

Cyclones and depressions over the Indian seas and neighbourhood during 1991*

1. Chief features

All the 8 storms and depressions (normal is 12 to 13) which formed during the year originated over the Bay of Bengal. There were 2 cyclones during the pre-monsoon season, 3 depressions/deep depressions during the monsoon season and 2 depressions and 1 cyclonic storm during the post monsoon period. Tracks of these depressions/cyclones are shown in Fig. 1 and brief history is given in Table 1. Monthly frequency and INSAT classifications are given in Tables 2 and 3 respectively.

2. Systems in the Bay of Bengal

2.1. Pre-monsoon season (March-May)

2.1.1. Bangladesh S.C.S. (H) — 24 to 30 April

A low pressure area over SE Bay and neighbourhood concentrated into a depression on April 24 at 0900 UTC. Moving in a northwesterly direction initially it intensified into a S.C.S. (H) on 27th. Then recurving to north-northeast it crossed Bangladesh coast near Sandwip Island (Bangladesh) around midnight of 29 and dissipated over Nagaland, Manipur, Mizoram & Tripura and adjoining parts of Myanmar. Relevant snips observations are given in Tables 4 and 5 and observations of coastal stations of Bangladesh and of Agartala are given in Tables 6 and 7 respectively.

INSAT classified maximum intensity of the system as T 6.5 on D'vorak's scale from 28/1200 UTC to 29/0300 UTC.

(i) Pressure and wind

Kutubdia in Bangladesh recorded lowest surface pressure of 969.5 hPa at 29th, 1800 UTC. Estimated central pressure using Mishra and Gupta's (1976) empirical formula was 920 hPa at 0000 and 0300 UTC of 29 when INSAT classified the intensity as T 6.5 (127 kt, 235 kmph). Kutubdia also recorded highest wind of 98 kt at 1800 UTC of the 29th. A few stations like Sandheads and Teknaf (in Bangladesh) also reported 40 kt wind on 29th.

(ii) INSAT cloud features

INSAT reported ragged 'eye' at 0700 UTC on 27 when intensity was T 4.5. Further a circular 'eye' formed at 0900 UTC of 28 and it became a large 'eye' at 0900 UTC of 29 when intensity was T 6.0.

INSAT reported 'eye' temperature as 221° K on 27 at 1000 UTC and 195° K on 27th, 2100 UTC.

Cyclone Detection Radar (CDR) at Paradip observed a closed circular 'eye' of diameter 60 to 69 km on 29th at 0400 UTC.

(iii) Movement of the storm

The storm moved initially in a northwesterly direction (10 kmph) from 24th to 27th as it was south of the middle and upper tropospheric ridge line. Then it recurved and moved NNE (20 to 25 kmph) when it entered into the upper tropospheric westerly regime.

(iv) Rainfall

Rainfall was heavy to very heavy in Bangladesh and Mizoram on 29/30 April. From the midnight of 29 April there was total disruption of communication system in Bangladesh. Some significant rainfall amounts (cm) in Bangladesh are given below :

29 April, 1200 UTC : Teknaf 21, Situkundi 16, Bhola 11, Kutubdia 10.

29 April, 1800 UTC : Kutubdia 52, Bhola 33, Khulna 4.

Assam, Meghalaya, Nagaland, Manipur, Mizoram & Tripura in India received heavy to very heavy rainfall on 29 and 30 April. Rainfall amounts (cm) are given below :

30 April : Aizwal 9, Imphal 5, Silchar & Shillong 4 each.

1 May : Agartala, Silchar, Hasimara & Dibrugarh AP 4 each.

* Compiled by : U.S. De, D.S. Desai and N.C. Biswas, Meteorological Office, Pune.

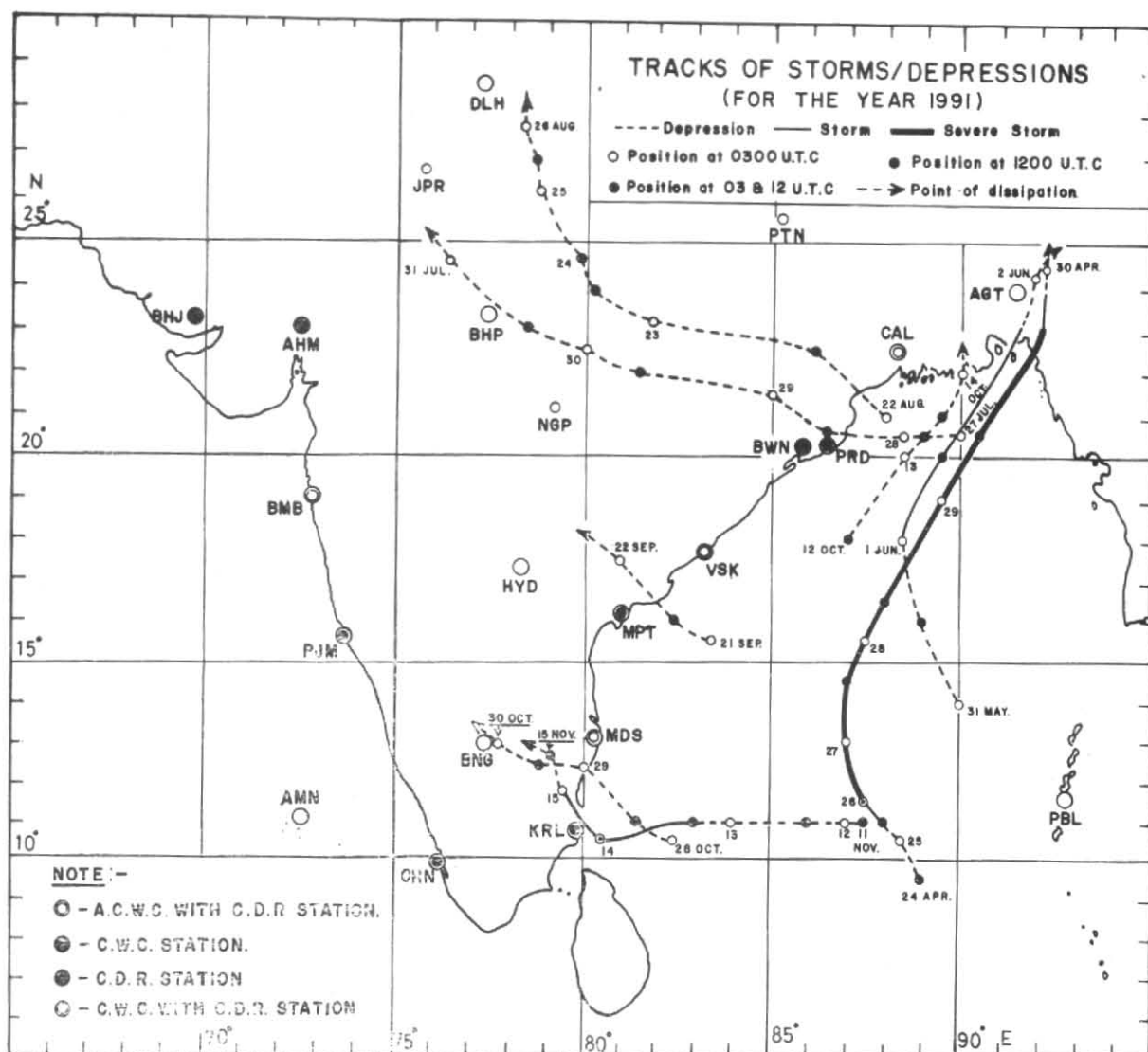


Fig. 1. Tracks of storms and depressions for the year 1991

Storm surge 5.5 m in height affected Bangladesh coast at the time of landfall of storm which coincided with the time of high tides. As per media reports tidal waves 6 m in height swept a coastal stretch of nearly 240 km in Bangladesh. It also affected the neighbouring off-shore islands.

(v) Damages

About 10 million people in 14 districts of Bangladesh were affected and about 1,32,000 human lives were lost. About 40 Bangladesh Airforce planes on the runway were badly damaged and the airfield was inundated by tidal waves. The tidal waves lifted the ship 'Comfort Marine' from Chittagong Port and carried it to a road about 2 km inland. Telecommunication links from Bangladesh to the outside world were completely cut-off. Saline inundation destroyed the paddy crops over an area of approximately 1000 sq km. The people in the cyclone hit area were affected by diarrhoea and gastroenteritis.

In India, sea water inundated in the coastal belt of Cuttack and Balasore districts of Orissa and caused considerable damage to the standing crops. In south 24-Parganas of West Bengal about 250 houses were damaged. Mizoram & Tripura experienced gale force winds and heavy rainfall which caused snapping of telecommunication links and flooding of low lying areas in these states. Landslides were also reported from Mizoram. In Tripura about 7,000 houses were damaged and 5 persons lost their lives. The loss of life in Mizoram was reported to be two.

2.1.2. Bay of Bengal cyclonic storm, 31 May-2 June

Under the influence of the low level circulation a depression formed on the morning of 31 May over the north Andaman Sea and adjoining east Central Bay. It moved in a northnorthwesterly direction up to 1 June. Then it intensified into a cyclonic storm, recurved and moved in a NNE'ly direction and crossed Bangladesh coast between Bhola and Hatia on the morning of 2 June and dissipated over south Assam and neighbourhood by 2 June.

TABLE 1

Brief history of depressions and cyclonic storms over Indian seas and neighbourhood during 1991

S. No.	Type of system	Life period	Point of crossing the coast	Recorded lowest pressure/ central pressure (hPa)	Recorded maximum wind	Highest T. No. recorded
1	SCS(H)	24-30 April	Chittagong coast across Sand-wip island around midnight of 29 April	Estimated 920 hPa. Kutubdia (41989)-969.5 hPa at 1800 UTC of 29 April	130°/98 kt at Kutubdia at 1800 UTC of April	6.5
2	CS	31 May-2 June	Bangladesh coast between Bhola and Hatia on the morning of 2 June	Estimated central pressure 988 hPa at 1200 UTC of 1 June	100°/45 kt at Chittagong on 02/0000 UTC	3.0
3	DD	27-31 Jul	Orissa coast about 30 km north of Paradip around 1200 UTC of 28th	982.7 hPa at Bhubaneswar at 1200 UTC of 28th	240°/35 kt by ship VWKZ over west central Bay & 160°/33 kt and 200°/33 kt at Paradip on 19 & 20 UTC of 28th	2.0
4	Depression	22-26 Aug	Orissa-West Bengal coast just north of Balasore around mid-day of 22nd	991.1 hPa at Khajuraho at 1200 UTC of 24th	SSW/20 kt at Bhubaneswar at 1200 UTC of 22nd	—
5	Do.	21-22 Sept	Andhra coast between Kakinada & Narsapur around midnight of 21st	1000.2 hPa at Ongole, Machilipatnam and Kakinada at 1200 UTC of 21st	200°/38 kt by ship ATJV (11.8/80.6) at 0000 UTC of 21st	1.5
6	Do.	12-14 Oct	Bangladesh coast in the forenoon of 14th	1001.3 hPa at Sandheads at 1200 UTC of 13th	190°/24 kt by ship ATIU (18.3/90.0) at 0030 UTC of 14th	1.5
7	Do.	28-30 Oct	Tamil Nadu coast near Pondicherry around 0300 UTC of 29th	999.7 hPa at Vellore and Cuddalore at 1200 UTC of 29th	N/15 kt at Pamban at 0300 UTC of 28th and NW/15 kt at Nagapattinam on 1200 UTC of 28th	1.5
8	CSj	11-15 Nov	Tamil Nadu coast north of Karaikal around 1900 UTC of 14th	Estimated 990.0 hPa. Cuddalore 995.1 hPa at 0100 UTC of 15th	NW/48 kt at Nagapattinam at 2200 UTC of 14th	3.0

(i) Pressure and wind

Estimated lowest central pressure following empirical formula of Mishra and Gupta was 988 hPa on 1 June at 1200 UTC, when INSAT reported peak intensity T 3.0 on D'vorak's scale : Chittagong recorded maximum wind of 100°/45 kt at 0000 UTC of 2nd. According to media reports gale force winds of 100 to 110 kmph were experienced in the coastal areas of Chittagong and Noakhali districts of Bangladesh. Along Chittagong coast tidal waves of height 2.5 m were reported at the time of landfall.

(ii) INSAT cloud features

INSAT gave maximum intensity of T 3.0 and did not report any 'eye'.

(iii) Movement of the storm

Between 31 May and 1 June the system moved (20 kmph) in a NNW'ly direction as a depression. Then the system intensified into cyclonic storm, recurved to NNE and moved with a speed of 30 kmph till it crossed coast.

(iv) Rainfall

Significant amounts of rainfall (cm) were :

2 Jun : Cherrapunji 14, Agartala AP & Bokajan 7 each.

3 Jun : Tezu 11, Chauldaghat 9, Cherrapunji, north Lakhimpur & Rajghat 8 each, Bokajan & Itanagar 7 each.

In association with the storm SW monsoon advanced into Assam, Meghalaya and adjacent states.

(v) Damages

According to press reports 300 fishermen were reported missing in the Meghna estuary of Bangladesh and were feared to have been drowned. Tidal waves 1 to 2 m in height damaged crops and houses in Bhola, Patuakhali and Joakhali areas of Bangladesh. Incessant rain accompanied by strong winds lashed several areas of Mizoram state in India. However, no casualties were reported in India.

*2.2. Monsoon season (June-September)**2.2.1. Deep depression, 27-31 July*

It was the first monsoon depression of the season. Under the influence of an upper air cyclonic circulation, a depression formed over the north Bay on 27th. Moving westwards it crossed Orissa coast, about 30 km north of Paradip around 1200 UTC of 28th. Moving further in a westnorthwesterly direction it intensified into a deep depression on 29th. Further continuing its westnorthwesterly movement across Madhya Pradesh, it dissipated over east Rajasthan on 31st.

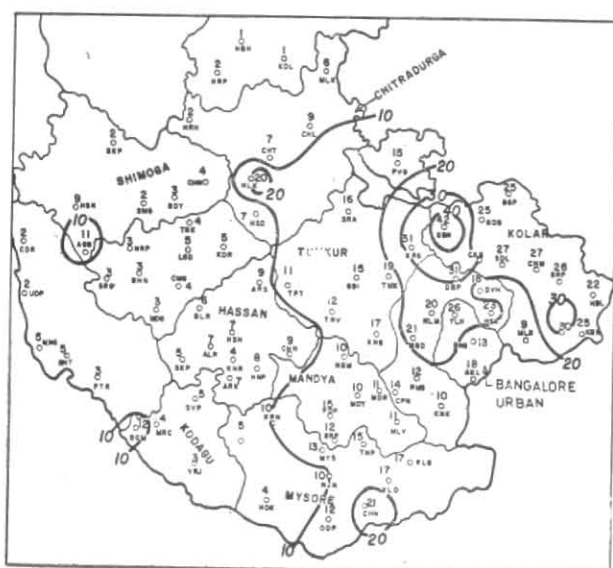


Fig. 2. Cumulative rainfall (cm) from 29 to 31 October, 1991.

TABLE 2

Storms/Depressions statistics 1991 over Bay of Bengal.

System	Jan to Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Depression	—	—	—	—	1	1	1	2	—	—	5
Cyclonic storm	—	—	1	—	—	—	—	—	1	—	2
Severe cyclonic storm	—	—	—	—	—	—	—	—	—	—	—
SCS (H)	—	1	—	—	—	—	—	—	—	—	1
Total	—	1	1	—	1	1	1	2	1	—	8

The lowest pressure of 982.7 hPa was recorded at Bhubaneswar while Paradip recorded 982.9 hPa on 28 at 1200 UTC. The highest wind speed of 35 kt reported by the ships was over W.C. Bay of Bengal on 27 at 0000 UTC. Paradip reported wind of 33 kt on 28th, 1900 UTC.

The DD caused heavy to very heavy rainfall and augmented the monsoon activity, in Orissa, Madhya Pradesh, east Rajasthan, Punjab, Himachal Pradesh, Gujarat region and Maharashtra. Torrential rain on 29 July over Vidarbha caused breach in the embankment of *Wardha* river in the early morning of 30 causing flash floods in Mowad village in Narkhed Tehsil of Nagpur district. Flood waters submerged Mowad and several other villages on the banks of the river. 228 persons were dead/missing. 20 people were drowned in flood waters at Malkhed in Amravati district. Heavy rains/floods damaged 6,291 houses in Nagpur, Wardha and Amravati districts. Heavy rains caused floods in the rivers *Baitarani*, *Bansadhara*, *Dholajor*, *Malaguni* and *Kasumi* in Orissa. Vast areas of paddy field were submerged by flood waters in Kalahandi, Cuttack, Puri and Koraput districts. Several villages in Balasore district were inundated by the flood water. 17 people

TABLE 3

Satellite observation of storms over Indian seas during 1991

Date/Time (UTC)	INSAT-1D T-Classification/CL No.	Coordinates of the centre given by the satellite		Assigned intensity of the system
		Lat. (°N)	Long. (°E)	

(1) Bangladesh — SCS(H), 24-30 April

24/1200	1.5	9.5	89.0	D
25/0300	2.0	11.0	88.5	DD
25/1200	2.5	11.0	88.5	CS
26/0000	3.0	10.5	87.5	CS
26/0300	3.0	10.5	87.5	CS
26/1200	3.5	11.0	87.7	SCS
27/0300	4.0	13.1	87.0	SCS(H)
27/1200	4.5	14.5	86.9	SCS(H)
28/0000	4.5	15.0	87.4	SCS(H)
28/0300	5.0	15.8	87.6	SCS(H)
28/1200	5.5	16.7	88.1	SCS(H)
29/0000	6.5	18.5	89.1	SCS(H)
29/0300	6.5	19.4	89.4	SCS(H)
29/1200	6.0	20.6	90.5	SCS(H)
29/2100	4.5/5.0	23.0	92.0	SCS(H)

(2) Bay cyclonic storm, 31 May-2 June

31/0300	1.5	14.0	90.0	D
31/1200	2.0	15.8	88.8	DD
01/0000	2.5	17.4	88.4	CS
01/0300	2.5	18.0	88.4	CS
01/1200	3.0	19.7	89.6	CS
02/0000	3.0	22.3	90.4	CS

(3) Karaikal — CS, 11-15 Nov

11/0300	1.0	12.5	91.0	—
11/0900	1.5	12.5	90.0	—
11/1200	1.5	12.5	90.0	D
12/0300	1.5	12.5	88.5	D
12/1200	1.5	12.0	86.5	D
13/0100	2.0	11.0	85.0	D
13/0300	2.0	11.0	84.5	DD
13/0600	2.5	11.0	84.0	DD
13/1200	2.5	10.7	83.4	CS
13/2000	3.0	—	—	CS
14/0300	3.0	10.3	80.6	CS
14/0900	2.5/3.0	10.6	80.3	CS
14/1200	2.5/3.0	10.7	80.3	CS
15/0000	2.5/3.0	11.2	79.8	CS
15/0300	—	11.7	79.6	CS

lost their lives in the State. In Srikakulam district of Andhra Pradesh heavy rains/floods claimed 15 lives. Torrential rain caused floods in Gujarat, which claimed 65 lives. 57 villages in Sabarkantha and Pachmahal districts in Gujarat were marooned.

TABLE 4
Ship observations, 24-29 April 1991

Call sign of the ship	Date/Time (UTC)	Position of ship		Wind		Remarks
		Lat. (°N)	Long. (°E)	Dir. (deg)	Speed. (kt)	
ATCX	24/1200	5.8	84.8	260	18	
VTKK	25/0600	13.7	88.0	060	24	Overcast sky
VTCN	26/0600	10.0	85.3	280	17	Overcast sky and PPPP-1003.5 hPa
VWJS	26/0600	5.7	89.4	220	26	Overcast sky
ATKE	26/1200	13.4	82.9	350	20	Overcast sky
C6IM	26/1200	5.7	85.9	250	26	Overcast sky
VVGC	27/0000	8.2	84.2	210	08	PPPP-1000.3 hPa
ATJV	27/0000	15.5	85.5	080	24	Overcast sky
ATIU	27/0600	10.6	91.6	180	25	
ATJV	27/1200	14.3	84.6	010	35	Overcast sky and PPPP-997.2 hPa
ATJV	28/0000	12.3	85.1	290	30	Overcast sky
VVGC	28/0300	9.8	90.7	230	25	
VVGR	29/0000	13.0	90.0	210	40	Overcast sky
VVGR	29/0300	13.3	89.7	210	40	Overcast sky
VVGC	29/0600	13.3	87.7	200	24	

TABLE 5
Observation of the ship HZJV, 27-29 April 1991

Date / Time (UTC)	Position of the ship		Wind		Remarks
	Lat. (°N)	Long. (°E)	Dir. (deg.)	Speed (kt)	
27/1030	16.9	85.3	NNE	33-37	998.5 hPa
27/1830	16.9	85.3	NE	30-44	997.5 hPa high and large swell
28/0330			NNE	37	986.0 hPa
28/0730	16.2	87.3	NNE	60	980.5 hPa
28/0930	—	—	N	60	983.0 hPa
28/1230	—	—	NW	60	988.0 hPa
29/0030	15.3	87.5	NW	44	1000.0 hPa
29/0330	—	—	NW	30	1002.5 hPa

Damage to property was estimated around Rupees 140 million in Mowad and about Rupees 30 million in Amravati.

The significant amounts of rainfall (cm) in association with system were :

28 Jul : Ambadale 33, Puri 32, Nimapada 23, Bhubaneswar AP & Naraj 15 each, Alipingal 12, Jennapur 11, Berhampur, Mohana & Surada 10 each.

29 Jul : Kotaghora 37, Balliguda 27, Puri 22, Khariur 20, Gudari 17, Nimapada 15, Junagarh & Surat 13 each, Alipingal & Kanker 12 each, Naraj 11, Jeypore 9, Gadchiroli, Jagdalpur, Mohana & Phulbani 8 each.

30 July : Betul & Narkhed 37 each, Hoshangabad 34, Amgaon 24, Dhanora 11, Lanji & Paratwada 21 each, Tirora 20, Gadchiroli 19, Nagpur AP 18, Selu & Waraseoni 15 each, Balod & Marshi 14 each, Wardha 13, Balaghat & Gondia 12 each, Amravati & Khandwa 11 each, Chandrapur 9.

31 July : Banswara 27, Thikri 25, Derol Bridge 21, Gandhinagar & Mansa 18 each, Hatmatiwair 17, Dohad 15, Shajapur 14, Jhabua & Narsingpur 13 each, Tankurd 12, Cooch-Behar & Dhar 11 each, Kheroi & Ujjain 10 each, Una 8, Hamirpur, Udaipur & Vidisha 7 each.

1 Aug : Kanga 15, Mausua 11, Banswara 9, Loharia 8, Shivpuri 7.

2.2.2. Depression, 22-26 August

The remnant of the typhoon 'Fred' moved from east over the NW Bay on 21st and concentrated into a depression in the morning of 22nd. The depression crossed north Orissa—west Bengal coast just north of Balasore around the mid day of 22nd and lay over Bihar Plateau and neighbourhood by the same evening. It moved westwards upto 23rd and later northwestwards and become unimportant by 26 Aug.

Khajuraho reported the lowest pressure 991.1 hPa on 24 at 1200 UTC. Bhubaneswar reported strongest wind SSW/20 kt on 22 at 12 UTC.

Heavy to very heavy rainfall occurred on 1 to 3 days in Gangetic West Bengal, Orissa, Plains of west Uttar Pradesh, Puniab, Rajasthan, Madhya Pradesh, Konkan and Goa and Vidarbha. Heavy rains caused floods in rivers *Baitarani*, *Mahanadi*, *Bhargavi*, *Dhanua*, *Kapilo*, *Koila* and others in Orissa, which submerged vast areas of paddy field in the State. Heavy rains/floods claimed 11 lives in Orissa and 9 lives in Alwar districts of Rajasthan.

The significant amounts of rainfall (cm) were :

22 Aug : Akhuapada & Bankura 15 each, Koltriguda & Nimapada 12 each, Bhubaneswar AP & Chandbali 11 each, Talchar 10, Dhenkanai 7.

TIME (UTC) \ STATION	1600	1700	1800	1900	2000	2100	2200	2300	0000	0100	0200	0300
CUDDLORE	046 ●	033 ● 8	028 ● 8	016 ● 8	999 ● 8	990 ● 8	977 ● 8	964 ● 8	958 ● 8	951 ● 8	982 ● 8	012 ● 8
KARAIKAL	016 ● 30	013 ● 32	004 ● 35		990 ● 46	998 ● 47	004 ● 48	006 ● 48	020 ● 48	034 ● 48	047 ● 48	056 ● 48
NAGAPATTINAM	032 ●	022 ●	014 ●	002 ●	011 ●	004 ●	013 ●	024 ●	039 ●	047 ●	063 ●	072 ● 29

Fig. 3. Hourly observations of Cuddalore, Karaikal and Nagapattinam between 1600 UTC of 14 Nov. and 0300 UTC of 15 Nov, 1991

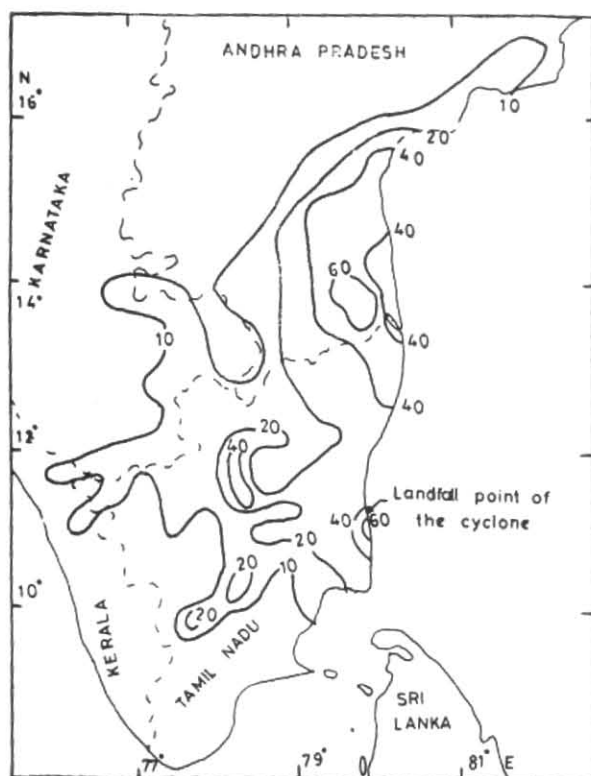


Fig. 4. Cumulative rainfall (cm) over Peninsular India for the period 14-17 November 1991

23 Aug : Katghora 28, Gariaband 23, Amgaon & Naipur 15 each, Pendra & Umaria 13 each, Pachmari 11, Bankura & Gondia 10 each, Durg & Rajnandgaon 9 each, Mandla 8, Bilaspur 7.

24 Aug : Jabalpur 22, Khanpur 18, Raisen & Vidisha 17 each, Koyna & Ratlam 16 each, Dungarwadi 14, Bhopal & Narsingpur 11 each, Hoshangabad 9, Churu, Gwalior & Shahbad 7 each.

25 Aug : Orchha 17, Pichore 16, Shivpur 15, Badi & Koyna 14 each, Dungarwadi 9, Rajapur 8, Datia, Mount Abu & Shajapur 7 each.

26 Aug : Sohagpur 16, New Delhi 11, Kaman 9, Dharmshala & Hajipur 8 each, Bharatpur 7.

27 Aug : Gurgaon 13, Rohtak 8, Gohana & Jhunjhunu 7 each.

2.2.3. Depression 21-22 September

Under the influence of a circulation in the low levels a depression formed over the WC Bay off Andhra coast on 21st. The depression moved in a NW'ly direction and crossed Andhra coast between Kakinada and Narsapur around the midnight of 21st and weakened over Telangana and neighbourhood on 22nd.

The system was a depression for one day only. The ship *ATJV* (11.8/80.6) reported 38 kt wind on 21st at 0000 UTC. The lowest pressure 1000.2 hPa was recorded at Kakinada, Ongole and Machilipatnam on 21st at 1200 UTC. The system caused heavy to very heavy rainfall in Andhra Pradesh. However, no damage has been reported from the State.

The significant amounts of rainfall (cm) were :

21 Sep : Bapatla 11, Avanigadda 9, Chinthalapudi 8, Kalingapatnam & Nellore 7 each.

22 Sep : Eluru 23, Nandigama & Tiruvur 17 each, Nalgonda 15, Vijayawada AP 14, Khammam & Madhira 13 each, Machilipatnam 12, Hyderabad AP 10, Srisaillam 9, Wanapathy 7.

23 Sep : Bhongir 22, Nalgonda 12, Maski & Shanigram 11 each, Yemminganur 10, Karimnagar 9, Huzurabad 7.

2.3. Post monsoon season (October-December)

2.3.1. Depression, 12-14 October

Under the influence of an upper air circulation a depression formed over the WC Bay on 12th at 1200 UTC.

The depression moved northnortheastwards and was near 20.0°N, 88.5°E on 1303 UTC and near 22.0°N, 90.0°E on 1403 UTC. Crossing Bangladesh coast in the forenoon of 14th the system took northerly course and weakened over coastal Bangladesh and neighbourhood by the afternoon of 14th.

TABLE 6

1800 UTC observations of 29th April 1991

Station	Surface wind		Surface pressure (hPa)	Prevailing weather
	Dir. (deg.)	Speed (kt)		
Akyab (48062)	SSE	25	999.0	Overcast sky
Kutubdia (41989)	130	98	969.5	Squally weather with shower
Sandwip (41984)	070	05	974.7	Raining
Khulna (41947)	020	38	994.3	Heavy shower
Bhola (41951)	360	18	—	Raining
Sandheads	ENE	10	999.0	—

TABLE 7

Observations of M.O. Agartala on 29 and 30 April 1991

Date	Time (UTC)	Wind	
		Dir. (deg.)	Speed (kt)
29 Apr 1991	2000	040	52
29 Apr 1991	2100	030	45
29 Apr 1991	2200	360	32 to 42
29 Apr 1991	2300	360	20 to 40
30 Apr 1991	0000	340	29 to 40
30 Apr 1991	0100	320	30 to 41
30 Apr 1991	0300	270	15 to 25

The depression and its remnant caused heavy rainfall over Assam and Meghalaya and Tripura. Rivers *Kopilli* and *Brahmaputra* were in spate. Landslides occurred at several places in the State. According to press reports, floods/heavy rain in Assam affected 5,94,249 people in 591 villages. There was also loss of 18 human lives and 109 cattle heads. It affected 47,680 hectares of agricultural land.

The significant amounts of rainfall (cm) were :

13 Oct : Bokajan 6, Arundhutinagar & Shillong 4 each.

14 Oct : Cherrapunji 31, Shillong 24, Dholai, Gharmura & Guwahati AP 12 each, Dharmatul 11, Arundhutinagar 10, Karimganj, Matizuri, Numalighat & Tezpur 6 each.

15 Oct : Guwahati AP & Shillong 16 each, Dharmatul 11, Rangiya 10, Panbari 7.

16 Oct : Matizuri & Tezu 4 each.

TABLE 8

Ship observations from Bay of Bengal during 12-15 Nov 1991

Date (Nov '91)	Time (UTC)	Call sign	Position		Wind	
			Lat. (°N)	Long. (°E)	Dir. (deg)	Speed (kt)
11	1200	VVMG	12.9	84.5	060	20
12	0000	ATGH	12.0	87.3	170	15
12	0300	VVMG	10.2	83.5	230	03
Do.	0300	ATGH	12.0	86.9	090	20
Do.	0600	ATGH	12.1	86.4	080	20
Do.	0600	VWVY	12.7	84.3	040	16
Do.	0600	VWPX	13.0	88.7	140	30
Do.	0600	VWXP	10.6	83.6	060	15
Do.	0900	ATGH	12.1	86.1	070	22
Do.	1200	ATGH	12.2	85.7	050	25
Do.	1800	ATGH	12.5	84.7	060	28
13	0000	ATGH	12.6	83.9	050	28
Do.	0300	ATGH	12.6	83.4	050	25
Do.	0600	ATGH	12.7	83.0	050	25
Do.	1200	ATGH	12.9	82.2	050	20
Do.	1200	VTYP	14.4	81.2	050	25
Do.	1800	ATGH	12.9	81.4	050	30
14	0000	ATGH	13.0	80.6	050	32
14	1200	ATUI	16.6	82.6	040	28
15	0000	ATKK	10.6	81.2	230	28

2.3.2. Depression, 28-30 October

Under the influence of an upper air system the depression formed over the SW Bay on 28 morning. It crossed coast near Pondicherry on 29 at 0300 UTC and weakened rapidly over south Andhra Pradesh and neighbourhood by 1 November.

Heavy rains in association with the system affected south Andhra Pradesh, Tamil Nadu and south interior Karnataka. Cumulative rainfall from 29 to 31 October over south interior Karnataka is shown in Fig. 2.

According to press reports, 21 persons each in Andhra Pradesh and Tamil Nadu and more than 20 in south interior Karnataka lost their lives due to heavy rains/floods. Due to blockage of railway track by sliding boulder from a hillock Bangalore — New Delhi, Karnataka express got derailed on the night of 30 near Doddaballapur. 29 people were killed and many were injured in the accident.

The significant amounts of rainfall (cm) were :

29 Oct : Parangipettai 27, Cuddalore & Paradip 22 each, Kumbakonam 21, Chidambaram & Pondicherry 19 each, Rapur 18, Red Hills & Satyaveedu 17 each, Tada 16, Dharmapur & Rajampet 15 each, Salem, Tirupati AP & Vellore 14 each, Madras 13, Arogyavaram & Karaikal 12 each, Sulerpet 11, Tumkur 10, Pakala 9, Cuddapah 7.

- 30 Oct : Bangarpet & Naduvattam 21 each, Guidiyatham 20, Puttur 19, Kollegal 17, Chittoor & Palskode 15 each, Chintamani & K.G. Field 14 each, Gudibande 13, Bangalore 12, Koderu, Nelamangala & Parangipettai 11 each, Hosur, Pakala & Uthagamandalam 10 each, Dharmapuri, Ongole & Vellore 9 each, Kavali 8.
- 31 Oct : Penukonda 19, Hally Mysore 18, Koratagere 17, Sompura 14, Bagepalli 13, Kavali 12, Anantapur & Sulurpet 11 each, Kundukur & Yelhanka 10 each, Badvel & Ongole 9 each, Tumkur 7.

2.3.3. Karaikal cyclone 11-15 November

This cyclone formed out of the remnant of T.S. 'Thelma'. Thelma formed over the NW Pacific, crossed Phillipines and emerged into Andaman Sea on 10th. Moving westwards over the SE Bay of Bengal, it intensified into a depression on 11th. Continuing its westward movement, it became a cyclonic storm over the SW Bay on 13 morning. Thereafter, it moved north-westwards and crossed Tamil Nadu coast and weakened over north Tamil Nadu and neighbourhood by the night of 15th.

Ship observations from the Bay of Bengal during 11-15 Nov are shown in Table 8. Hourly observations of Cuddalore, Karaikal and Nagapattinam on 15 Nov 1991 are given in Fig. 3.

(i) Pressure and wind

Ship ATGH (about 200 km away from storm) reported surface pressure 1008.0 hPa on 14th at 1200 UTC. Cuddalore reported surface pressure of 995.1 hPa and pressure change of 13.6 hPa on 15 at 0100 UTC. Estimated lowest central pressure according to Mishra and Gupta's empirical formula was 990.0 hPa at the time of landfall.

Nagapattinam reported peak wind speed of 48 kt at 2200 UTC on 14. Many ships reported winds of 30 kt near the storm centre.

(ii) INSAT cloud features

INSAT gave peak intensity of T 3.0 (83 kmph) on 14th at 1200 UTC and on 15th at 0000 UTC.

(iii) Movement of the storm

Cyclone moved in a westerly direction over the Bay of Bengal till its landfall, as the upper tropospheric strong easterly winds steered the system. After landfall the system moved in a NW'ly direction under the influence of SE/S'ly winds.

(iv) Rainfall

Widespread rainfall with heavy to very heavy falls occurred over Tamil Nadu, south coastal Andhra Pradesh, Rayalaseema and south interior Karnataka during 14-17 November. An all time record rainfall of 48 cm occurred at Karaikal on 15 Nov. Venkatagiri in Nellore district of coastal Andhra Pradesh reported 48 cm of rainfall on the same day. Isohyetal map of rainfall (cm) over Peninsular India for the period 14-17 Nov 1991 is shown in Fig. 4. The significant amounts of rainfall (cm) were :

14 Nov : Madras AP 20, Satyaveedu & Sulurpet 19 each, Tambaram 17, Kovelong 12, Ponneri 11, Chengalpatti, Karaikal, Poondi & Tirupathi AP 8 each, Cuddalore & Nagapattinam 7 each.

15 Nov : Karaikal & Venkatagiri 48 each, Mayiladuthurai 31, Sirkali 30, Nagapattinam 29, Kumbakonam 27, Gudur 21, Kodur & Ponneri 19 each, Mannargudi 18, Chidambaram & Vedaranyam 16 each, Chittoor, Sulurpet & Thanjavore 15 each, Nellore 14, Kavali 12, Adirampattinam & Tiruchirapalli 11 each, Madras, Pondicherry, Tirupathi AP & Vellore 10 each.

16 Nov : Yeroud 33, Nellore 26, Kavali 24, Kandukur 23, Kodur 18, Ponneri 14, Koderu, Sulurpet 12 each, Bangalore, Dharmapuri, Gudur & Yelhanka 11 each, Narasapur & Ongole 10 each, Chittoor, K.G. Field, Madras & Vedaranyam 9 each, Bapatla & Machilipatnam 8 each.

17 Nov : Ongole 21, Usilampatti 18, Kovelong & Tambaram 11 each, Erode & Udayagiri 10 each, Badvel & Madras AP 9 each, Bapatla 8, Chittoor, Kodur, Pakala & Tirupathi AP 7 each.

(v) Damage

Due to the storm sea water entered 200 to 250 m inland near the landfall point. Considerable damage to standing crops and properties was reported from the coastal regions of Tamil Nadu as a result of inundation caused by heavy rains. Floods/heavy rains claimed 185 human lives in Tamil Nadu. 540 cattle heads also perished in Tamil Nadu. Damage was estimated around Rupees 1724 million due to crop loss and Rupees 1508 million as a result of damages to buildings and public works. In Andhra Pradesh, Prakasam, Nellore, Chittoor and Cuddapah districts suffered considerable damage due to heavy rains. 16 persons lost their lives in Nellore and Chittoor districts.