°
90°
95°
100°
105°
11.0° E
L
12320
12400
12400
12440
12400
12480
12440
H
12440
12480
H
H
12480
12440
A

FIG. 21(a)

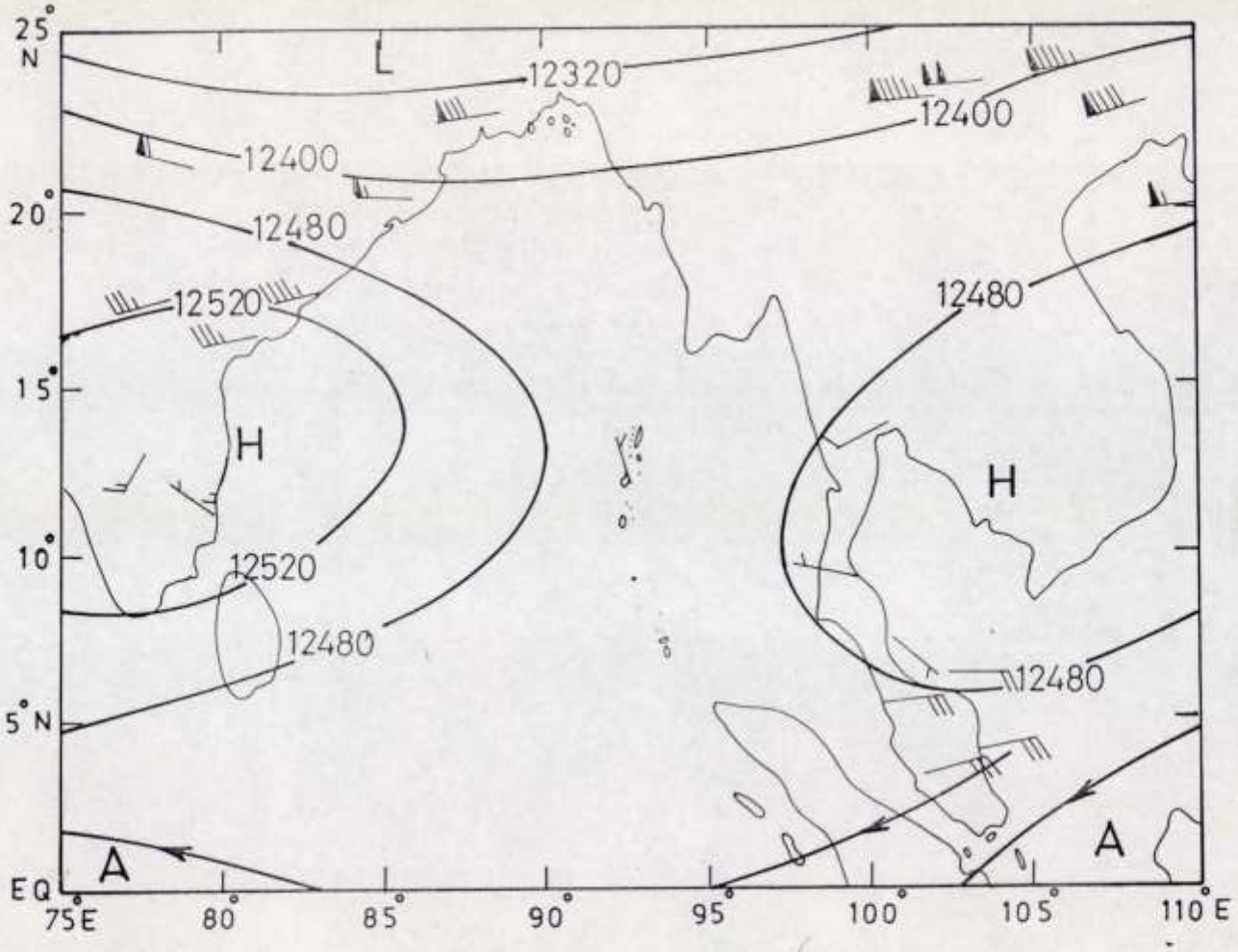
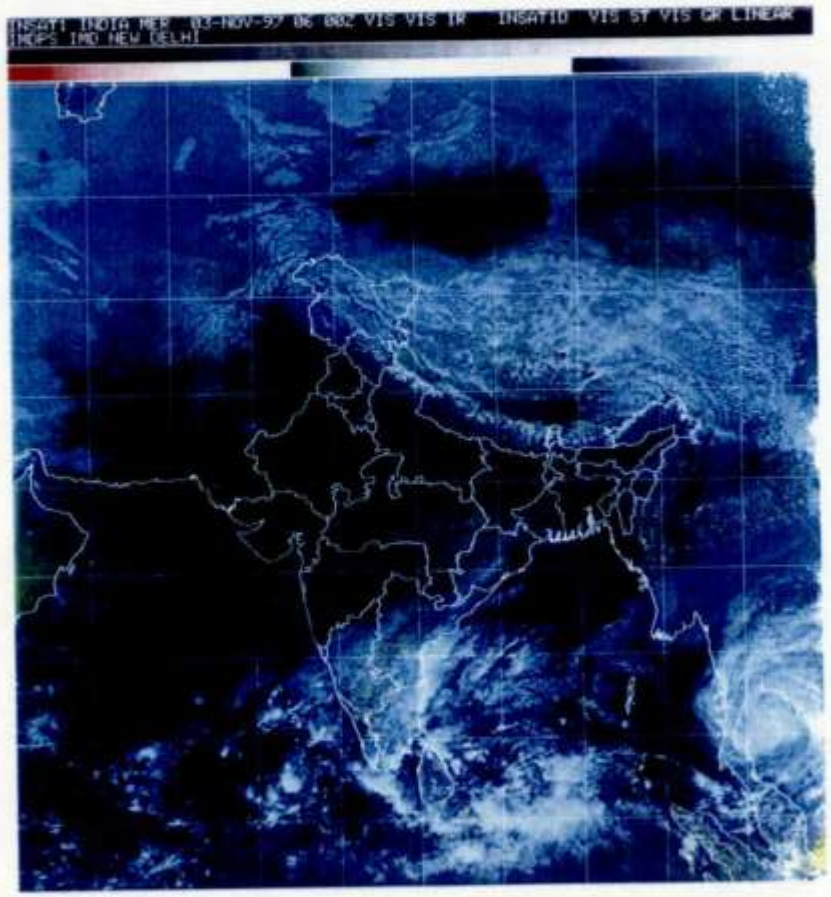
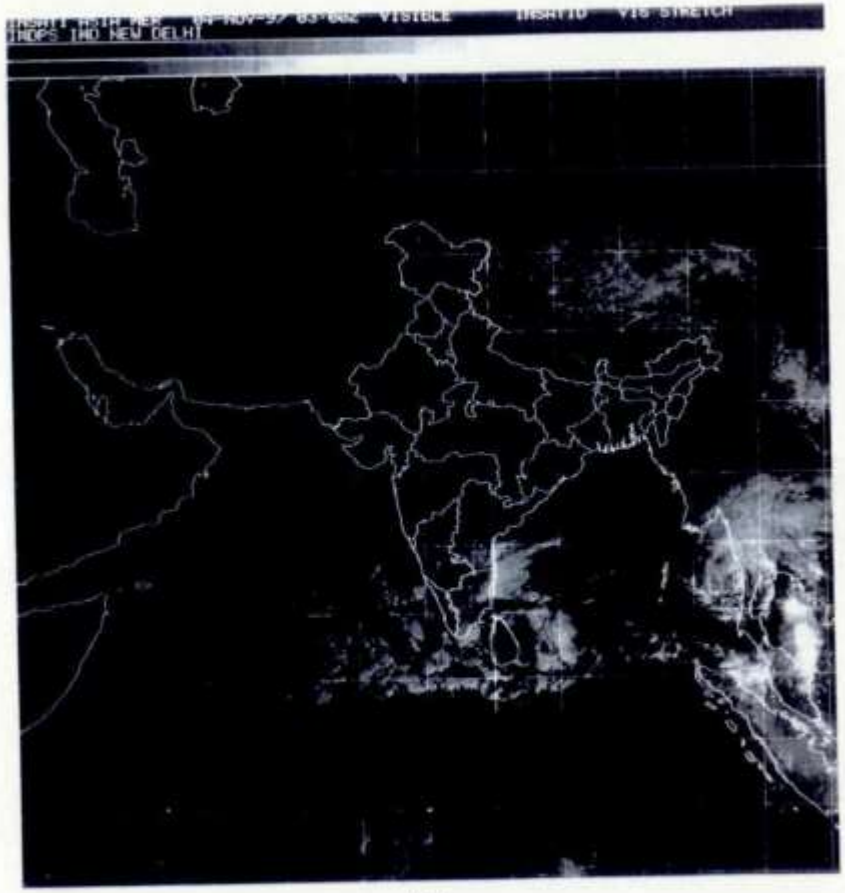

25° N
20°
15°
10°
5° N
EQ
75E
80°
85°
90°
95°
100°
105°
110° E
L
12320
12400
12400
12480
12520
12480
H
12520
12480
H
12480
A
A

FIG. 21(b)

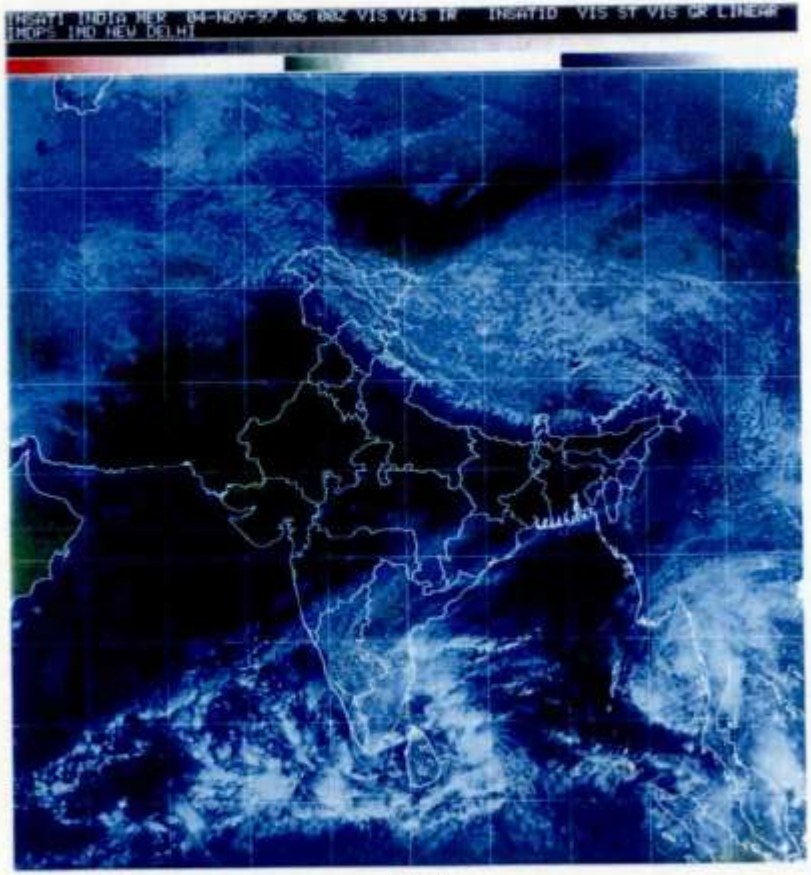


(a)



(b)

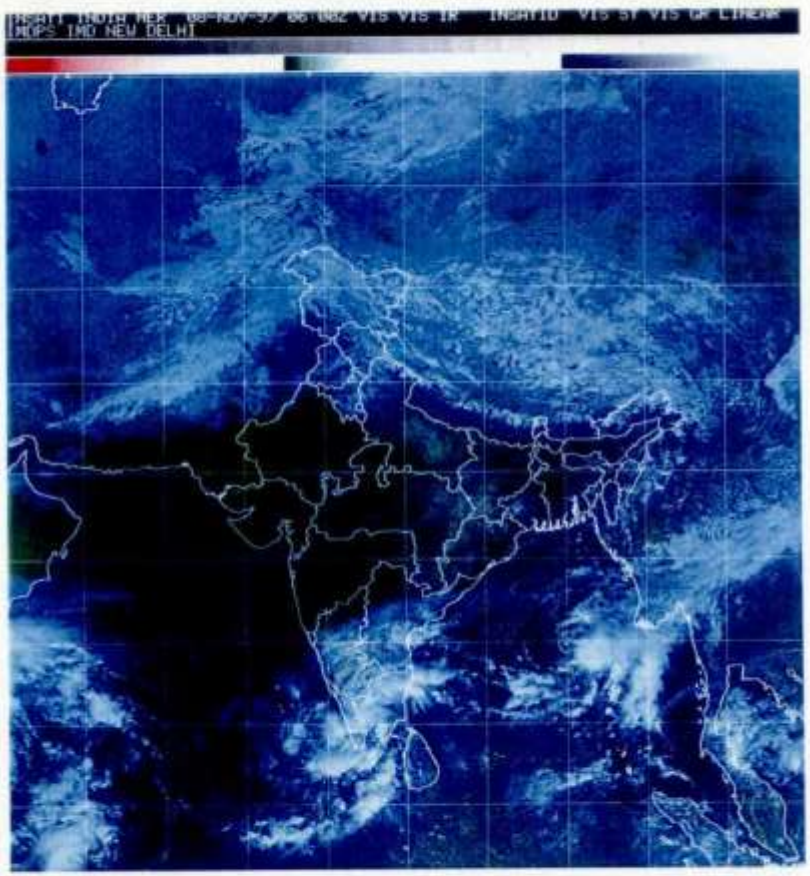
FIG. 22



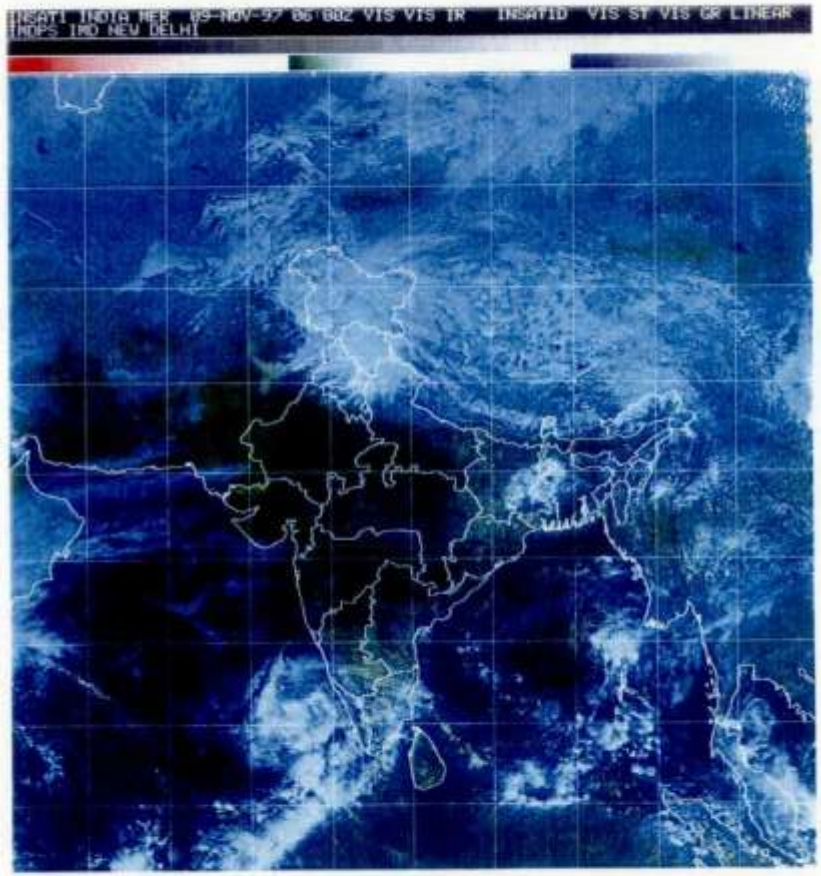
(c)

(d)

FIG. 22



(e)

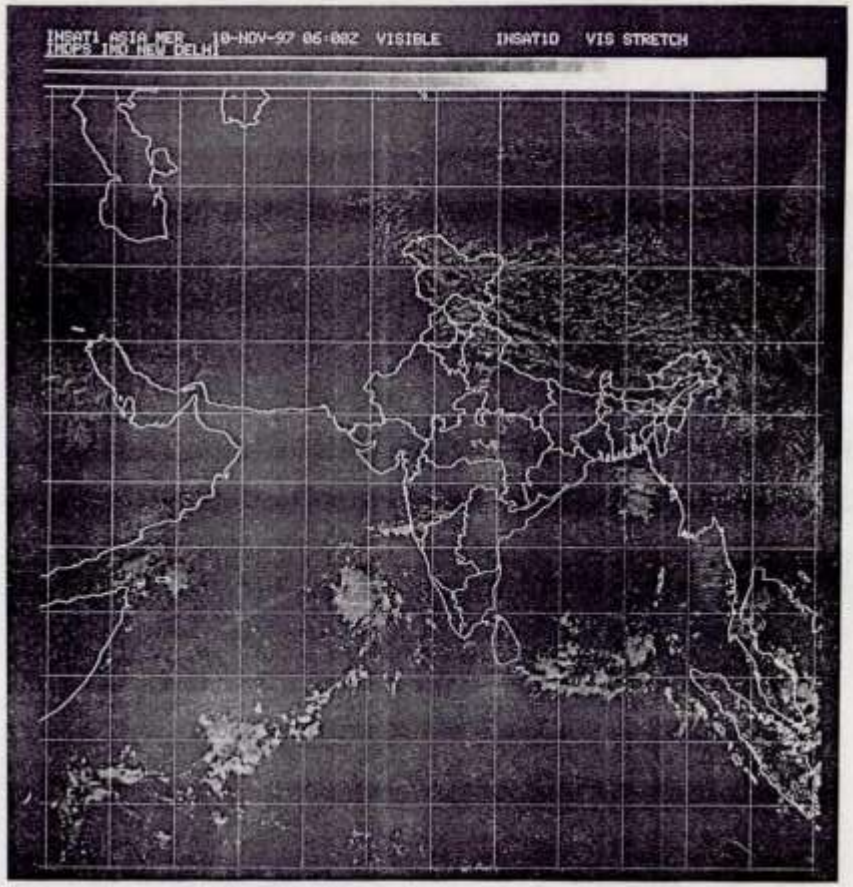


(f)

FIG. 22


INSAT1 ASIA MER 09-NOV-97 10:00Z IR BAND INSAT1D IR SUMMER ENH
IMDPS IMD NEW DELHI

(a)

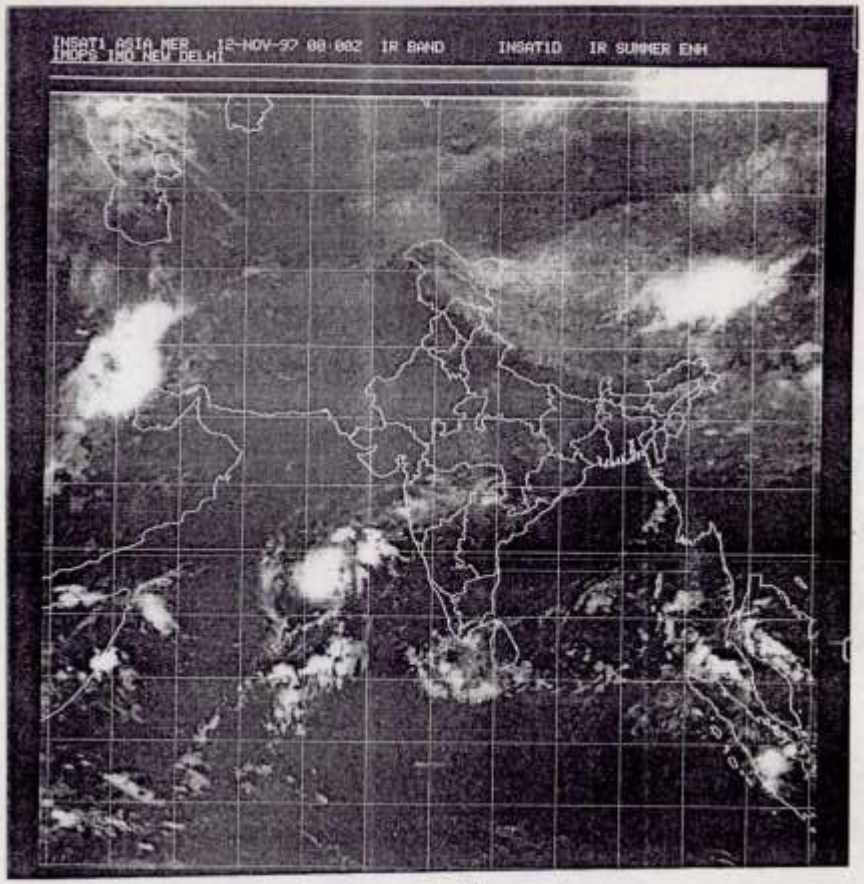

INSAT1 ASIA MER 10-NOV-97 06:00Z VISIBLE INSAT1D VIS STRETCH
IMDPS IMD NEW DELHI

(b)

FIG. 23


INSAT1 ASIA MER 11-NOV-97 21:00Z IR BAND INSAT1D IR SUMMER ENH
IMDPS IMD NEW DELHI

(c)


INSAT1 ASIA MER 12-NOV-97 00:00Z IR BAND INSAT1D IR SUMMER ENH
IMDPS IMD NEW DELHI

(d)

FIG. 23

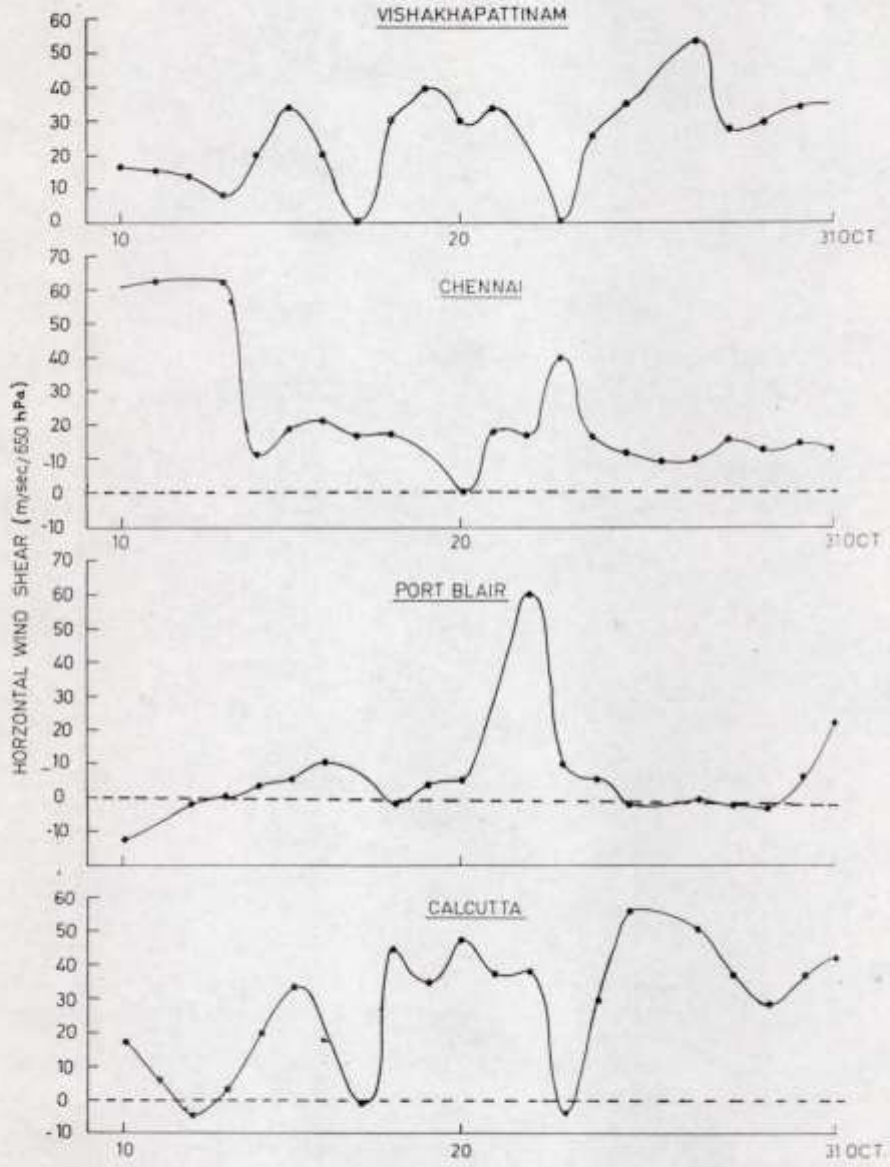

VISHAKHAPATTINAM
CHENNAI
PORT BLAIR
CALCUTTA
HORIZONTAL WIND SHEAR (m/sec/650 hPa)
10
20
31 OCT

FIG 24(a)

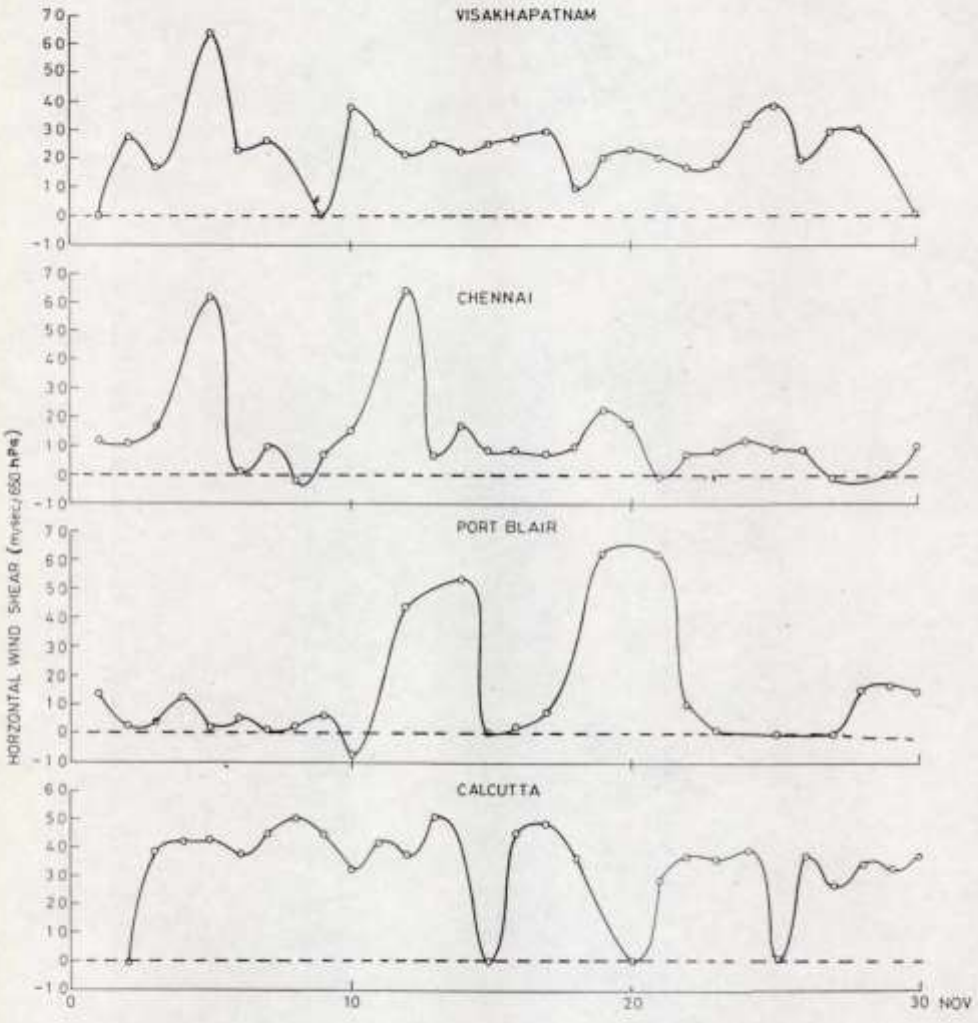

VISAKHAPATNAM
CHENNAI
PORT BLAIR
CALCUTTA
HORIZONTAL WIND SHEAR (m/sec./650 hPa)
70
60
50
40
30
20
10
0
-10
0
10
20
30 NOV

FIG 24(b)

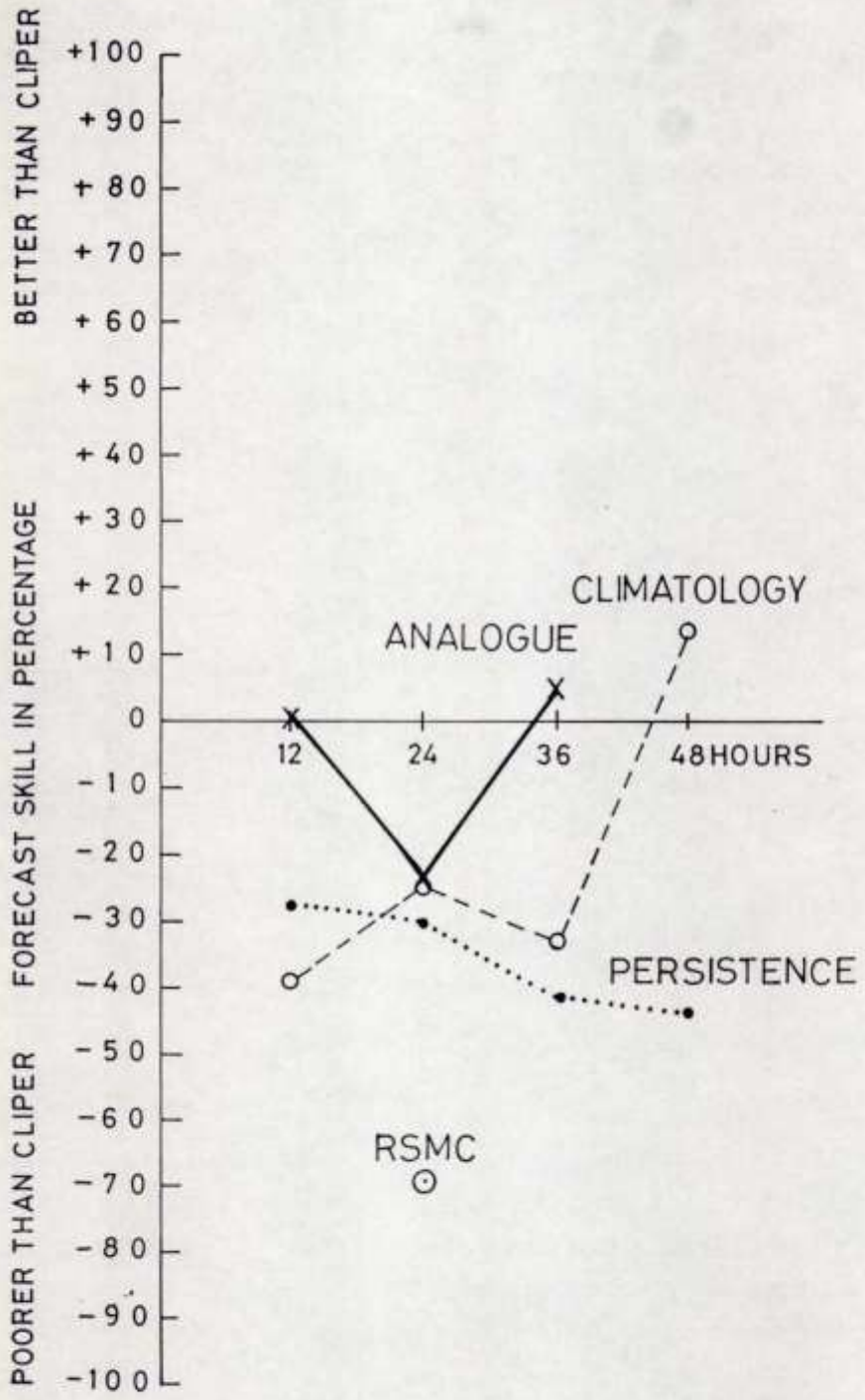

BETTER THAN CLIPER
FORECAST SKILL IN PERCENTAGE
POORER THAN CLIPER
+100
+90
+80
+70
+60
+50
+40
+30
+20
+10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
12
24
36
48 HOURS
CLIMATOLOGY
ANALOGUE
PERSISTENCE
RSMC

FIG. 25.

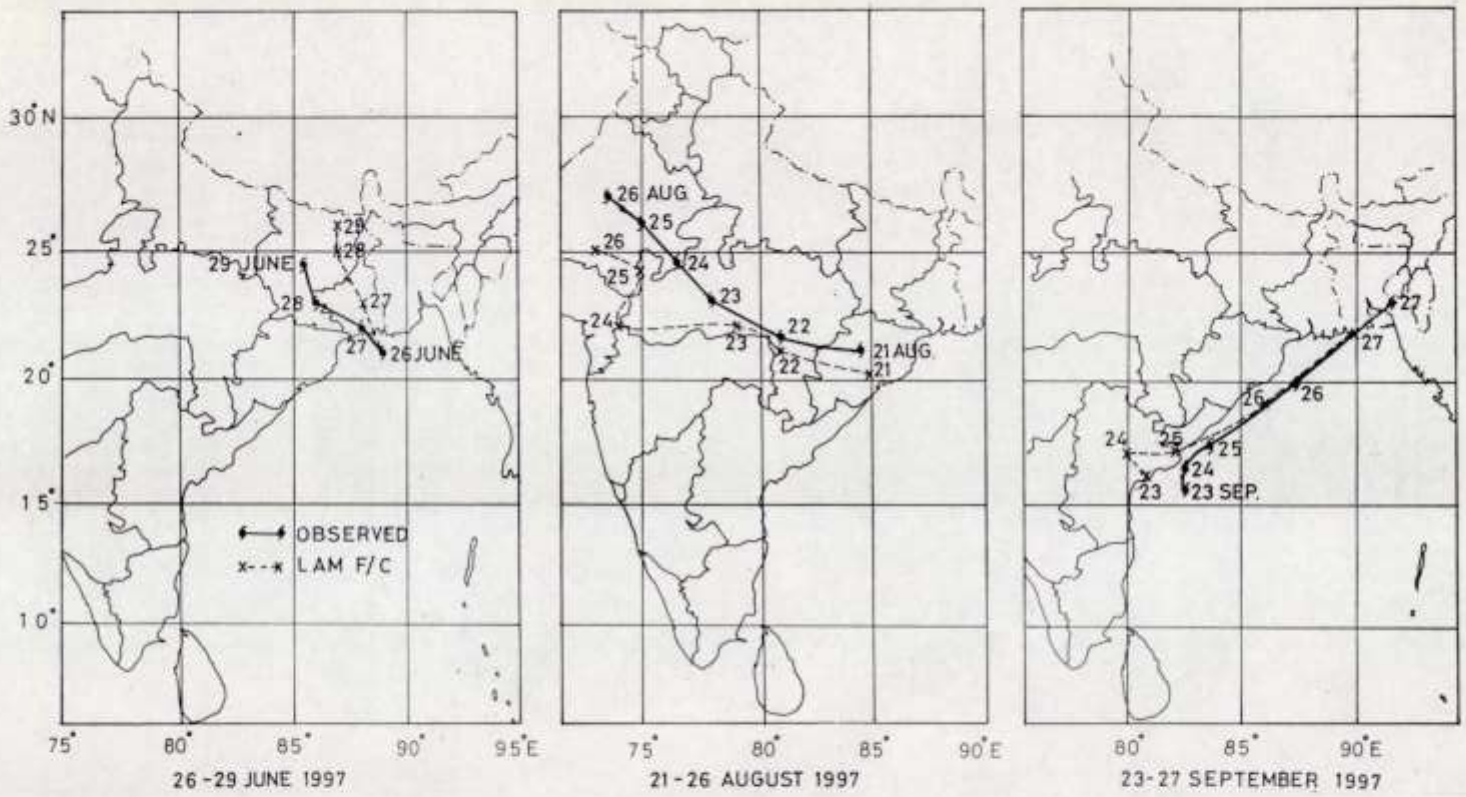

30°N
25°
20°
15°
10°
75°
80°
85°
90°
95°E
29 JUNE
26 JUNE
OBSERVED
LAM F/C
26 AUG.
21 AUG.
23 SEP.
26 -29 JUNE 1997
21 - 26 AUGUST 1997
23 - 27 SEPTEMBER 1997

FIG. 26

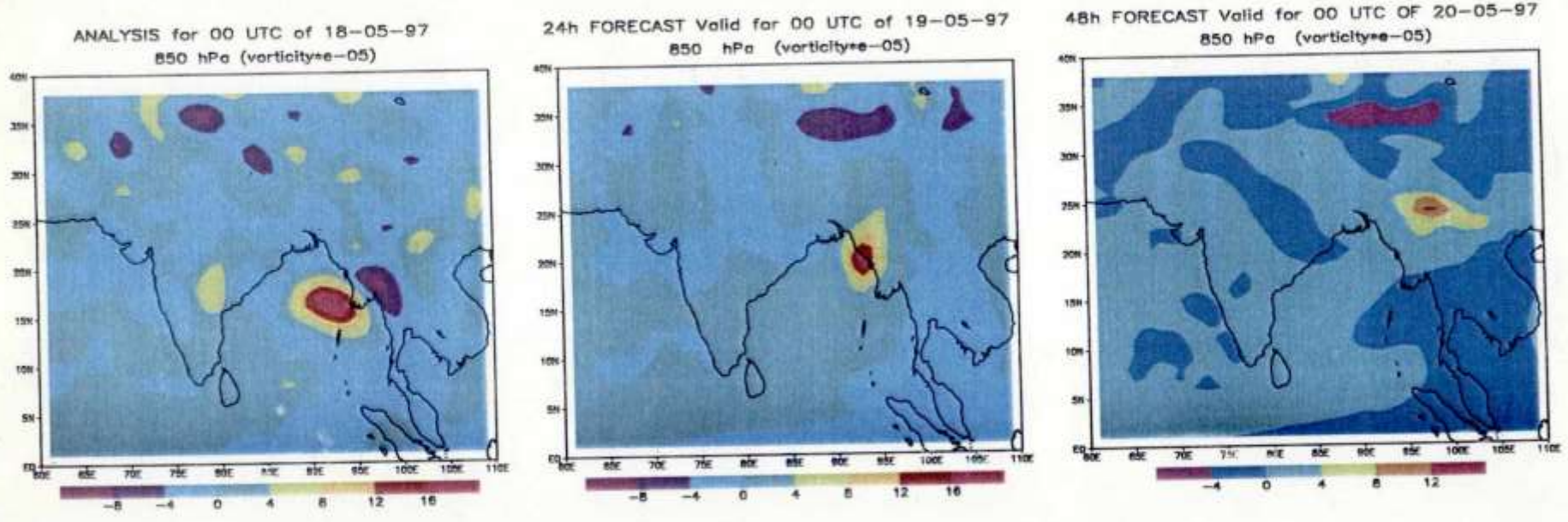

ANALYSIS for 00 UTC of 18-05-97
850 hPa (vorticity*e-05)
24h FORECAST Valid for 00 UTC of 19-05-97
850 hPa (vorticity*e-05)
48h FORECAST Valid for 00 UTC OF 20-05-97
850 hPa (vorticity*e-05)

FIG 27(a)

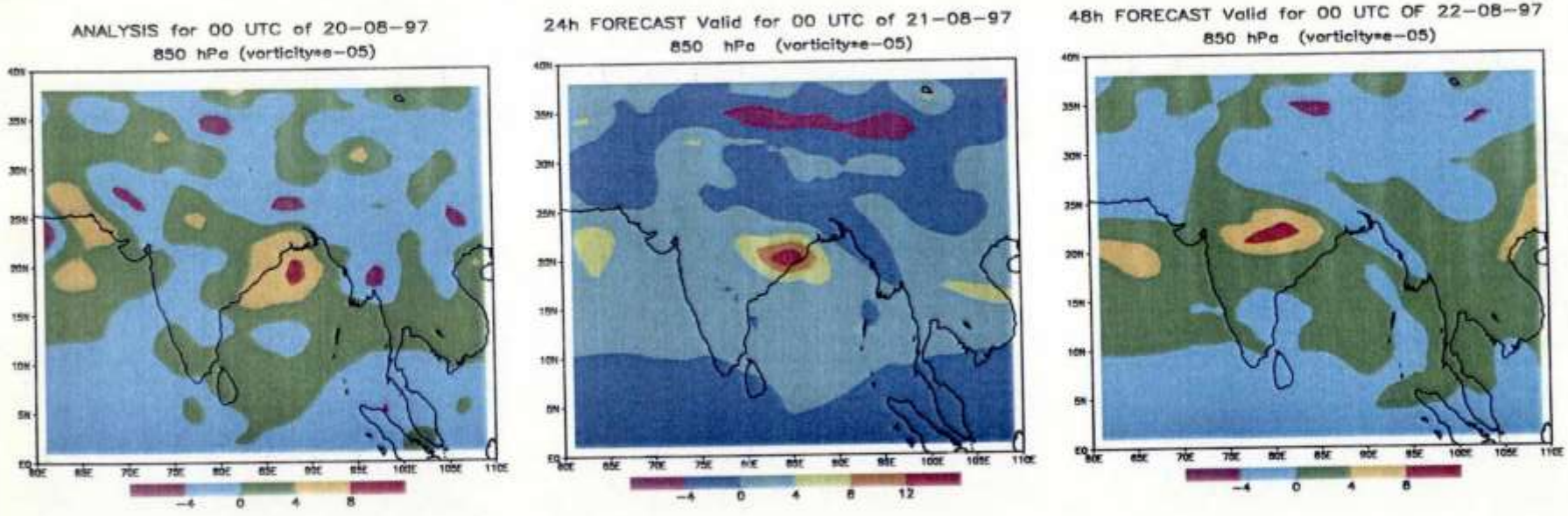

ANALYSIS for 00 UTC of 20-08-97
850 hPa (vorticity*e-05)
24h FORECAST Valid for 00 UTC of 21-08-97
850 hPa (vorticity*e-05)
48h FORECAST Valid for 00 UTC OF 22-08-97
850 hPa (vorticity*e-05)

FIG 27(b)

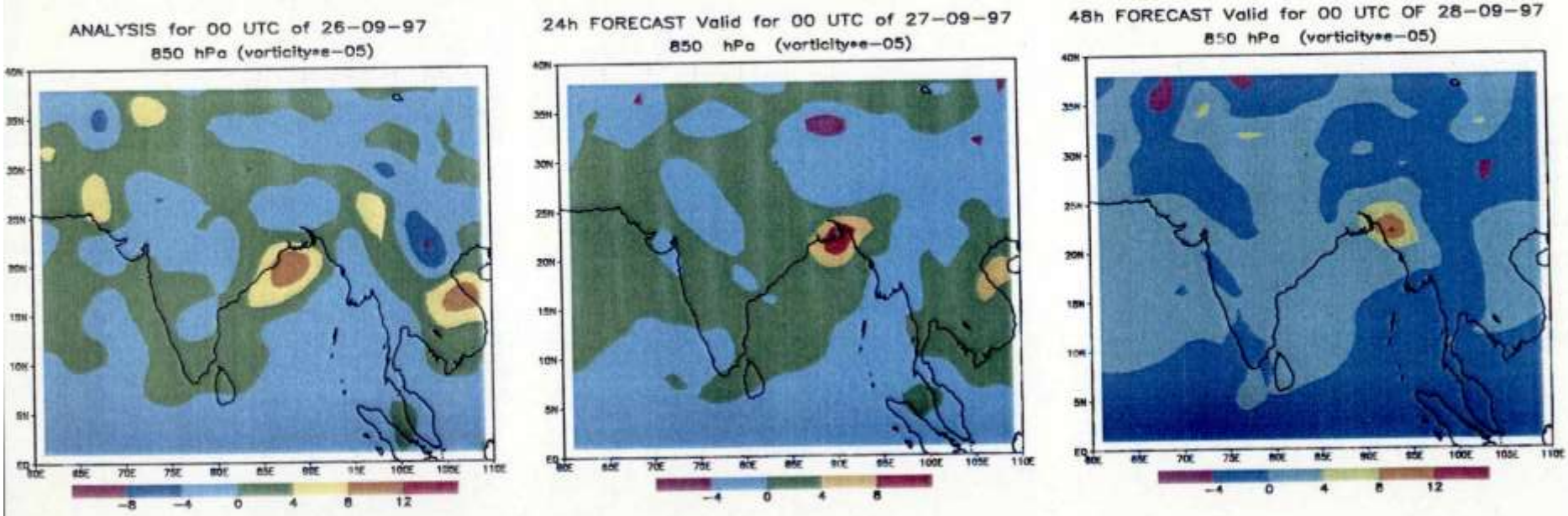

ANALYSIS for 00 UTC of 26-09-97
850 hPa (vorticity*e-05)
24h FORECAST Valid for 00 UTC of 27-09-97
850 hPa (vorticity*e-05)
48h FORECAST Valid for 00 UTC OF 28-09-97
850 hPa (vorticity*e-05)

FIG 27(c)

DEEP DEPRESSION CAUSED VAST DEVASTATION OVER 'DIGHA' (WEST BENGAL) ON THE NIGHT OF 19 AUGUST 1997