

## Cyclones and depressions over north Indian Ocean during 2003\*

### 1. Introduction

The storm activity was subdued over both Bay of Bengal and Arabian Sea, this year with only 3 cyclonic storms (2 over Bay of Bengal and 1 over Arabian Sea) and 4 depressions (including 2 monsoon depressions). The first one was a very severe cyclonic storm over the Bay of Bengal, during 10 – 19 May, which after a prolonged stay over the ocean re-curved and crossed Myanmar coast on 19th night. Subsequently, two monsoon depressions formed, *viz.*, one a Deep Depression over Bay of Bengal (25-28 July) and the other a depression over Bay of Bengal (27-28 August). Both of them crossed Orissa coast and further moved in a westnorthwesterly direction across the country until weakening. It was followed by another depression over Bay of Bengal during 6-9 October 2003; which crossed north Andhra coast, near Kalingapatnam on 7. The fifth one was a Deep Depression (26-28 October 2003) over the Bay of Bengal. It also crossed Andhra coast between Visakhapatnam and Kalingapatnam on 28. Subsequently, a severe cyclonic storm (12-15 November 2003) formed, which was the only intense system over the Arabian Sea this year. As it formed in a much lower latitude and followed a westerly course, it did not affect the weather over the country. The last system of the year, also a Severe Cyclonic storm, formed over the Bay of Bengal during 11-16 December 2003. Following a northwesterly track, it crossed south Andhra coast close to Machilipatnam around the mid-night of 15 December.

Tracks of these systems are given in Fig. 1. The brief history and monthly distribution are given in Tables 1 and 2. The relevant ship observations are given in Table 3. Season wise description of these systems are given below.

### 2. Disturbances formed during the Winter season (January and February)

No intense cyclonic disturbance formed during the season.

### 3. Disturbances formed during the Pre-monsoon season (March to May)

During the season, one very severe cyclonic storm formed over the Bay of Bengal. Details are given below :

#### 3.1. *Very severe cyclonic storm formed over the Bay of Bengal (10-19 May)*

This is the only cyclonic storm formed during pre-monsoon season. It intensified into a Severe Cyclonic Storm.

##### 3.1.1. *Life cycle*

A trough of low over south Bay organised into a low pressure area over southeast Bay in the evening of 7. It lay as a well marked low pressure area over southeast Bay and neighbourhood on 8. It, subsequently, concentrated into a depression and lay centred within half a degree of Lat. 6.0° N/ Long. 90.5° E at 0300 UTC of 10. It intensified into a deep depression in the same evening and lay centred near Lat 8.0° N/Long. 89.5° E at 1200 UTC of 10. It further intensified into a cyclonic storm which lay centred at 0300 UTC of 11 near Lat. 9.5° N/ Long. 87.5° E and then into a severe cyclonic storm, centred at 1200 UTC of 11, near Lat. 10.5° N/ Long. 86.5° E. Moving in a northwesterly direction, it lay centred near Lat. 11.0° N/ Long. 86.0° E, at 0300 UTC of 12 and near Lat. 11.5° N/ Long. 85.5° E, at 1200 UTC of 12. Subsequently, it intensified into a very severe cyclonic storm over the same area at 1800 UTC of 12. Slightly moving in a northwesterly direction, it lay centred near Lat. 12.0° N/ Long. 85.0° E at 0300 UTC of 13 and near Lat. 12.5° N/ Long. 85.0° E at 1200 UTC of 13. Subsequently, it weakened into a severe cyclonic storm at 0300 UTC of 14 and lay centred near Lat. 14.0° N/Long. 85.0° E and further into a cyclonic storm at 1200 UTC of 14 and lay centred near Lat. 14.5° N/ Long. 85.5° E. Slowly moving eastwards, it lay centred near Lat. 14.5° N/ Long. 86.0° E at 0300 UTC of 15 and remained practically stationary over there until 1200 UTC of 15. It lay centred near Lat. 14.5° N/ Long. 86.5° E at 0300 UTC of 16 and weakened into a deep depression, lay centred at 1200 UTC of 16 near Lat. 14.5° N/ Long. 87.0° E. It lay centred at 0300 UTC of 17, near Lat. 14.5° N/ Long. 87.5° E and at 1200 UTC of 17 near Lat. 14.5° N/ Long. 88.0° E. Continuing

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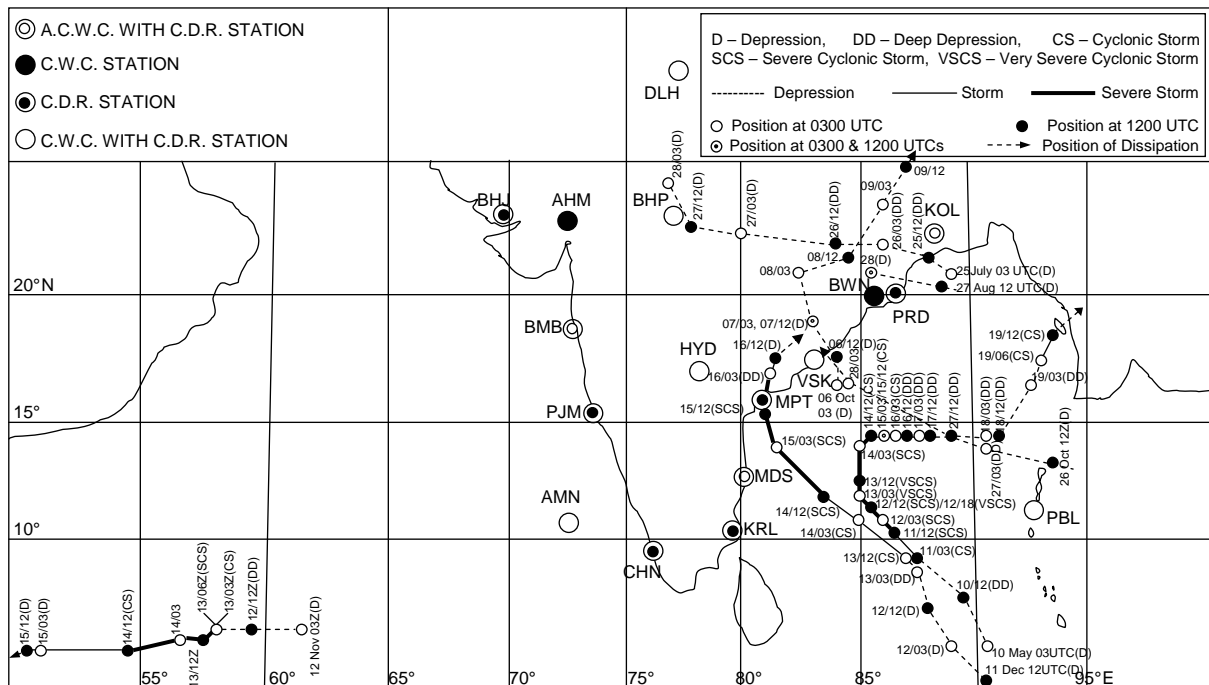


Fig. 1. Tracks of depression/storms during 2003

its easterly movement, it lay centred near Lat.  $14.5^{\circ}$  N/ Long.  $90.5^{\circ}$  E, at 0300 UTC of 18 and near Lat.  $14.5^{\circ}$  N/ Long.  $91.0^{\circ}$  E, at 1200 UTC of 18. Thereafter, it moved in a northeasterly direction and lay centred near Lat.  $16.5^{\circ}$  N/ Long.  $92.5^{\circ}$  E at 0300 UTC of 19. It further intensified into a cyclonic storm over northeast Bay at 0600 UTC of 19 and lay centred near Lat.  $17.5^{\circ}$  N/ Long.  $93.0^{\circ}$  E and near Lat.  $18.5^{\circ}$  N/ Long.  $93.5^{\circ}$  E at 1200 UTC of 19. It crossed Myanmar coast during the night of 19. Moving inland, it rapidly weakened and lay as a low pressure area over Myanmar at 0300 UTC of 20.

### 3.1.2. Satellite cloud features and other observations

Maximum intensity of the system as given by Kalpana – 1, imagery was T – 4.5 at 0600 UTC and at 0900 UTC of 13. No ‘EYE’ was noticed by the satellite.

There were no significant RADAR observations as the system was out of the RADAR range, throughout its life period. DWR Chennai could not estimate the storm centre as no well defined bands with consistency were seen in the RADAR. The centre of the system was beyond the RADAR range throughout. Also, no organised bands were observed at any time during the period by CDR Machilipatnam.

The estimated lowest central pressure of the system was 980 hPa during 0600 to 0900 UTC of 13. Maximum estimated wind speed was 77 knots. The system initially moved in a northwesterly direction, till 13 morning. It, subsequently, showed the signs of re-curvature by moving northwards initially for the next 24 hours, *i.e.*, till 14 morning and then re-curved northeastwards and moved very slowly eastwards, while weakening into a Deep Depression in due course of time until the evening of 18. Thereafter, gathering momentum, it moved in a northeasterly to northnortheasterly direction and intensified once again into a cyclonic storm before crossing Myanmar coast on 19 night. It may be inferred from available upper air observations that the system was steered throughout by the upper level flow patterns. There were no significant ship/buoy observations during the entire period.

### 3.1.3. Weather and damage

As the system did not cross the Indian coast, damage was ‘nil’ along east coast. However, the unusually prolonged trajectory of the system caused a change in the atmospheric flow pattern, which might have caused the severe heat wave conditions prevailing over the coastal Andhra Pradesh and many other parts of the country during May to continue until the first fortnight of June,

TABLE 1

## Brief history of cyclonic storms and depressions over the Indian seas and neighbourhood during 2003

S. No.	Type of System	Life period	Point of crossing the coast	Lowest estimated central pressure (hPa)	Recorded max. wind (kts)	Highest "T" No. (estimated)
1.	VSCS	10-19 May	Myanmar coast during midnight of 19	980	75	4.5
2.	DD	25-28 July	Orissa coast close to Balasore during the evening of 25	-	-	2.0
3.	D	27-28 August	Orissa coast near Chandbali in the early morning of 28	-	-	1.5
4.	D	6-9 October	North Andhra Pradesh coast near Kalingapatnam around 2100 UTC on 6 October	-	-	1.5
5.	DD	26-28 October	Andhra coast between Visakhapatnam and Kalingapatnam around 1000 UTC of 28	-	-	2.0
6.	SCS	12-15 November	No landfall	-	-	3.5
7.	SCS	11-16 December	South Andhra coast close to Machilipatnam around midnight of 15	990	55	3.5

D- Depression, DD-Deep depression, SCS - Severe cyclonic storm, VSCS – Very severe cyclonic storm

TABLE 2

## Storms/depressions statistics 2003

Name of the system	Winter	Pre-monsoon			Monsoon				Post-monsoon			Total
	Jan-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
<b>Over Bay of Bengal</b>												
Depressions/Deep depressions	0	0	0	0	0	1	1	0	2	0	0	4
Cyclonic storms	0	0	0	0	0	0	0	0	0	0	0	0
Severe cyclonic storms	0	0	0	0	0	0	0	0	0	0	1	1
Very severe cyclonic storms	0	0	0	1	0	0	0	0	0	0	0	1
Super cyclonic storm	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	1	0	1	1	0	2	0	1	6
<b>Over Arabian Sea</b>												
Depressions/Deep depressions	0	0	0	0	0	0	0	0	0	0	0	0
Cyclonic storms	0	0	0	0	0	0	0	0	0	0	0	0
Severe cyclonic storms	0	0	0	0	0	0	0	0	0	1	0	1
Very severe cyclonic storms	0	0	0	0	0	0	0	0	0	0	0	0
Super cyclonic storm	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	0	0	0	1	0	1	1	0	2	1	1	7

TABLE 3

## Crucial Ship observations during the storm periods

Call Sign	Date/Time (UTC)	Lat. (°N)	Long. (°E)	Dir. (°)	Speed (kts)
(1)	(2)	(3)	(4)	(5)	(6)
<b>Severe cyclonic storm over Bay of Bengal 11-16 December 2003</b>					
MQYA3	11 Dec / 0000	6.0	87.3	60	10
ELZK4	11 Dec / 0000	6.1	89.3	345	15
ELZK4	11 Dec / 1200	5.8	85.5	20	4
A8CJ9	12 Dec / 0000	6.4	89.9	270	18
3ETX6	12 Dec / 0000	2.5	89.9	290	8
9KKS	12 Dec / 1200	7.1	88.6	200	9
PGCU	12 Dec / 1200	6.0	87.9	330	14
PHKL	12 Dec / 1200	5.9	92.5	120	5
ELOI6	13 Dec / 0000	5.7	82.9	300	21
SHIP	13 Dec / 1200	5.8	85.5	290	20
ELDI6	14 Dec / 0000	6.0	88.1	160	13
FNAT	14 Dec / 0000	5.8	83.5	300	24

causing the death toll to mount upto 1400 over Andhra Pradesh, Orissa, Tamil Nadu, etc., states.

Principal amounts of rainfall in cm are :

Andaman & Nicobar Islands :

11 May 2003 : Car Nicobar 4.1, Port Blair 3.7, Maya Bandar 3.3

12 May 2003 : Nancowry 4.0, Maya Bandar 3.7

19 May 2003 : Hut Bay 8.9, Car Nicobar 3.9

Orissa :

10 May 2003 : Swampatna 5.3, Champua 3.4, Jaleswar & Rajghat 2.6 each.

11 May 2003 : Mohana 2.1

20 May 2003 : Narsingpur 2.3.

#### 4. Disturbances formed during the Monsoon season (June to September)

No cyclonic storm formed during the season. However, two depressions formed during the season, both over the Bay of Bengal. The first one, a deep depression

(25-28 July) which subsequently moved inland and caused rainfall over the central parts of the country and the second, a depression (27-28 August) which also moved inland but rapidly weakened into a low pressure area over Chattisgarh and adjoining Orissa. The remaining two months, June and September, were devoid of depressions. Details are given below :

#### 4.1. Deep depression over the Bay of Bengal (25 – 28 July)

##### 4.1.1. Life cycle

A low pressure area which had been persisting over northern parts of Bay and adjoining land areas since 22, concentrated into a depression over northwest Bay on 25 morning. It lay centred at 0300 UTC of 25, near Lat. 21.0° N/ Long. 89.0° E. Moving northwestwards, it intensified into a deep depression and lay centred near Lat. 21.5° N/ Long. 88.0° E, at 1200 UTC on 25. It rapidly moved inland and lay close to Keonjhar at 0300 UTC of 26. Further moving westwards, it lay near Jharsuguda at 1200 UTC of 26. Thereafter, it weakened into a depression and lay centred over east Madhya Pradesh, near Jabalpur at 0300 UTC of 27 and over west Madhya Pradesh, near Bhopal at 1200 UTC of 27. Moving in a northwesterly direction, it lay over northwest Madhya Pradesh, close to Rajgarh at 0300 UTC of 28 and thereafter weakened into a low pressure area over south Rajasthan and neighbourhood in the evening of 28.

##### 4.1.2. Satellite cloud features and other observations

Maximum T-number assigned by Satellite Imagery had been T-1.0.

No RADAR observations were received on real time or delayed mode.

##### 4.1.3. Weather and damage

Being a monsoon system it followed the expected westnorthwesterly course after crossing coast. The rainfall also had been concentrated in the southwest sector. It moved along the monsoon trough and merged with the heat low after weakening into a low pressure area.

The system did not cause damage to the Orissa – West Bengal coast. However widespread rainfall activity with very heavy rainfall was observed in Orissa on 25. Widespread rainfall activity was also observed in Gangetic West Bengal on the same day.

Principal amounts of rainfall in cms are as follows :

Orissa :

25 July 2003 : Kendrapara 25, Soro 20, Paradip 19, Cuttack 18, Jenapur, Akhuapada & Rajonoka 17 each, Chandbali & Tikaipada 15 each, Jaipur, Naraj, Narsingpur & Rajkishorenagar 13 each, Nilgiri, Dhankanal & Baripada 12 each, Athamalik & Bhubaneswar 11 each, Thakurmuna & Khandapada 10 each, Alipingal, Udala, Nimapada & Pipili 9 each, Balasore 8.

Gangetic West Bengal :

Canning Town 5, Barrackpur, D.P. Ghat, Kalaikunda & Kharagpur 3 each.

#### 4.2. Depression over Bay of Bengal (27-28 August 2003)

##### 4.2.1. Life cycle

A well marked low pressure area over northwest Bay, concentrated into a depression, which lay centred at 1200 UTC of 27 near Lat. 20.5° N/Long. 88.5° E. It moved in a westnorthwesterly direction and crossed Orissa coast near Chandbali in the early morning of 28. It lay centred at 0300 UTC of 28, near Lat. 21.0° N/Long. 85.5° E, close to Angul and remained practically stationary over there till the evening. Subsequently moving westwards, it weakened into a low pressure area over Chattisgarh and adjoining Orissa on 29.

##### 4.2.2. Satellite cloud features and other observations

According to Satellite Imagery, the system, throughout its life period was defined as a low level circulation (LLC) as clouds associated with the system never showed organisation to be classified as a more intense vortex. Convective clouds associated with the system were mainly on land extending over adjoining Bay area without any definite shape. Convective clouds associated with the circulation showed westward movement.

No RADAR observations received on real time basis or delayed mode.

Depression was declared on the basis of coastal wind of Kolkata, which reported southeasterly 30 kts at 0.9 km a.s.l. and pressure departure field of 5.0 hPa at Balasore at 1200 UTC of 27.

##### 4.2.3. Weather and damage

No damage was reported by ACWC Kolkata. However, widespread rainfall activity with heavy to very heavy rain at a few places in Orissa and fairly widespread rain in West Bengal was reported on 27. Principal amounts of rainfall in cms. are as follows :

Orissa :

25 August 2003 : Kantamal 20, Khairamal 13, Naraj & Paradip 12 each, Kotraguda 11, Berhampur 9, Cuttack, TIKARAPADA, Madnabarida, Purusottampur and Gudari 7 each.

West Bengal :

27 August 2003 : Dum Dum 4, Uluberia and Diamond Harbour 3 each.

#### 5. Disturbances formed during the Post-monsoon season (October to December)

During this season, two severe cyclonic storms and two depressions formed. Details are presented below :

##### 5.1. Depression over the Bay of Bengal (6 – 9 October 2003)

###### 5.1.1. Life cycle

A low pressure area lay over south Bay and adjoining west-central Bay off north Tamil Nadu-south Andhra coasts on 4 & 5. It concentrated into a depression over west-central Bay and lay centred at 0300 UTC of 6 near Lat. 16.5° N/ Long 84.0° E. Moving northwards, it lay near Lat. 17.5° N/ Long 84.0° E at 1200 UTC of 6 and crossed north Andhra coast near Kalingapatnam in the early morning of 7. It lay centred at 0300 UTC of 7 near Lat. 19.0° N/ Long 83.0° E, about 100 kms east of Jagdalpur and remained practically stationary over there until the evening of 7. Subsequently, it moved further northnorthwestwards and lay centred near Lat. 21.0° N/ Long. 82.5° E, about 100 kms eastsoutheast of Raipur at 0300 UTC of 8. Then moving in a northeasterly direction, it lay centred near Jharsuguda in the evening of 8. Further moving in a northeasterly direction, it lay over Jharkhand, centred close to Dhanbad at 0300 UTC of 9 and over Bihar and neighbourhood, centred near Bhagalpur at 1200 UTC of 9. Subsequently, it weakened into a well-marked low pressure area over Sub-Himalayan West Bengal & Sikkim and neighbouring areas on 0300 UTC of 10 and lay as low pressure area over the same region in the evening.

### 5.1.2. *Satellite cloud features and other observations*

The maximum intensity of the system, as reported by satellite was T-1.5 during 0800 UTC of 6 to 0300 UTC of 7.

There were no RADAR observations received during the storm period and also on delayed mode. No organised bands/patterns were observed by CDR Visakhapatnam.

### 5.1.3. *Weather and damage*

As per press reports, following damage was caused in Srikakulam, Vizianagaram and Visakhapatnam districts of Andhra Pradesh.

No of deaths	8
No of tanks breached	73
No of villages flooded	20
Paddy Submerged	39,000 acres

As per press reports and information received from Government of West Bengal, 13 people died and lakhs of people were affected in Kolkata and other districts on 7 & 8 October. On 9, light tornadoc in Murshidabad district injured 11 persons and damaged houses and agricultural products on 6 acres of land.

Widespread rainfall activity with exceptionally heavy rains occurred on 6 & 7 in West Bengal on 6 in Orissa and on 8 in Jharkhand. Widespread rainfall activity with heavy rain was also observed on 7 in coastal Andhra Pradesh. Principal amounts of rainfall in cm are as follows:

#### West Bengal :

6 October 2003	: Digha 23, Kalaikunda 10, Durgachak, Mohanpur & Midnapore 9 each, Alipore and Diamond Harbour 7 each.
7 October 2003	: Canning Town 23, Dum Dum 16, Mohanpur 14, Midnapore 13, Alipore 11, Diamond Harbour 8, Durgachak 7.
8 October 2003	: Gajoldoba 9, Narayanpur & Canning Town 7 each.
9 October 2003	: Malda 15, Cooch Behar 13, Gajoldoba 12, Alipurduar & Jalpaiguri 11 each, Chapan and Damohani 10 each, Baghdogra, Mathabhanga & Behrampore 9 each.

#### Orissa :

6 October 2003	: Chandbali 27, Balasore 23, Cuttack 11, Paradip & Gopalpur 10 each, Bhubaneswar 8, Puri 7.
7 October 2003	: Akhuapada 12, Anandapur, Baripada, Chandbali, Balimundali & Jaipur 11 each, Rajghat, Chandrapur & Jamsolaghat 9 each.
8 October 2003	: Jharsuguda 9, Sundargarh & Baripada 7 each.

#### Jharkhand :

8 October 2003	: Tenughat 22, Kona 16, Ramgarh 15, Messanjore 13, Hindigir and Moharo 11 each, Ranchi and Barkisurya 10 each.
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#### Bihar :

9 October 2003	: Bhagalpur 11.
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#### Coastal Andhra Pradesh :

6 October 2003	: Kalingapatnam 12, Waltair 4.
7 October 2003	: Sompata 17, Visakhapatnam 15, Salur and Parvathipuram 13, Waltair and Chepurupalli 12 each, Chintapalli and Paderu 11 each, Bobbili 8.

## 5.2. *Deep Depression over the Bay of Bengal (26 – 28 October 2003)*

### 5.2.1. *Life cycle*

Under the influence of cyclonic circulation which extended upto mid tropospheric levels over southeast Bay and adjoining Andaman Sea, a low pressure area formed over north Andaman Sea on 0300 UTC of 26. In the evening of the same day, it concentrated into a depression and lay centred within half a degree of Lat. 13.5° N / Long. 93.5° E. It further intensified into a deep depression at 0300 UTC of 27 and lay centred within half a degree of Lat. 14.0° N / Long. 90.5° E, about 900 kms southeast of Visakhapatnam. Moving in a westnorthwesterly direction, it lay over east-central Bay at 1200 UTC of 27 within half a degree of Lat. 14.5° N / Long. 89.0° E. Continuing its northwesterly movement, it lay centred at 0300 UTC of 28 within half a degree of Lat. 16.5° N / Long. 84.5° E. It crossed Andhra coast between Visakhapatnam and Kalingapatnam around 0900 UTC of 28 and rapidly weakened into a low pressure area and lay over northern

parts of coastal Andhra Pradesh and adjoining Chattisgarh on 28 evening. It became less marked on 29.

#### 5.2.2. *Satellite cloud features, Radar and other observations*

The system was identified as a Depression on the basis of satellite observations.

No RADAR observations were received on real time/ delayed mode.

#### 5.2.3. *Weather and damage*

No significant damage were reported due to this system along the coast. However, heavy rainfall at isolated places was reported in coastal Andhra Pradesh. Fairly widespread rainfall activity was observed in Orissa on 27 & 28 and in Gangetic West Bengal on 28.

Principal amounts of rainfall in cms. are as follows:

Orissa :

27 October 2003 : Rajghat 3.7, Chandbali 3  
28 October 2003 : Chatrapur 3.0, Baripada 2.9  
29 October 2003 : Pollangi 2.7.

Gangetic West Bengal :

28 October 2003 : Diamond Harbour & Digha 5 each, Alipore & Bardhaman 4 each, Berhampore, Canning Town & Krishnanagar 3 each.

Coastal Andhra Pradesh :

29 October 2003 : Dummagudem 12, Chodararam, Prathipadu and Salur 3 each, Anakapalli, Narsipatnam, Tuni & Waltair 2 each.

### 5.3. *Severe Cyclonic Storm over the Arabian Sea (12-15 November 2003)*

#### 5.3.1. *Life cycle*

Under the influence of trough of low over southeast Arabian Sea, a depression formed over southwest Arabian Sea at 0300 UTC of 12 and lay centred within half a degree of Lat. 6.5° N / Long. 61.5° E. It intensified into a Deep Depression and lay centred within half a degree of Lat. 6.5° N / Long. 59.5° E at 1200 UTC of 12. Continuing its westerly course, it intensified into a Cyclonic Storm and lay centred at 0300 UTC of 13 near Lat. 6.5° N / Long. 58.0° E. It further intensified into a Severe Cyclonic Storm at 0600 UTC of 13, over the same

area. Slowly moving westwards it lay centred at 1200 UTC of 13 near Lat. 6.0° N / Long. 57.5° E. Further moving westwards, it lay near Lat. 6.0° N / Long. 56.5° E at 0300 UTC of 14. Thereafter, it weakened into a Cyclonic Storm and lay centred at 1200 UTC of 14 near Lat. 5.5° N / Long. 54.5° E. Further moving westwards, it rapidly weakened into a depression which lay centred at 0300 UTC of 15 near Lat. 5.5° N / Long. 51.0° E and near Lat. 5.5° N / Long. 50.5° E at 1200 UTC of 15. The system weakened into a low pressure area on 16 morning and dissipated over the sea off Somalia coast thereafter.

#### 5.3.2. *Satellite cloud features, Radar and other observations*

The system was tracked over the ocean mainly by the satellite imageries. The maximum intensity reported by Kalpana 1 was T 3.5 at 0600 UTC of 13.

The system remained far away from the RADAR stations, throughout its life period.

The system was embedded in the lower latitude easterlies and kept a westward track. Its formation and intensification were in comparatively lower latitude. Also, it showed a slight southward drift of 0.5°, which is rather unusual for a system in the Northern Hemisphere.

#### 5.3.3. *Weather and damage*

As the system did not cross coast, no damage were caused.

### 5.4. *Severe Cyclonic Storm the Bay of Bengal (11-16 December 2003)*

#### 5.4.1. *Life cycle*

A trough in easterlies over Andaman Sea and adjoining southeast Bay organised into a low pressure area over southeast Bay on 0300 UTC of 11. It subsequently concentrated into a Depression and lay centred at 1200 UTC of 11 near Lat. 4.5° N / Long. 90.5° E, at 0300 UTC of 12 near Lat. 6.0° N / Long. 89.0° E and at 1200 UTC of 12 near Lat. 7.5° N / Long. 88.0° E. Moving further northwestwards, it intensified into a Deep Depression and lay centred at 0300 UTC of 13 near Lat. 9.0° N / Long. 87.5° E. Slowly moving northwestwards, it further intensified into a Cyclonic Storm which lay centred at 1200 UTC of 13, near Lat. 9.5° N / Long. 87.0° E. Thereafter, it continued to move in a northwesterly direction, lay centred at 0300 UTC of 14 near Lat. 11.0° N / Long. 85.0° E; further intensified into a Severe Cyclonic Storm which lay centred at 1200 UTC of 14 near Lat. 12.0° N / Long. 83.5° E; at 0300 UTC of 15 near Lat.

14.0° N / Long. 81.5° E and at 1200 UTC of 15, near Lat. 15.5° N/Long. 81.0° E, about 80 kms south of Machilipatnam. Subsequently moving northwards, it crossed south Andhra coast close to Machilipatnam around the midnight and weakened into a Cyclonic Storm, which lay centred at 2100 UTC of 15 close to Gannavaram. It moved northeastwards and further weakened into a Deep Depression, and lay centred at 0300 UTC of 16 close to Nidadavolu. Thereafter, it rapidly weakened into a low pressure area over north coastal Andhra Pradesh in the evening of 16 and became less marked on 17.

#### 5.4.2. Satellite cloud features, Radar and other observations

Maximum intensity of the system as given by Kalpana – 1 was T – 3.5 between 1200 UTC of 14 and 1800 UTC of 15. No 'EYE' was noticed in the Satellite Imagery.

The system was tracked by Doppler Weather Radar (DWR) Chennai and also by CDR Machilipatnam from 15 morning with fair confidence. In the DWR observations Spiral bands with significant feature started appearing from 1056 UTC of 14 and probable vortex centre was first reported at 1156 UTC of 14. Vortex centre could be reported with 'fair' confidence from 1800 UTC to 2100 UTC of 14 and at 0300 UTC of 15 as fairly defined 'EYE' was seen during this period. During the remaining period vortex centre could be estimated only by the spiral bands and reported with 'poor/very poor' confidence. Later from 0700 UTC of 15 hourly dissemination of special observations was discontinued as vortex centre could not be estimated due to ill defined spiral bands.

Overall intensity of the RADAR echoes were seen to be moderate to strong (40 to 45 dBZ) and the vertical extent of the major cloud mass was limited to  $10 \pm 2$  km only. As the system remained more than 200 kms away from the RADAR for major part of surveillance, many detailed features of the intense core region could not be probed by the RADAR. However a few important features were visible when the system centre was less than 200 kms from the RADAR. The maximum sustained wind speed measured by the RADAR was 30 mps (108 kmph) at a height of 1.8 km at about 150 km to the northeast of RADAR. Occasional maximum wind speed of about 34 mps (122 kmph) was also observed. Horizontal velocity estimated through Volume Velocity Processing (VVP) in a cylinder of 30 km radius from DWR indicated the storms position towards east of DWR on 14 and its northward movement on 15.

CDR Machilipatnam also kept continuous special RADAR watch from 0300 UTC of 15 with hourly

observations till 0000 UTC of 16. The centre of the cyclone was located from 0300 to 1100 UTC of 15 based on the spiral bands.

The estimated lowest central pressure was 992 hPa and the maximum estimated wind speed was 55 kts. Lowest central pressure of 993.7 hPa was reported by Machilipatnam at 151900 UTC soon after its crossing the coast. The system generally moved in a northwesterly direction on a slow pace and recurved after crossing the coast and weakened into a cyclonic storm. It weakened gradually into a low pressure area over south Orissa and adjoining north Andhra Pradesh on 17th morning.

#### 5.4.3. Weather and damage

No damage were reported in Tamil Nadu. The system after crossing the coast caused heavy rainfall over Andhra Pradesh. The following are the principal amounts of rainfall (in cm) :

Tamil Nadu :

15 December 2003 : Chennai 2.

Andhra Pradesh :

16 December 2003 : Repalle 19, Bheemadole and Koida 17 each, Nuzivid and Tenali 16 each, Machilipatnam & Kakinada 15 each, Gannavaram & Prakasam barrage 13 each, Guntur 11, Tuni 10, Narsipatnam & Bapatla 8 each, Prathipadu, Dowleswaram, Peddapuram & Achanta 7 each, Gajapathinagaram, Elamanchili & south Kota 6 each, Chodavaram & Anakapalli 5 each.

17 December 2003 : Salur & Chintapalli 10 each, Parvathipuram 9, south Kota 7, Paderu & Narsipatnam 5 each, Visakhapatnam, Waltair & Gajapathinagaram 4 each, Mandasa & Anakapalli 3 each.

According to official reports, the system caused the following damage over coastal Andhra Pradesh.

No. of deaths	81
Agricultural area affected	61898.5 hectares
Houses damaged partially and completely	9090

Also a ship named M. V. Nandkawas got damaged and was at the verge of sinking, near Machilipatnam coast. Crew members were rescued by the coast guard.



