

Cyclones and depressions over north Indian Ocean during 1996*

1. Chief features

There were five cyclonic storms and three depressions over the Indian seas during the year 1996. One depression formed over the land in July.

Two cyclonic storms formed over the Arabian Sea and other three formed over the Bay of Bengal. Two cyclonic storms, one each in the Bay of Bengal and the Arabian Sea, formed in the month of June. Three cyclonic storms, two over the Bay of Bengal and one over the Arabian Sea, formed in post-monsoon season (October-December). Two storms over the Bay of Bengal (One in June and the other one in November) crossed Andhra Pradesh coast, while the third storm crossed Tamil Nadu coast. One storm over the Arabian Sea crossed south Gujarat coast while the other storm over the Arabian Sea in October dissipated over the west-central Arabian Sea.

Three depressions formed over the Bay of Bengal. One formed in May, intensified into a deep depression and crossed Bangladesh-Myanmar coast. The other two depressions formed in October. First one crossed Andhra Pradesh coast and the second crossed the coastal Indo-Bangladesh border. One depression formed over land in July.

Tracks of the systems are given in Fig. 1 and their brief history is given in Table 1.

Monthly frequencies are given in Table 2 and crucial ship observations are recorded in Table 3.

2. Pre-monsoon season (March-May 1996)

One depression formed during the season in the month of May.

2.1. Deep depression over the Bay (7-8 May)

A well-marked low pressure area formed over west-central and adjoining east-central Bay on the

evening of 5 May. It concentrated into a deep depression on 7 morning and lay over northwest Bay with its centre near $19.0^{\circ}\text{N}/89.0^{\circ}\text{E}$. The system, then, moved in a north-northeasterly direction and intensified into a deep depression by 1800 UTC of 7 with centre near $21.5^{\circ}\text{N}/92.5^{\circ}\text{E}$. The system moving in a northeasterly direction crossed Bangladesh-Myanmar coast near Cox's Bazar on the early morning of 8 and weakened rapidly into a well-marked low pressure area over Myanmar and adjoining parts of Mizoram and became less marked by 9 morning. System did not produce any severe weather over Indian region.

(i) *INSAT cloud features* — Estimated maximum intensity of the system was T 2.0 on Dvorak's scale from 1800 UTC of 7 to 0000 UTC of 8 May.

3. Monsoon season (June to September)

During the monsoon season one cyclonic storm formed over the Arabian Sea and one severe cyclonic storm formed over the Bay of Bengal. Both these storms formed during June. Only one monsoon depression formed over land in July.

3.1. Cyclonic storm over the Bay of Bengal (12-16 June 1996)

A depression formed over the southeast and adjoining southwest Bay on the evening of 12 June. It intensified into a deep depression with centre near $12.5^{\circ}\text{N}/83.0^{\circ}\text{E}$ on 13 morning. It moved in a northwesterly direction and lay over the southwest Bay about 200 km east of Chennai on 13 evening. The system further intensified into a cyclonic storm by 14 morning and lay centred near $14.0^{\circ}\text{N}/80.5^{\circ}\text{E}$. It then recurved in a north-northeasterly direction and lay about 70 km southeast of Kakinada on the morning of 15 June. Skirting the coast, the system moved in a north-northeasterly direction and crossed the coast near Vishakhapatnam around 0500 UTC of 16. The system, then rapidly weakened into a

*Compiled by : S.K. Dikshit, D.S. Desai and S.G. Bhandari, Meteorological Office, Pune - 411005, India

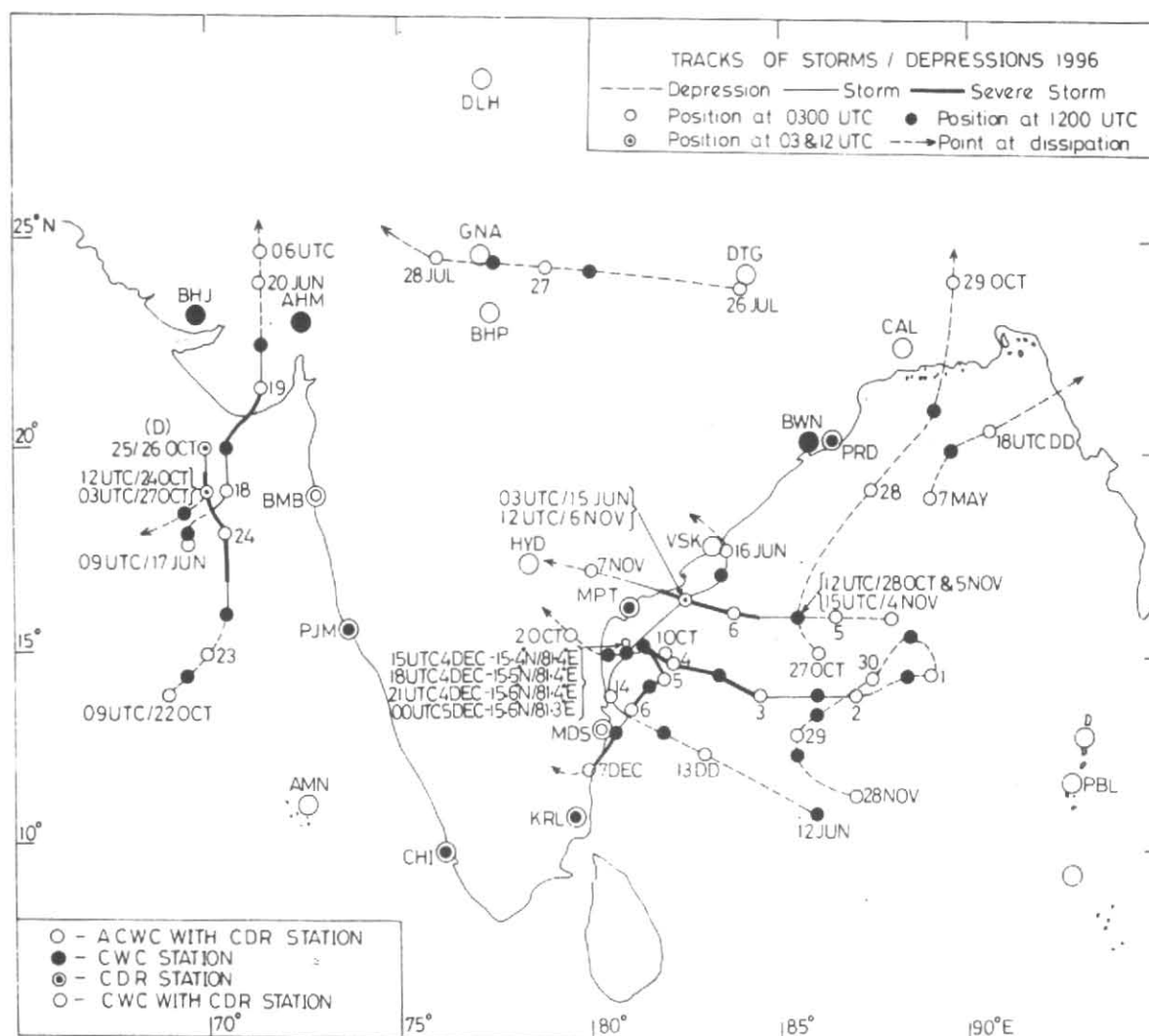


Fig. 1. Tracks of cyclonic storms/depressions during 1996

TABLE 1

Brief history of cyclonic storms and depressions over Indian seas and neighbourhood during 1996

S. No.	Type of system	Life period	Point of crossing of the coast	Minimum surface pressure (Estimated)	Maximum wind speed reported (Estimated)	Highest "T" No.
1.	DD	7-8 May	Bangladesh-Myanmar coast near Cox's Bazaar	-	-	2.0
2.	CS	12-16 June	Andhra Pradesh coast near Vishakhapatnam	986 hPa	60-80 kmph	2.5
3.	SCS	17-20 June	South Gujarat coast close to Diu	972 hPa	80-100 kmph	3.5
4.	D	26-28 July	-	-	-	-
5.	D	1-2 Oct	South Andhra Pradesh coast near Ongole	-	-	2.0
6.	SCS	22-27 Oct	(Did not cross the coast)	984 hPa	100-105 kmph	4.0
7.	DD	27-29 Oct	West Bengal-Bangladesh coast	-	-	2.0
8.	SCS (H)	5-7 Nov	Andhra Pradesh coast, 50 km south of Kakinada	974 hPa	140-150 kmph	4.5
9.	SCS (H)	28 Nov-7 Dec	North Tamil Nadu coast (after down grading to Severe cyclonic storm)	986 hPa	100 kmph	4.5

D - Depression, DD - Deep Depression, SCS - Severe cyclonic storm, SCS (H) - SCS with a core of hurricane winds

TABLE 2
Storm depression statistics 1996

Name of the system	Winter	Pre-monsoon			Monsoon				Post-monsoon			Total
	Jan and Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Over Bay of Bengal												
Depression/Deep Depression	-	-	-	1	-	-	-	-	2	-	-	3
Cyclonic Storm	-	-	-	-	1	-	-	-	-	-	-	1
Severe Cyclonic Storm	-	-	-	-	-	-	-	-	-	1	-	1
Severe Cyclonic Storm (CHW)	-	-	-	-	-	-	-	-	-	1	-	1
Total	-	-	-	1	1	-	-	-	2	2	-	6
Over Land												
Depression	-	-	-	-	-	1	-	-	-	-	-	1
Over Arabian Sea												
Depression	-	-	-	-	-	-	-	-	-	-	-	-
Cyclonic Storm	-	-	-	-	-	-	-	-	-	-	-	-
Severe Cyclonic Storm	-	-	-	-	1	-	-	-	1	-	-	2
Severe Cyclonic Storm (CHW)	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	1	-	-	-	1	-	-	2

well-marked low pressure area over north Andhra Pradesh coast by the evening of 16.

(i) *INSAT Cloud features and other observations—*

The system was mainly tracked by using INSAT imageries when the system was away from the coast. CDR Madras reported spiral bands on 14 June. CDR Machilipatnam and CDR Vishakhapatnam also reported spiral bands on 16. Hourly observations of Nellore, Ongole and Machilipatnam and radar fixes were very useful for fixing the centre of the system accurately.

Maximum intensity of the system derived from INSAT cloud imagery was T 2.5 on Dvorak's scale from 15 evening to 16 morning. Lowest estimated central pressure was 986 hPa at 1200 UTC of 15.

(ii) *Weather and damages —* Coastal districts of Tamil Nadu and Andhra Pradesh reported very heavy rain of the order of 20 to 25 cm from 14 to 17 June. Koida, a station in Khammam district in Andhra Pradesh, reported a record rainfall of 675 mm.

Coastal districts of Andhra Pradesh reported 68 human deaths and about 6000 houses damaged. Estimated loss is reported to be Rs. 82 crores.

In Tamil Nadu, 41 persons were killed, 4 fishing vessels were drowned, road and rail traffic was badly affected.

3.2. *Severe cyclonic storm (SCS) over the Arabian Sea (17-20 June 1996)*

A well-marked low pressure area formed over east-central Arabian Sea on 17 morning. The system concentrated into a depression and lay near 18.0°N/69.5°E on the evening of 17 June. The system intensified into a deep depression on 18 morning. It further intensified into a cyclonic storm with centre near 20.0°N/70.5°E, about 100 km south of Veraval on 18 evening. The system further intensified into a severe cyclonic storm on 18 night and crossed south Gujarat coast close to Diu during early hours of 19 (between 2200 and 2300 UTC). Thereafter, the system weakened into a cyclonic storm and lay centred near 21.5°N/71.5°E at 0300 UTC of 19. The system further weakened gradually over southwest Rajasthan into a well-marked low pressure area by evening of 20.

TABLE 3

Crucial ship observations during the storm periods						
Call sign	Date/Time (UTC)	Position		Wind		pppp (hPa)
		Lat. (°N)	Long. (°E)	Direction (°)	Speed (kt)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Cyclone over Bay of Bengal (12-16 June)						
S6EP	12/0600	6.0	86.8	260	21	1005.0
S6EP	12/1200	5.9	85.1	260	21	1003.3
FMPU	12/0600	4.9	58.4	240	19	1009.0
S6EP	13/0000	5.8	81.9	250	35	1004.8
VTKR	13/0900	16.5	85.8	110	25	997.6
S6EP	13/1200	6.7	79.0	270	18	1005.3
VVKV	13/1200	15.3	92.6	280	26	1001.4
P3ZZ6	14/0600	6.0	93.1	230	28	1007.0
OXWC	14/1200	6.0	93.1	220	05	1006.7
WGMJ	14/1200	5.7	88.0	250	24	1004.0
DLBB	15/0000	5.7	87.9	230	28	1005.0
P3ZZ6	15/0000	5.9	88.3	230	28	1003.0
S6EP	15/0600	13.3	71.2	270	33	1007.3
WGMJ	15/0600	5.8	93.4	230	16	1007.0
VVKZ	15/0600	12.1	74.3	290	33	1004.0
DLBB	15/1200	5.9	91.4	230	20	1006.8
VTJR	15/1200	17.6	88.5	160	18	996.5
OXWC	16/0000	5.8	84.1	240	18	1006.0
Severe Cyclonic Storm over Arabian Sea (17-20 June)						
S6EP	17/0000	19.5	64.5	310	18	999.3
VRCV	17/1200	17.6	64.6	280	30	996.1
DATA	14/1200	12.9	71.7	250	35	1000.0
VVRC	18/0000	15.3	67.8	260	38	996.1
VRCV	18/0600	14.8	69.8	240	30	999.0

(i) INSAT Cloud features and other observations — The system when away from the coast, was mainly tracked with the help of satellite imageries and a few observations of ONGC Rigs in the vicinity of the storm. Hourly observations of coastal stations of Gujarat, particularly hourly wind observations derived from automatic instrument of Gujarat Ambuja

TABLE 3 (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
VVPL	18/0600	14.4	71.0	250	30	-
ATKU	18/0900	18.9	72.5	180	35	992.2
9MWG	18/1200	13.3	67.9	110	06	1012.9
ATKU	18/1200	18.9	72.4	220	40	989.7
OXWC	18/1800	13.6	70.5	230	30	1004.5
OXWC	19/0600	15.9	68.9	220	24	1002.5
Severe Cyclonic Storm over Arabian Sea (22-27 October)						
SHIP	22/1200	13.8	68.5	320	35	1002.0
VSBN3	22/1200	18.9	65.1	090	20	1007.4
PJAB	22/1200	17.5	71.9	150	16	1005.5
D3 (Ship)	22/1800	14.9	67.4	360	20	1006.5
D1 (Ship)	22/1800	15.1	66.3	330	18	1006.9
VSBN3	22/1800	19.8	63.8	020	20	1011.3
V7AA4	23/0000	14.8	68.5	260	20	1003.8
GWAP	23/0000	15.5	67.2	340	25	1000.5
V7AA4	23/0600	12.8	69.2	260	16	1007.5
GWAP	23/0600	16.1	66.2	350	22	1007.6
V7AA4	23/1200	12.0	70.0	250	25	1006.6
MWPM2	23/1200	6.3	97.1	280	05	1009.1
HZXS	24/1200	16.1	66.3	050	36	1007.8
SHIP	24/1200	19.4	71.3	090	50	-
SHIP	24/1200	19.2	71.2	170	45	-
J8CVS	24/1800	19.2	65.8	040	18	1008.4
J8CVS	25/0600	17.6	68.2	040	18	1008.2
J8CVS	25.1200	16.6	69.5	230	18	1006.5
J8CVS	25.1800	15.7	70.6	230	18	1008.5
Severe Cyclonic Storm (CHW) over Bay of Bengal (28 Nov - 8 Dec)						
VVJV	29/0600	13.1	86.5	100	18	-

Cements Ltd., at Kodinar, were very helpful to decide the time and place of the system crossing the coast. Radar observations of CDR Bhuj were also useful in tracking the system on 19.

Highest intensity of the system was T 3.5 on Dvorak's scale between 18/1800 UTC and 19/0000 UTC. Estimated central pressure (ECP) was 980 hPa at 0000 hr of 19.

(ii) *Weather and damages* — Widespread rainfall with very heavy falls, of the order of 15 to 25 cm, was reported from the coastal districts of north Konkan, south Gujarat region and Saurashtra from 18 to 21 June. As per post-cyclone survey report, the maximum winds estimated was 100 to 120 kmph and storm surge estimation based on water levels at Dahaj and Mahua to the right of the track of the system was 3 to 4 m above astronomical level.

In all the 19 districts, 161 Talukas and 5573 villages were affected by the cyclonic storm in Gujarat. About 33 deaths of human lives and 2082 cattles were reported. Fourteen people and 31 cattles were killed in Thane, Ratnagiri and Mumbai districts due to heavy rains and gale force winds.

3.3. Land depression (26-28 July 1996)

A well-marked low pressure area formed over northwest Bay and neighbourhood, moved in a northwesterly direction and concentrated into a depression over land near Daltonganj at 0300 UTC on 26. Associated cyclonic circulation was extended upto mid-tropospheric levels. Then, it moved in a west-northwesterly direction and lay centred near 24.5°N/79.0°E, on 27 morning. The system was 50 km southeast of Kota on 28 morning and weakened into a low pressure area over south Rajasthan by the evening of 28 and later merged with the seasonal trough.

(i) *Rainfall* — The system caused widespread rains with heavy spells in west Madhya Pradesh on 26 to 28 and in Gujarat region on 27 to 29.

4. Post-monsoon season (October-December)

There were five intense cyclonic disturbances during the season. Out of these, three were cyclonic storms; one over the Arabian Sea and the two over the Bay of Bengal and two were depressions over the Bay of Bengal.

4.1. Depression over the Bay of Bengal (1-2 October)

A well-marked low pressure area over west-central Bay off south Andhra Pradesh coast concentrated into a depression on the morning of 1 October with centre near 15.0°N/82.0°E. It moved in a westerly direction and was centered near 15.0°N/80.5°E about 50 km

northeast of Nellore on the evening of 1. The depression crossed south Andhra Pradesh coast near Ongole by midnight of 1 October and lay close to Nandyal on 2 morning. It further moved in a west-northwesterly direction and weakened into a well-marked low pressure area by the evening of 2 over northern parts of Rayalaseema and adjoining north interior Karnataka. Moving in a west-northwesterly direction the system weakened further.

(i) *INSAT Cloud features* — Maximum intensity of the system derived from INSAT cloud imageries was T 2.0 on Dvorak's scale.

(ii) *Weather and damages* — Widespread rain with spells of heavy rainfall occurred in coastal districts of Andhra Pradesh during 30 September to 2 October. Due to heavy rains, 23 people were reported dead in coastal districts of Andhra Pradesh.

4.2. Severe cyclonic storm (SCS) over the Arabian Sea (22-27 October 1996)

A well-marked low pressure area formed over east-central Arabian Sea on the morning of 21. It concentrated into a depression and was centred near 14.0°N/69.0°E at 0900 UTC of 22. It further intensified into a deep depression at 1200 UTC of 22 and into a cyclonic storm at 1200 UTC of 23 and was centred near 16.0°N/70.5°E. The system moved northwards and further intensified into a severe cyclonic storm at 1800 UTC of 23. Moving in a northerly direction the system lay centred near 18.0°N/70.5°E at 0300 UTC of 24. It then moved in a north-northwesterly direction and by the morning of 25, it weakened into a cyclonic storm and lay off Gujarat coast near 20.0°N/70.0°E. The system then weakened into a depression by 25 evening and remained stationary upto 26 evening. Later, it moved in a southerly direction and weakened into a well-marked low pressure area by 28 morning over the west-central Arabian Sea. The system moved further southwestwards and became unimportant.

(i) *INSAT Cloud features and other observations*— The system was mainly tracked using INSAT observations. However, a few crucial ship's observations (Table 3) within the storm field were very useful for fixing the centre of the system. Radar observations of CDR, Mumbai and ONGC Rigs' observations were also helpful

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IMDPS IMD NEW DELHI ## BAY CYCLONE ##

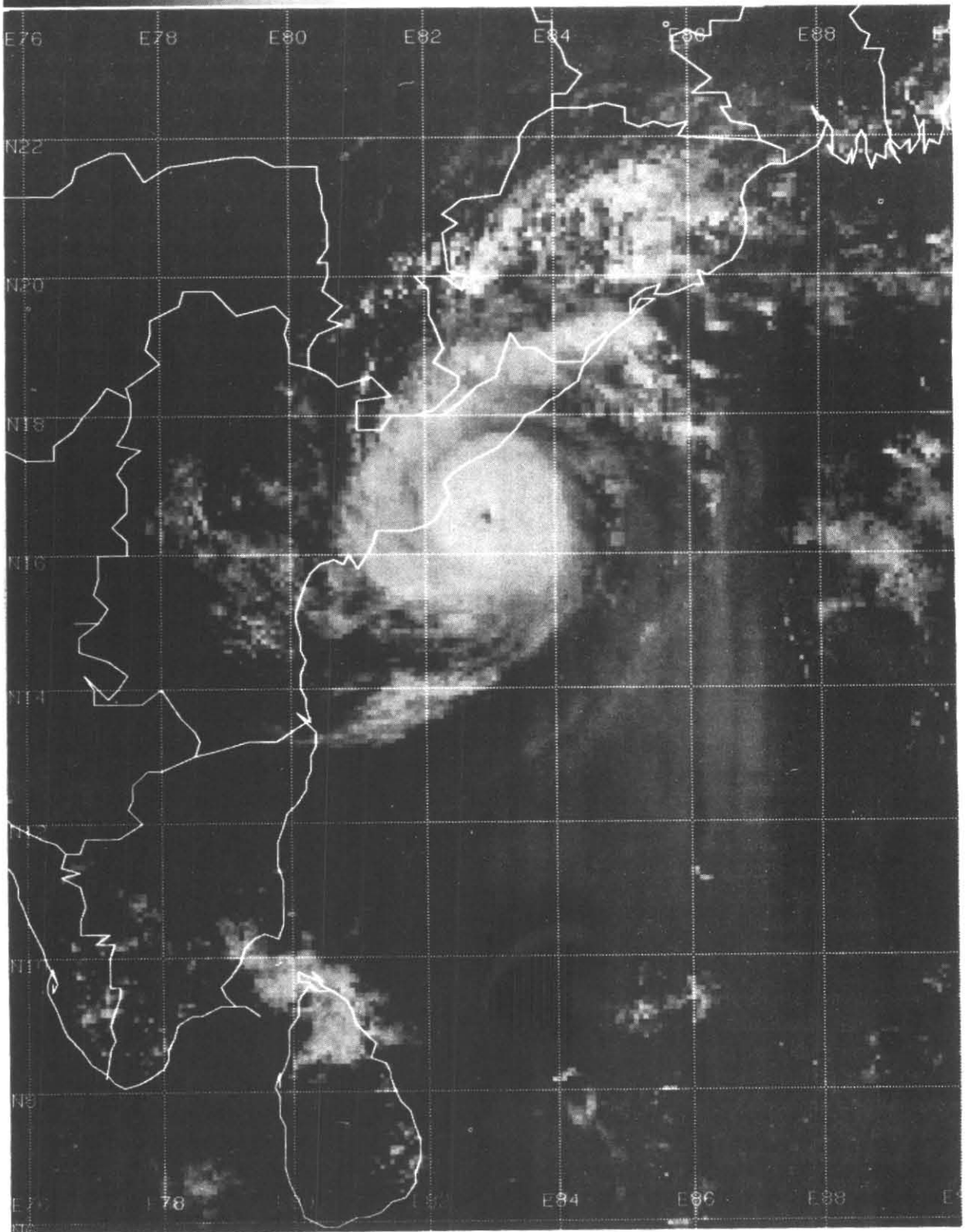


Fig. 2. INSAT-1D (visible) cloud picture of 6 November 1996 at 0900 UTC

in fixing the centre. CDR, Mumbai reported "open eye" of the cyclone from 24/1000 UTC to 24/1200 UTC.

Maximum intensity of the system derived from INSAT imageries was T 4.0 from 24/0600 UTC to 24/1400 UTC. Lowest estimated central pressure (ECP) was 990 hPa at 1200 UTC of 24.

- (ii) *Weather and damages* — Amreli, Junagarh, Bhavnagar, Rajkot, Ahmedabad and Kheda districts of Gujarat reported widespread rainfall on 25 and 26. Eleven fishing boats were missing off Veraval port and about 50 boats were stranded in the high sea due to strong winds.

4.3. *Deep depression over Bay of Bengal (27-29 October 1996)*

A well-marked low pressure area formed over the southeast Bay and the adjoining parts of east-central Bay on the morning of 25. It concentrated into a depression over the east-central Bay with centre near 15.0°N/86.0°E on the morning of 27. The system moved initially northwestward and then northeastward and further intensified into a deep depression at 1800 UTC and was located near 19.0°N/87.5°E about 400 km south-southwest of Calcutta on 28 morning. The system moved fast in a northeasterly direction and crossed coast near Indo-Bangladesh border around midnight of 28 and weakened into a depression with centre near 24.0°N/89.5°E on the morning of 29. The system, further weakened over north Bangladesh and adjoining Meghalaya.

- (i) *INSAT Cloud features* — INSAT cloud imageries were useful for determining the intensity and movement of the system. Maximum intensity of the system was reported T 2.0 from 28/0300 UTC to 28/1800 UTC.

- (ii) *Weather and damages* — Widespread rain with spells of heavy rains was reported in Gangetic West Bengal on 28 and 29. Storm surge of 3m was also reported.

Heavy rains caused breaches in embankments and affected 1,60,000 people in north 24 Paraganas district (W.B.). Nine fishing trawlers/boats and 100 fishermen were reported missing off West Bengal coast. Paddy crop and a number of houses were damaged and 14 lives were lost in coastal Gangetic West Bengal.

As per press reports, at Cox's Bazaar in Bangladesh, 20,000 people became homeless due to inundation. Also, storm surge of nearly 3 m was reported.

4.4. *Severe cyclonic storm with a core of hurricane winds over Bay of Bengal (5-7 November 1996)*

A depression formed over the east-central and adjoining west-central Bay on the evening of 4. The system moved westwards and intensified rapidly into a deep depression and was centred near 16.0°N/86.5°E on the morning of 5 November. It continued to move in a westerly direction and intensified into a cyclonic storm by 0900 UTC of 5. Thereafter, it moved in a west-northwesterly direction and further intensified into a severe cyclonic storm on the morning of 6 and into a severe cyclonic storm with a core of hurricane winds at 0900 UTC of 6 with its centre near 16.3°N/83.0°E. Moving in a west-northwesterly direction, it crossed the Andhra Pradesh coast around 1600 UTC of 6 about 50 km south of Kakinada and weakened rapidly into a deep depression and lay centred near 17.0°N/80.0°E close to Khammam on the morning of 7. Subsequently, moving west-northwestards it weakened further.

- (i) *INSAT cloud features and other observations*— During the initial stages of the system, it was mainly tracked by INSAT observations. As the system approached the coast, it was tracked by CDRs at Machilipatnam and Vishakhapatnam very accurately. "Eye" of the system was reported by both these CDRs. Maximum intensity of the system as derived from INSAT observations was T 4.5 from 06/0800 UTC to 06/1500 UTC. Lowest central pressure of 976 hPa was estimated at 06/1200 UTC. Fig. 2 is the satellite cloud photograph taken at 0900 UTC of 6 November 1996.

- (ii) *Weather and damages* — Heavy rains occurred in many districts of coastal Andhra Pradesh, particularly, in east and west Godavari districts on 6, 7 and 8 November. Strong winds with an estimated speed reaching 150-200 km in gusts, affected east and west Godavari districts. A microwave tower at Telephone Exchange, about 30 km southwest of Kakinada, collapsed due to strong winds. Tidal waves of 2.6m were reported at Kakinada coast.

The system caused extensive damages to property and took a toll of about 1058 human lives in coastal Andhra Pradesh. More than 1677 fishermen were missing and 6800 fishing boats were also damaged.

4.5. *Severe cyclonic storm with a core of hurricane winds (28 November-8 December 1996)*

The system formed as a depression over the southeast Bay on 28 morning and intensified into a deep depression on 29 morning when its centre was near $13.0^{\circ}\text{N}/85.5^{\circ}\text{E}$. The system, then, moved in a northeasterly direction till 30th evening. The system, then, had an unusual southeasterly movement and was centred near $14.5^{\circ}\text{N}/89.0^{\circ}\text{E}$ on the morning of 1 December. Then it moved in a westerly direction and intensified into a cyclonic storm on the early morning of 2, when it was centred near $14.0^{\circ}\text{N}/87.0^{\circ}\text{E}$.

The system further intensified into a severe cyclonic storm with a core of hurricane winds by the evening of 3 and was centred near $14.5^{\circ}\text{N}/83.5^{\circ}\text{E}$. It moved in a west-northwesterly direction and lay about 180 km southeast of Machilipatnam of Andhra Pradesh coast on the morning of 4. After 4th evening, the system weakened into a severe cyclonic storm and moved southwards unusually and was centred near $14.5^{\circ}\text{N}/82.0^{\circ}\text{E}$ on the morning of 5. Moving in a southwesterly direction, the system was about 115 km from Chennai on 6 morning. Thereafter, it crossed the north Tamil Nadu coast between 1600

UTC and 1700 UTC of 6 and lay as cyclonic storm over land near Pondicherry at 1800 UTC of 6. It weakened into a well-marked low pressure area on 7 over north Tamil Nadu.

(i) *INSAT cloud features and other observations—*

The system was mainly tracked by using INSAT observations when it was out over the sea. CDR Chennai observations were helpful for fixing centre of the storm when it was close to the coast. The maximum intensity of the system was T 4.5 on Dvorak's scale from 03/1200 UTC to 04/2100 UTC. Lowest estimated central pressure was 986 hPa at 1200 UTC on 3 December.

(ii) *Weather and damages —* Widespread rainfall occurred over coastal Tamil Nadu with spells of heavy rainfall. Gale force winds exceeded 100 kmph over north Tamil Nadu coast. However, the system did not cause any damage to life.

This system made first loop over central Bay of Bengal near long 87.0°E on the night of 30 November and later had a second loop near the coast of Andhra Pradesh during the night of 4 December. Thus, the system created a unique history in its movement over the Bay of Bengal. There is no parallel example in the past when a cyclone executed two loops in the Bay of Bengal.