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Cyclones and depressions over north Indian Ocean during 1998*

1. Chief features

There were six cyclonic storms and six deep depressions over the north Indian Ocean during the year 1998. In addition, one deep depression also formed over the land in September.

During the year, three cyclonic storms and three deep depressions formed over the Bay of Bengal and same number of cyclonic storms and depressions also formed over the Arabian Sea. In addition, one deep depression formed over land. Three cyclonic storms (one over the Arabian Sea (4-10 June 1998) and two over the Bay of Bengal (13-16 November and 19-22 November 1998) reached the intensity of very severe cyclonic storm. Seasonwise, one severe cyclonic storm and one deep depression formed in the month of May, in pre-monsoon season, three deep depressions and a very severe cyclonic storm formed during the monsoon season and two very severe cyclonic storms, one severe cyclonic storm, one cyclonic storm and three deep depressions formed in the post- monsoon season. Out of 3 storms over the Arabian Sea, two crossed Gujarat coast and third moved away westwards and crossed the Saudi Arabia coast. One of the storms (4-10 June 1998) caused heavy damage over Gujarat State. Out of 3 storms over the Bay of Bengal, one (17-20 May 1998) crossed Bangladesh coast, second (13-16 November 1998) crossed Andhra Pradesh coast and caused little damage. The third storm (19-22 November 1998) crossed West Bengal-Bengladesh coast near Sunderban area and caused some damage over there.

Tracks of these systems are given in Fig. 1. Their brief history and monthly distribution are given in Tables 1 and 2 respectively. In Table 3 crucial ship observations are given.

2. Pre-monsoon season (March-May)

2.1. *Severe cyclonic storm over the Bay of Bengal (17-20 May 1998)*

2.1.1. *Life cycle*

A well-marked low pressure area formed on 17 morning over southern parts of central Bay and adjoining southwest Bay near Lat. 14.0° N/Long. 88.0° E. It concentrated into a depression at 0900 UTC of 17 near Lat. 14.0° N/Long. 88.0° E and lay on 18 at 0300 UTC near Lat. 15.5° N/Long. 88.5°E. Moving in a northnortheasterly direction, it intensified into a deep depression in the afternoon of 18 and into a cyclonic storm at 0900 UTC of 18 and was centred at 1200 UTC of 18 near Lat. 17.0° N/89.5°E and on 19 at 0300 UTC it lay near Lat. 19.5° N/Long. 90.5°E. Continuing, its northnorthesterly movement, it intensified into a severe cyclonic storm at 1200 UTC of 19 near Lat. 20.5° N/Long. 90.5°E. It crossed Bangladesh coast in the morning of 20 and weakened into a deep depression at 0300 UTC of 20 near Lat. 22.0° N/Long. 92.5°E, about 50 kms northeast of Cox's Bazar. The deep depression moved in a northeasterly direction and weakened into a depression at 1200 UTC of 20 near Lat. 23.5° N/Long. 93.0° E and further weakened into a low pressure area over Assam & Meghalaya on 21.

2.1.2. *Satellite cloud features and other observations*

The system was tracked mainly with the help of INSAT Cloud Imagery (ICI) throughout. When the system was close to Bangladesh coast, coastal observations of Bangladesh were helpful. Bangladesh bulletins giving the radar observations were helpful in finding the time and place of landfall. Peak intensity of T 3.5 was from 0600 UTC of 19 to 0000 UTC of 20 on D'vorak's scale.

2.1.3. *Weather and damages*

As the system crossed Bangladesh coast, the system did not cause any damage over India. However, fairly widespread rain occurred over Nagaland, Manipur, Mizoram & Tripura in association with the depression near Aijwal (in Mizoram).

2.2. *Deep depression over the Arabian Sea (28 May 1998)*

2.2.1. *Life cycle*

A well-marked low pressure area formed near Lat. 14.0° N/Long. 60.0°E over west- central and adjoining east-central Arabian Sea on the evening of 27. It rapidly concentrated into a deep depression and lay centred at 0300 UTC of 28 near Lat. 13.5° N/Long. 60.0°E. It moved in a westerly direction and lay centred as deep depression near

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TABLE 1

Brief history of cyclonic storms and depressions over the Indian seas and neighbourhood during 1998

S. No.	Type of system	Life period	Point of crossing the coast	Estimated central pressure (hPa)	Recorded max. wind	Highest "T" No. (Estimated)
1.	SCS	17-20 May	Bangladesh coast between Sitakundu and Chitagong	970	55 kt	3.5
2.	DD	28 May	Dissipated over WC Arabian sea	-	-	-
3.	VSCS	4-10 June	Gujarat coast near Porbandar	962	98 kt recorded at AF Jamnagar	5.0
4.	DD	13-15 June	N. Andhra coast very close to Visakhapatnam	992	30 kt	2.0
5.	DD	14-18 Sept	-	-	-	-
6.	DD	30 Sept	Dissipated over WC and adjoining NW Arabian sea	-	-	-
7.	DD	6-9 Oct	Dissipated over EC and adjoining WC Arabian sea	-	-	2.5
8.	CS	11-17 Oct	Gujarat coast near Veraval	996	-	2.5
9.	DD	13-15 Oct	Andhra coast near Narsapur	-	-	2.0
10.	DD	26-30 Oct	Dissipated near 300 kms SE of Machilipatnam	-	-	2.0
11.	VSCS	13-16 Nov	N. Andhra coast just south of Visakhapatnam	998	-	4.5
12.	VSCS	19-22 Nov	West Bengal coast between Sagar Island and Sundarban area of West Bengal	984	80- 100 kmph	4.0
13.	SCS	13-17 Dec	Dissipated over EC Arabian sea	996	-	3.5

D- Depression, DD- Deep depression, CS- Cyclonic storm, SCS- Severe cyclonic storm, VSCS- Very Severe cyclonic storm

TABLE 2

Storms/depressions statistics 1998

Name of the system	Winter		Pre-monsoon			Monsoon				Post-monsoon			
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Over Bay of Bengal													
Deep depression	-	-	-	-	-	1	-	-	-	2	-	-	3
Cyclonic storm	-	-	-	-	-	-	-	-	-	-	-	-	-
Severe cyclonic storm	-	-	-	-	1	-	-	-	-	-	-	-	1
Very severe cyclonic storm	-	-	-	-	-	-	-	-	-	-	2	-	2
Total	-	-	-	-	1	1	-	-	-	2	2	-	6
Over land													
Deep depression	-	-	-	-	-	-	-	-	1	-	-	-	1
Over Arabian Sea													
Deep depression	-	-	-	-	1	-	-	-	-	1	-	-	3
Cyclonic Storm	-	-	-	-	-	-	-	-	1	1	-	-	1
Severe cyclonic storm	-	-	-	-	-	-	-	-	-	-	-	1	1
Very severe cyclonic storm	-	-	-	-	-	1	-	-	-	-	-	-	1
Total	-	-	-	-	1	1	-	-	1	2	-	1	6

Lat. 13.5° N/Long. 59.0°E. It further moved in a westerly direction and weakened into a low pressure area over western parts of west-central Arabian Sea by 29 morning.

2.2.2. *Weather and damages*

Since the system was far awa y from the land, it did not cause any damage over Indian land.

3. Monsoon season (June-September)

3.1. *Very severe cyclonic storm over the Arabian Sea (4-10 June 1998)*

3.1.1. *Life cycle*

A low pressure area formed over southeast Arabian Sea and adjoining Lakshadweep area on 2 evening and became well-marked on 4 with its central region near Lat. 11.0° N/Long. 71.0° E. It concentrated into a depression at 0900 UTC of 4 and further intensified into a deep depression at 1200 UTC of 4 June near Lat. 11.0° N/Long 69.0°E. It further intensified into a cyclonic storm in the evening of 5 and moved in a northnorthwesterly direction and at 0300 UTC of 6 it lay near Lat. 12.5° N/Long. 69.5°E, about 560 kms southwest of Goa. It further intensified into a severe cyclonic storm at 0900 UTC of 6 and at 1200 UTC of 6 it lay near Lat. 13.0° N/Long. 69.0°E and moved in a north-northwesterly direction and lay at 0300 UTC of 7 near Lat. 14.5° N/Long.68.0°E, about 650 kms westsouthwest of Goa. It further intensified into a very severe cyclonic storm and lay at 1200 UTC of 7 near Lat. 16.0° N/Long. 68.0° E. At 0300 UTC of 8, it lay near Lat. 18.0° N/Long. 68.0° E, about 400 kms southwest of Veraval. Then, it moved in a north-northeasterly direction and crossed Gujarat coast near Porbandar on 9 morning and lay as a very severe cyclonic storm about 50 kms north-northeast of Porbandar on 9 morning. It moved in a northnortheasterly direction and weakened into a severe cyclonic storm and further weakened into a depression and lay at 0300 UTC of 10 near Lat. 26.5° N/Long. 73.5° E, about 50 kms northeast of Jodhpur. It further weakened into a low pressure area over Punjab and adjoining parts of Himachal Pradesh.

3.1.2. *Satellite cloud features and other observations*

Maximum intensity reported by ICI was T 5.0 at 0600 UTC of 8. "Eye" also was clearly visible within the CDO at the same time. The system was tracked mainly by INSAT

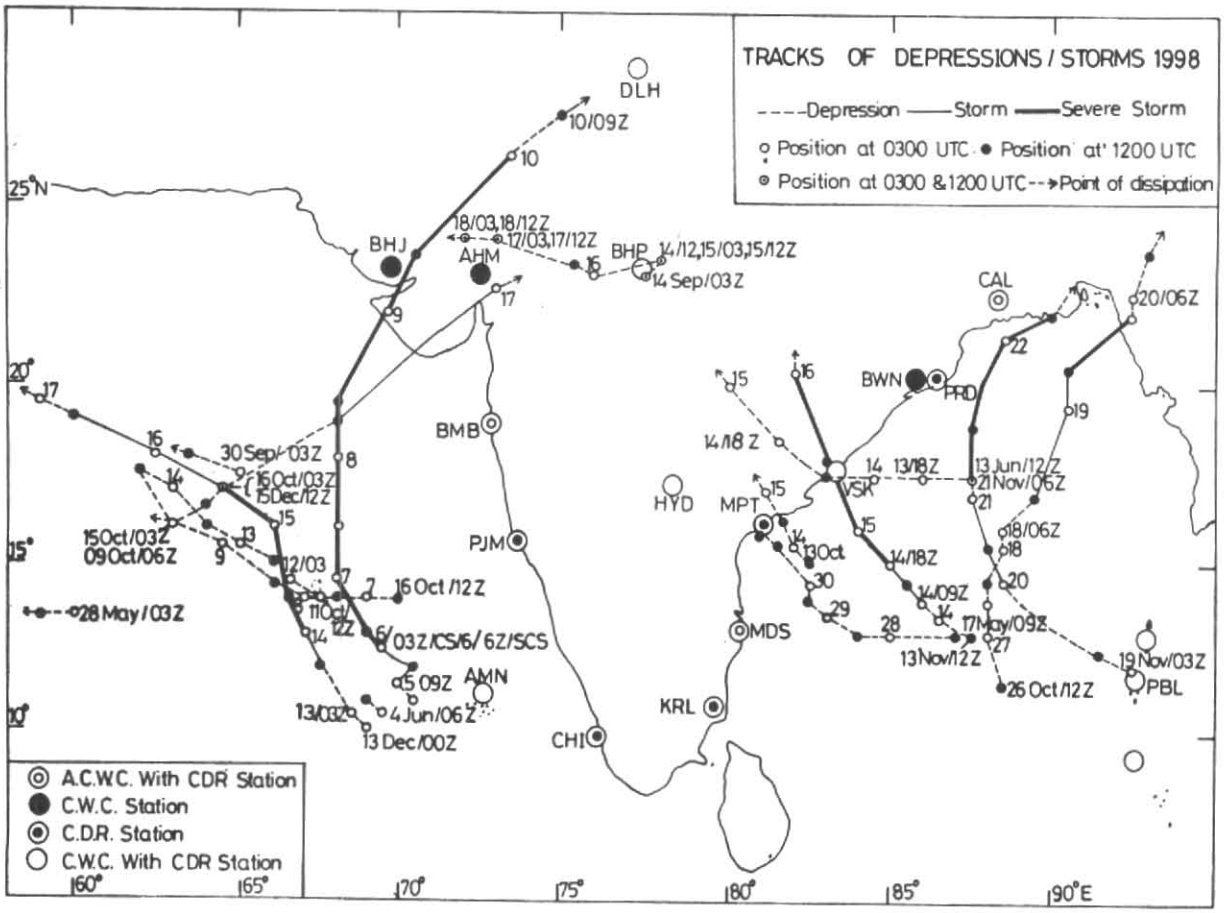

Fig. 1. Tracks of cyclonic storms/depressions during 1998

imageries, while out at Sea. CDR Bhuj reported the centre of the system at 0000 UTC, 0100 UTC and 0200 UTC of 9. CDR Bhuj also reported "partial eye" of the system at 0300 UTC of 9 (not on real time basis). Thus, radar observations helped in fixing the centre of the system and also the time of landfall point of the system. Coastal observations of Porbandar, Jamnagar and Kandla agreed very well with radar and INSAT fixes. Fig. 2 is the satellite cloud photograph of Arabian cyclone at 0600 UTC of 8 June 1998.

The lowest estimated central pressure was 962.0 hPa at Sea at 0900 hr (IST) of 9. IAF Jamnagar reported maximum wind of 98 kts at 0900 hrs (IST) of 9. Fig. 3 shows the radar picture at 0200 UTC of 9.

3.1.3. *Weather and damages*

According to the report given by Gujarat Government, death toll in the cyclone was as high as 1173 with another 1774, missing and feared to have been washed away. More than 2.5 lakh houses have been destroyed or damaged. The total extent of damage to the state of Gujarat was of the order of Rs. 190 crores.

3.2. *Deep depression over Bay of Bengal (13-15 June 1998)*

3.2.1. *Life cycle*

A well-marked low pressure area formed over northern parts of west-central and adjoining east-central Bay on the morning of 13. It concentrated into a depression and was centred at 1200 UTC of 13 near Lat. 17.5° N/Long. 87.5° E. It moved in a westerly direction and further intensified into a deep depression and was centred at 1800 UTC of 13 near Lat. 17.5° N/Long. 86.0° E. Continuing its westerly movement, it lay as a deep depression at 0300 UTC near Lat. 17.5° N/Long. 84.5° E of 14. The deep depression then crossed north Andhra coast, very close to Visakhapatnam (little south of Visakhapatnam) between 1300 and 1400 UTC of 14 and weakend into a depression and lay centred at 1800 UTC of 14 near Lat. 18.5° N/Long. 81.5° E. It then moved

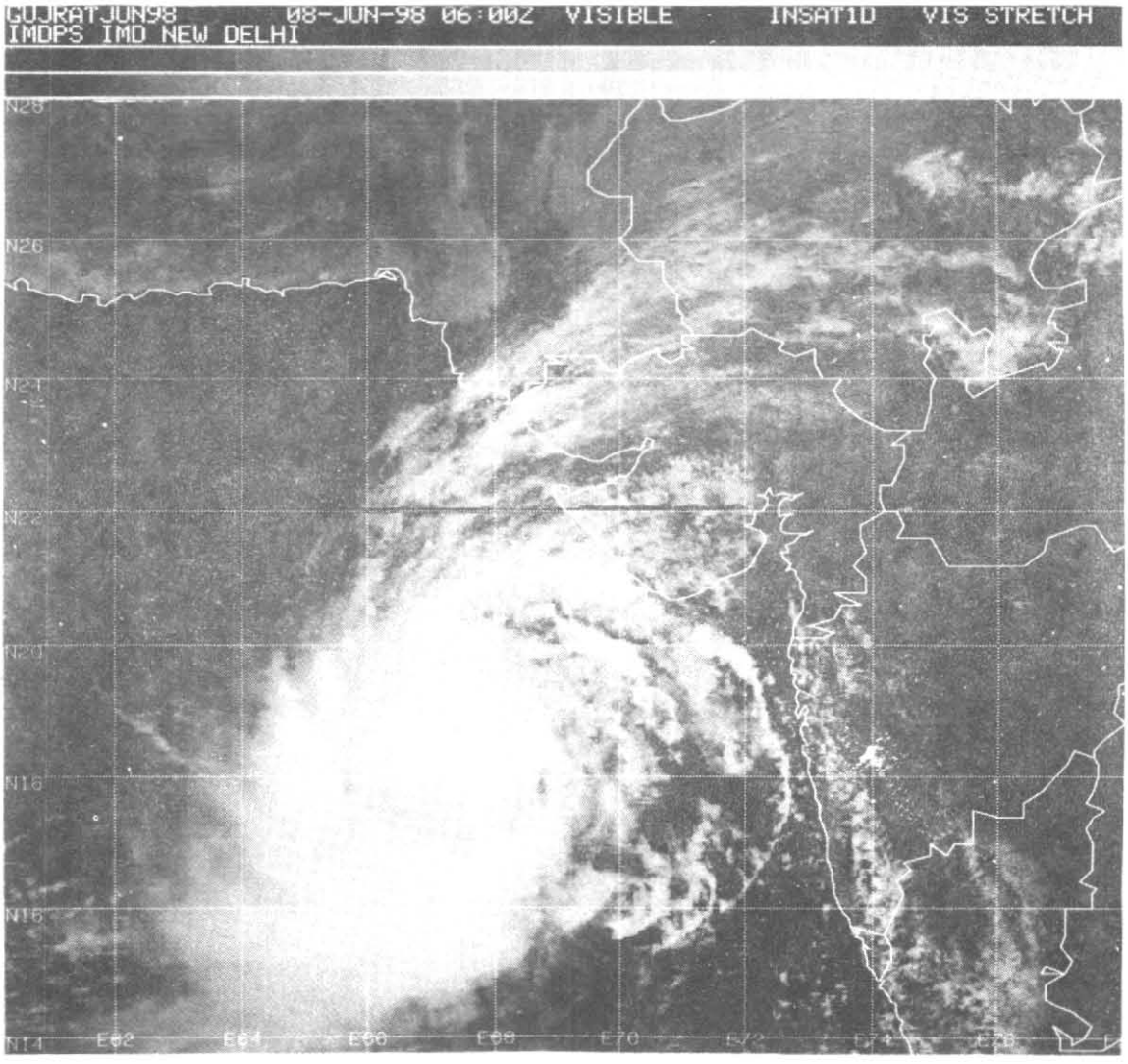

Fig. 2. INSAT-1D(visible) cloud picture of 8 June 1998 of 0600 UTC

in a northwesterly direction and lay centred at 0300 UTC of 15 as a depression near Lat. 20.0° N/Long. 80.0° E. It further moved in a northwesterly direction and weakened into a low pressure area over Vidarbha by 15 afternoon.

3.2.2. *Satellite cloud features*

INSAT reported peak intensity of T 2.0 from 1500 UTC of 13 to 0400 UTC of 14 on D'vorak's scale.

3.2.3. *Weather and damages*

Widespread rainfall occurred over Andhra Pradesh and adjoining south Orissa on 14 and 15.

3.3. *Land depression over west Madhya Pradesh (14-18 September 1998)*

3.3.1. *Life cycle*

A well-marked low pressure area moved over north Vidarbha and adjoining parts of west Madhya Pradesh on the evening of 13. It concentrated into a depression and lay centred at 0300 UTC of 14 near Lat. 23.0° N/Long. 77.5°E, about 50 kms north of Hoshangabad. The system did not show any appreciable movement and lay centred at 1200 UTC of 14 near Lat. 23.5° N/Long. 78.0° E. It then remained

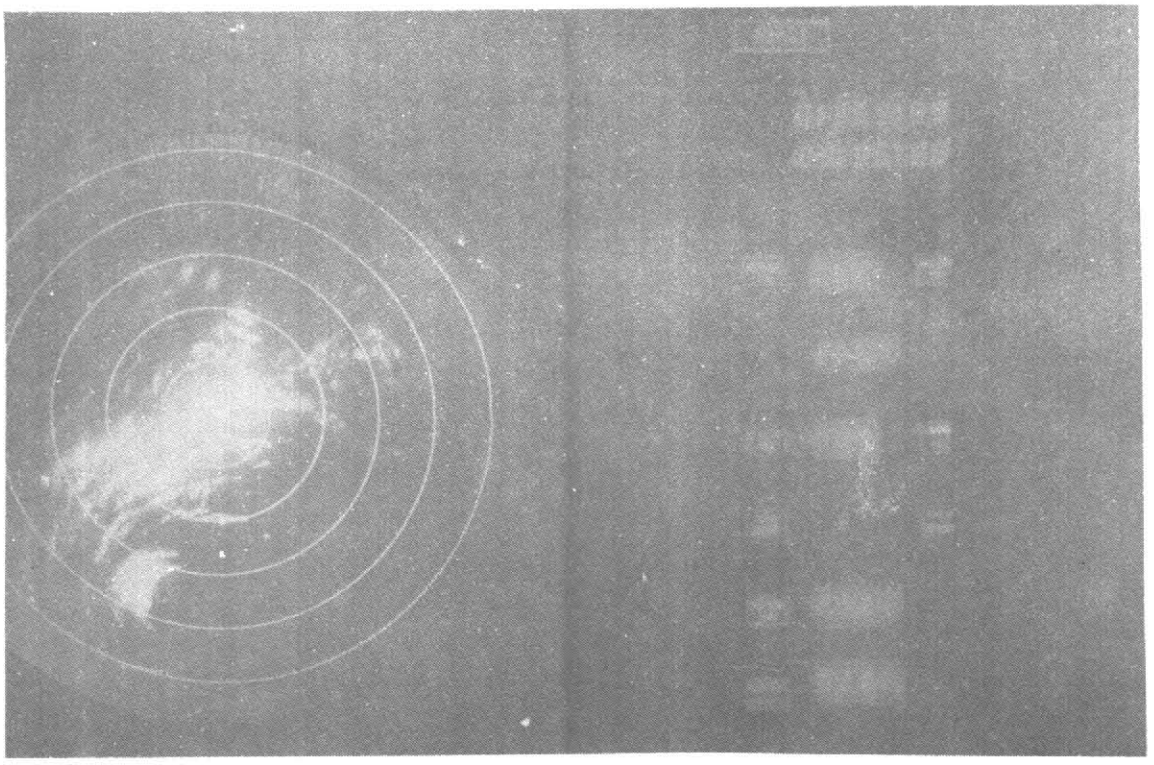

Fig. 3. Radar picture of CDR Bhuj at 0200 UTC of 9 June 1999

practically stationery and intensified into a deep depression and was centred near Lat. 23.5° N/Long. 78.0°E. The system then changed its direction of movement and moved in a westerly direction and lay centred at 0300 UTC of 16 as a deep depression near Lat. 23.0° N/Long. 76.0° E. It moved in a westnorthwesterly direction and weakened into a depression and lay centred at 1200 UTC of 16 near Lat. 23.3° N/Long. 75.5° E, near Ujjain. Continuing westnorthwesterly movement, it lay centred at 0300 UTC and 1200 UTC of 17 near Lat. 24.0° N/Long. 73.0° E, close to Idar. Further moving in a westnorthwesterly direction, it lay as a depression near Deesa at 0300 UTC and at 1200 UTC of 18 near Lat. 24.0° N/Long. 72.0° E. It then moved in a westerly direction and weakened into a well-marked low pressure area over north Gujarat Region and adjoining parts of west Rajasthan.

3.3.2. *Weather and damages*

The system caused widespread rainfall over Madhya Pradesh, Vidarbha, Gujarat Region and south Rajasthan.

3.4. *Deep depression over the Arabian Sea (30 September 1998)*

3.4.1. *Life cycle*

A low pressure area moved into east-central Arabian Sea from peninsular India and became well-marked over east-central and adjoining west-central Arabian Sea on the evening of 29. It concentrated into a deep depression centred at 0300 UTC of 30 near Lat. 17.5° N/Long. 65.0°E. It moved in a westnorthwesterly direction and was centred at 1200 UTC of 30 as a deep depression near Lat. 18.0° N/Long 63.5° E. It further moved in a westnorthwesterly direction and weakened into a low pressure area over northern parts of west-central Arabian Sea.

4. Post-monsoon season (October-December)

4.1. *Deep depression over Arabian Sea (6-9 October 1998)*

4.1.1. *Life cycle*

A well-marked low pressure area formed over southeast Arabian Sea and neighbourhood. It concentrated into a depression and centred at 1200 UTC of 6 near Lat. 14.0°

TABLE 3

Crucial ship observations during the storm periods

Call sign (1)	Date/Time (UTC) (2)	Position		Wind		PPPP (hPa) (7)
		Lat. (°N) (3)	Long(°E) (4)	Direction(°) (5)	Speed (kt) (6)	
		Severe cyclonic storm over Bay of Bengal (17-20 May)				
VTBX	18/0600	20.0	86.8	050	20	1000.6
VTBX	18/1200	11.8	85.3	220	30	1002.2
		Very severe cyclonic storm over Arabian Sea (4-10 June)				
3FFI	04/0600	8.7	69.9	240	26	1008.4
ELVO5	04/0600	9.4	68.0	270	16	1012.5
ELVO5	04/1200	8.9	69.9	300	18	1010.0
DDPH	05/1200	13.4	59.2	250	21	1006.5
MWSS6	06/1800	16.4	66.1	320	12	1011.6
VWPN	07/0600	16.6	72.6	170	32	1004.4
PGDE	08/0000	17.2	59.4	220	26	1006.8
S6JQ	08/0600	9.3	69.9	230	25	1009.3
V7AJ2	09/0600	11.1	71.0	270	39	1010.3
DATKO	09/0000	16.7	69.3	190	30	1000.1
V7AG2	09/1200	12.2	71.0	270	39	1006.9
DATKED	09/1200	16.0	70.3	180	20	1001.6
ZCBF	10/0600	10.1	64.9	250	20	1011.0
DQLM	10/1200	13.5	49.1	240	22	1001.2
DQLL	10/1200	21.9	59.9	210	24	999.0
		Cyclonic storm over Arabian Sea (11-17 Oct)				
PGNE	14/0000	15.3	68.7	220	22	1005.6
PDHP	15/1200	10.2	60.4	250	18	1007.8
PDHP	16/0000	9.2	65.1	250	20	1007.8
VVPG	16/0600	21.2	65.8	040	35	1007.6
PDPH	16/0600	8.7	67.5	240	18	1012.2
SHIP	160600	16.0	63.0	290	30	1002.5
ECRZ	16/1200	11.5	60.0	270	16	1008.0
		Very severe cyclonic storm over Bay of Bengal (13-16 Nov)				
PGNE	14/0600	5.8	85.8	230	14	1008.9
ATUJ	14/1200	5.9	85.9	270	20	1007.7
ATUJ	15/1200	5.8	80.9	260	18	1009.1
PCSS	15/1200	5.6	82.4	250	20	1008.9
DHEF	16/0000	5.8	83.8	240	34	1009.5
		Very severe cyclonic storm over Bay of Bengal (19-22 Nov)				
PDHU	19/0000	5.9	88.6	270	20	1004.5
SMUX	20/0000	14.3	81.0	170	15	1008.4
MSDM7	21/0000	5.9	88.6	230	15	1009.7
VVJT	21/0600	17.8	85.3	320	35	1005.5
DGRF	21/1200	5.8	89.7	250	13	1010.8
PGND	22/0000	5.9	87.0	230	14	1011.2
VWLF	22/0600	8.5	89.2	250	12	1010.4
		Severe cyclonic storm over Arabian Sea (13-17 Dec)				
VSBU3	12/1800	9.5	67.2	350	25	1002.1
C60T7	12/1800	10.5	70.8	150	27	1006.2
C60T7	13/0000	10.8	70.8	140	27	1005.9
C60T7	13/0600	11.2	70.9	120	27	1009.0
3FE16	13/0600	9.0	68.3	220	56	1002.9
C60T7	14/0000	11.9	70.5	160	27	1007.0
WWXB	14/0600	5.6	68.5	250	35	1011.3
C60T7	14/0600	12.1	70.5	160	24	1008.4
C60T7	14/1800	12.5	70.3	180	27	1009 1
JBEL	15/0000	17.6	63.9	020	28	1005.0
JBEL	15/0600	16.1	63.9	340	33	1003.0
JBEL	15/1200	15.0	64.7	280	29	1010.0
PCSS	16/0000	17.6	66.4	160	29	1009.2
9VFC	16/0000	19.7	66.0	090	48	1008.4
PCSS	16/0600	19.1	64.7	150	24	1011.8
PCSS	16/1200	20.7	63.0	150	24	1010.9
PCSS	16/1800	22.1	61.2	060	24	1014.2

N/Long. 70.0° E. It moved in a westerly direction and further intensified into a deep depression and lay centred at 0300 UTC of 8 near Lat. 14.0° N/Long. 67.0 °E. Then, it moved in a westnorthwesterly direction and lay centred at 1200 UTC of 8 as a depression near Lat. 14.5° N/Long. 66.0°E. Then, it moved in a northwesterly direction and lay centred

at 0300 UTC of 9 near Lat. 15.5° N/Long. 64.5° E. Continuing its northwesterly movement, it weakened into a depression and lay centred at 0600 UTC of 9 near Lat. 16.0° N/63.0° E. It, then moved in a northwesterly direction and weakened into a low pressure area over the sea area.

4.1.2. *Satellite cloud features*

INSAT reported peak intensity of T 2.5 from 1000 UTC of 8 to 0000 UTC of 9 on D'vorak's scale.

4.2. *Cyclonic storm over Arabian Sea (11-17 October 1998)*

4.2.1. *Life cycle*

A well-marked low pressure area formed on 10 over east-central and adjoining Southeast Arabian Sea off Karnataka-north Kerala coast. It concentrated into a depression, at 1200 UTC of 11 near Lat. 14.0° N/Long. 67.5° E and centred at 0300 UTC of 12 near Lat. 14.5° N/Long. 66.5° E. It intensified into a deep depression at 0900 UTC of 12 near Lat. 14.5° N/Long. 66.5° E and was centred at 0300 UTC of 16 near Lat. 17.0° N/Long. 64.5° E. It intensified into a cyclonic storm in the evening of 16 near Lat. 19.0° N/Long. 68.0° E. Moving in a northeasterly direction, it crossed south Gujarat coast near Veraval in the morning of 17. Continuing its northeasterly movement after crossing the coast, it weakened into a deep depression over south Gujarat Region when it was about 50 kms northwest of Bhavnagar. Then it moved in a northeasterly direction and weakened into a well-marked low pressure area on 17 evening over south Rajasthan and adjoining north Gujarat and adjoining northwest Madhya Pradesh.

4.2.2. *Satellite cloud features*

The system was mainly tracked with the help of satellite observations and there were no supporting ship's observations till it came close to the coast.

Positions and intensities given by ICIs were not consistent. This caused difficulty in assessing the intensity of the system and fixing the centre of the system. Sat. Met. relocated the position of the system on 0300 UTC and 0600 UTC of 12, 0300 UTC of 13 and 0300 UTC of 15, probably based on visible imageries. As a result, it was difficult to keep continuity of the system on real time basis. When the system was close to the coast, coastal observations, ONGC rigs off Mumbai were helpful. CDR Bhuj at 2100 UTC of 16 reported broken cloud configuration in the range of about 100-200 kms. There were no significant signals reported from CDR Mumbai and Bhuj.

4.2.3. *Other observations*

Maximum intensity reported by satellite (ICI) was T 2.5 from 1700 UTC to 2200 UTC of 16. The lowest estimated central pressure was 996 hPa when the system intensified into a CS near Lat. 18.5° N/Long. 68.0° E at 1200 UTC of 16. After 1200 UTC of 15, the system came under the influence of a strong westerly trough aloft. As a result, the system recurved to the northeast and moved very fast. It moved with the speed of 15 kmph from 1200 UTC of 15 to 0300 UTC of 16, 38 kmph from 0300 UTC to 1200 UTC of 16 and 26 kmph from 1200 UTC of 16 to 0100 UTC of 17. Associated cloud structure and the convection got sheared off northeastwards into the Gujarat region at the time of crossing the coast.

A well-marked trough of low extending upto lower tropospheric levels lay over northern parts of east-central Arabian Sea of coastal area of Saurasthtra. ICI also showed well-organised clouds indicating intense convection. The cyclonic storm moving northeastwards merged with the above trough of low on 16 evening.

In addition, there was a deep depression between 13 evening and 14 evening over west-central Bay of Bengal. Thus, there was a simultaneous presence of deep depression over the west-central Bay of Bengal and deep depression over central parts of Arabian Sea which are separated by about 16° longitude. The interaction between these two deep depressions can not be ruled out.

4.2.4. *Weather and damages*

The system caused widespread heavy rainfall over Gujarat, south Rajasthan and adjoining parts of west Madhya Pradesh. There was no report of loss of life or damage to property in Gujarat and Maharashtra. Principal amounts of rainfall were as follow:

Station	*Rainfall (cm)*
16 October 1998	
Danta	11.5
Mehsana	7.2
Viramgam	6.5
17 October 1998	
Deesa	16.3
Savarikandla	15.0
Bhakudar	14.5
Danta	10.8

4.3. *Deep depression over Bay of Bengal (13-15 October 1998)*

4.3.1. *Life cycle*

A well-marked low pressure area formed over west-central Bay off Andhra coast on the morning of 13. It concentrated into a depression and lay centred at 1200 UTC of 13 near Lat. 15.0° N/82.5° E. It moved in a northwesterly direction and further intensified into a deep depression and

was centred near Lat. 15.5° N/Long. 82.0° E. It continued its northwesterly movement retaining its intensity as deep depression and was centred at 1200 UTC of 14 near Lat. 16.2° N/Long. 81.5° E. The system then crossed Andhra coast between Machilipatnam and Kakinada, very close to Narasapur at 1600 UTC of 14. Then, it weakened into a depression and lay centered at 0300 UTC of 15 near Lat. 17.0° N/Long. 81.0 E°. The system then moved in a northwesterly direction and weakened into a low pressure area over Telangana.

4.3.2. *Satellite cloud features*

INSAT reported peak intensity of T 2.0 from 1200 UTC of 13 to 0200 UTC of 14 on D'vorak's scale.

4.3.3. *Weather and damages*

The system took a toll of 101 human lives, 50 villages got submerged and corps in thousands acres of agricultural land got damaged. Total loss of about Rs 600 crores was reported by Andhra Pradesh Government. Widespread heavy rainfall also experienced in north coastal Andhra Pradesh. Principal amounts of rainfall were as follows :

Station	*Rainfall (cm)*
13 October 1998	
Kalingapatnam	11
Tirupathi	8
14 October 1998	
Kallingapatnam	12
Tekali	10
Ongole	9
15 October 1998	
Avanigadda	15
Gudiwada	10
Kaikalu	9
Paradip	9
Repali	8

4.4. *Deep depression over Bay of Bengal (26-30 October 1998)*

4.4.1. *Life cycle*

A well-marked low pressure area moved into southeast Bay and neighbourhood on the morning of 26. It concentrated into a depression and was centred at 1200 UTC of 26 near Lat. 11.5° N/Long. 88.5° E. It moved in a northwesterly direction and further intensified into a deep depression and lay centred at 1200 UTC of 27 near Lat. 13.0° N/Long. 87.0° E. It then moved in a westerly direction and lay centred at 1200 UTC of 28 as a deep depression near Lat. 13.0° N/Long. 84.0° E. It, then changed the course and moved in a northwesterly direction and weakened into a depression at 0900 UTC of 29 and was centred near Lat. 14.0° N/Long. 82.5° E. Continuing its northwesterly movement, it lay as a depression at 1200 UTC of 30 near Lat. 15.5° N/Long. 81.5° E. Then, it weakened into a low pressure area off Andhra coast.

4.4.2. *Satellite cloud features*

INSAT reported peak intensity of T 2.0 from 1200 UTC of 27 to 0800 UTC of 29 on D'vorak's scale.

4.4.3. *Weather and damages*

Most of the crops like paddy sugar, cotton etc. submerged in water in all the coastal districts of Andhra Pradesh. Very heavy rainfall experienced in the coastal area on 31 October. Principal amounts of rainfall were as follows:

Station	*Rainfall (cm)*
31 October 1998	
Bhimunipatnam	15
Vedadri	14
Tuni	13
Sattenpalli	12
Waltair	11

4.5. *Very severe cyclonic storm over Bay of Bengal (13-16 November 1998)*

4.5.1. *Life cycle*

A low pressure area formed over southeast Bay on 13 with central region near Lat. 11.5° N/Long. 88.0° E. It became well-marked over southeast and adjoining west-central Bay. It rapidly concentrated into a deep depression over central and adjoining south Bay at 0300 UTC of 14 near Lat. 13.5° N/Long. 86.5° E, about 600 kms southeast of Visakhapatnam. Moving in a northwesterly direction, it intensified into a cyclonic storm in the afternoon of 14 and was centred at 1200 UTC of 14 near Lat. 14.5° N/Long. 85.5° E. It further intensified into a severe cyclonic storm in the early morning of 15. It moved in a northwesterly direction and further intensified into a very severe cyclonic storm and was centred at 0300 UTC of 15 near Lat. 16.0° N/Long. 84.0° E, about 220 kms southsoutheast of Visakhapatnam. It moved in a northwesterly direction and crossed north Andhra Pradesh coast close to but south of Visakhapatnam in the evening of 15. It weakened into a severe cyclonic storm with its centre at 1200 UTC of 15 near Lat. 18.0° N/Long. 83.0° E, about 50 kms west of Visakhapatnam. It further moved in a northnorthwesterly direction and weakened into a deep depression with centre at 0300 UTC of 16 near Lat. 20.5° N/Long. 82.0° E, about 100 kms southeast of Raipur. It weakened into a well-marked low pressure area over central parts of east Madhya Pradesh in the afternoon

of 16 and further weakened into a low pressure area in the same evening.

4.5.2. *Satellite cloud features and other observations*

Position given by ICI were consistent and correct and helped to track the system accurately. CDR Machilipatnam and Visakhapatnam reported radar fixes from 0100 UTC to 1500 UTC of 15 and from 1500 UTC of 14 to 1500 UTC of 15 respectively. The position given by CDR Machilipatnam, CDR Visakhapatnam and ICI agreed very well and there was no difficulty to track the system accurately. All these observations also agreed very well with hourly coastal observations. This helped to forecast the landfall point and time without any difficulty. X-band radar at Visakhapatnam only reported at 1000 UTC of 15 "EYE" of diameter 20 kms and eye wall width of 20 kms.

Maximum intensity reported by ICI on D'vorak's scale was T 4.5 at 0600 UTC and 0700 UTC of 15. The system had lowest estimated central pressure of 988 hPa while on sea at 0300 UTC of 15.

4.5.3. *Weather and damages*

The system caused 16 human deaths. About 28,000 families affected, thousands of houses got damaged in Visakhapatnam district. Very heavy rain reported on 16 in north coastal Andhra Pradesh. Gale force wind exceeding 75 kts were recorded at Visakhapatnam and Waltair observatories. Strong winds and heavy rainfall caused damage to the property to the extent of rupee 306 crores as per the report given by the State Government officials. Principal amounts of rainfall were as follows :

Station	*Rainfall (cm)*
16 November 1998	
Yellamanchilli	15
Chodavaram	12
Palasa	10
Kalingapatnam	7

4.6. *Very severe cyclonic storm over Bay of Bengal (19-22 November 1998)*

4.6.1. *Life cycle*

A well-marked low pressure area formed over Andaman Sea on 18. It concentrated into a depression with centre at 0300 UTC of 19 near Lat. 12.0° N/Long. 92.5° E. It moved in a northwesterly direction and intensified into a deep depression with centre at 1200 UTC of 19 near Lat. 12.5° N/Long. 91.5° E, about 130 kms northwest of Port Blair. It further moved in a northwesterly direction and intensified into a cyclonic storm and was centred at 0300 UTC of 20 near Lat. 14.5° N/Long. 88.5° E, about 650 kms southeast of Visakhapatnam. It moved in a northwesterly direction with centre at 1200 UTC of 20 near Lat. 15.5° N/Long. 88.0° E. It further moved in a northwesterly direction and intensified into a severe cyclonic storm with centre at 0600 UTC of 21 near Lat. 17.5° N/Long. 87.5° E, about 520 kms south of Balasore. It further moved in a northerly direction and intensified into a very severe cyclonic storm at 1200 UTC of 21 near Lat. 19.0° N/Long. 87.5° E and at 0300 UTC of 22, it lay near Lat. 21.5° N/Long. 88.5° E, about 120 kms south of Calcutta. It crossed West Bengal coast between Sagar Island and Sundarban area of West Bengal at noon of 22. It rapidly weakened into a deep depression with centre at 1200 UTC of 22 near Lat. 22.0° N/Long. 90.0°E. It further weakened into a depression and into a low pressure area over Bangladesh and neighbourhood.

4.6.2. *Satellite cloud features and other observations*

The system was tracked mainly with the help of INSAT Cloud Imageries. The maximum intensity reported by ICI was T 4.0 from 1000 UTC of 21 to 0000 UTC of 22. The position given by ICI were consistent and accurate for fixing the centre. CDR Paradip reported Radar observations from 0600 UTC of 20 to 0900 UTC of 22. It reported "EYE" at 0900 UTC, 1000 UTC and 1100 UTC of 21. On the basis of spiral bands, CDR Paradip reported centre of the system at 1200 UTC, 1800 UTC and 1900 UTC of 21. CDR Calcutta reported Radar observations from 0600 UTC of 20 to 0900 UTC of 22. On the basis of spiral bands, it reported the centre of the system at 2300 UTC of 21, 0000 UTC of 22 and 0100 UTC of 22. The centres given by CDR Calcutta, CDR Paradip and ICI agreed very well and helped not only to fix the centre of the system, but to predict landfall time and place accurately.

The lowest estimated central pressure was 984 hPa at 0300 UTC of 22. The system recurved to the northeast under the influence of strong westerly trough aloft.

4.6.3. *Weather and damages*

It is reported that strong winds speed reaching 80-100 kmph accompanied by heavy rain caused damage to crops, uprooted trees and electric poles in north Balasore district. Parts of Sagar Island submerged and affected 25,000 people in eight villages and 3,000 mud houses were collapsed. Lakhs of people were affected in 24-Paraganas and Midnapore districts. Principal amounts of rainfall were as follows :

Station	*Rainfall (cm)*
22 November 1998	
Sagar Islands	16.0
Contai	9.5
Durgachak	8.2
Digha	7.1
23 Novermber 1998	
Krishnanagar	9.7
Basirahat	6.8
Canning town	6.2

4.7. *Severe cyclonic storm over Arabian Sea (13-17 December 1998)*

4.7.1. *Life cycle*

A low pressure area formed on 9 off Kerala coast and adjoining Commorin-Maldives area. It became well-marked over northern parts of southeast Arabian Sea and neighbourhood on 12 evening. It concentrated into a depression and was centred at 0300 UTC of 13 near Lat. 10.5° N/Long. 68.5° E, about 750 kms southwest of Goa. It moved in a northwesterly direction and intensified into a cyclonic storm with centre at 1200 UTC of 13 near Lat. 12.0° N/Long. 67.5° E, about 780 kms southwest of Goa. It then moved in a northwesterly direction and further intensified into a severe cyclonic storm and was centred at 1200 UTC of 14 near Lat. 14.0° N/66.5° E. It moved in a northerly direction and then in a northnorthwesterly direction and weakened into a cyclonic storm and lay at 1200 UTC of 15 near Lat. 17.0° N/Long. 64.5° E and was centred at 0300 UTC of 16 near Lat. 18.0° N/Long. 62.5° E, about 620 kms westsouthwest of Veraval. It further weakened into a deep depression in the afternoon of 16 and further rapidly weakened into a well-marked low pressure area over west-central Arabian Sea and neighbourhood in the evening. It further moved westwards.

4.7.2. *Satellite cloud features and other features*

The position given by ICI were inconsistent, did not help to track the system on real time basis. Many times the positions were relocated adding further difficulties in maintaining the continuity of the system. Number of ships, some of them were crucial, helped to track the system to some extent. As the system was far away out in the Sea, no radar observations were reported.

The lowest estimated central pressure was 996 hPa from 1200 UTC of 14 to 0000 UTC of 15 and again from 0900 UTC of 15 to 0000 UTC of 16. INSAT reported peak intensity of T 3.5 from 0700 UTC of 14 to 2100 UTC of 14 on D'vorak's scale. Formation of severe cyclonic storm over the Arabian Sea in the month of December is rare. The earlier cyclonic storm which formed over the Arabian Sea were 14-21 December 1971, 6-12 December 1965, 1-7 December 1963, 17-23 December 1923, 17-18 December 1912, 30 November- 2 December 1909, 29 November - 2 December 1920 and 7-12 December 1902.

4.7.3. *Weather and damages*

The system did not cause any weather or damage over India.