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# Extreme sea level variability along the coast of India

**Volume I**

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# **Extreme sea level variability along the coast of India**

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## **BACKGROUND**

India has along coastline (about 6000 km) and a significant fraction of her population resides in coastal area, the most densely populated being the deltas along the east coast. Flooding and erosion associated with changes in coastal sea level therefore have a major impact on life and property. Other vulnerable areas include offshore drilling platforms, which now account for a large fraction of India's indigenous petroleum and natural-gas resources. The east coast is particularly vulnerable because of the large number of cyclones and storms that form in the Bay of Bengal. For example, the super cyclone that crossed Orissa during October, 1999 caused a loss of about 10,000 lives, besides causing tremendous destruction to property. Though the occurrences of these incidents are more along the east coast, the west coast is also not free from such events. During the onslaught of a cyclone into a coastal region, the maximum damage is created by the storm surges. These damages include destruction to life and property, besides losses in agricultural production due to the intrusion of saline waters into the field. Thus, the study on impacts of extreme sea level in the coastal regions of India becomes extremely important.

Global warming is expected to cause an increase in sea level. The analysis of sea level data in the 20 th century shows an increase in sea level between 1.0 and 2.0 mm/year. However, projections for the future are much higher. A sea level rise of 0.09 to 0.88 m is projected for 1990 to 2100 for different scenarios (Inter Governmental Panel on Climate Change (IPCC), 2001). Low lying areas in coastal areas will be particularly

vulnerable to the sea level rise. Moreover, the increase in mean sea level will cause increased flood risks associated with storm surges.

## **OBJECTIVES**

The present project envisages a study on the impact of climate change on extreme sea level variability along the coast of India. The main objectives can be listed as follows.

### **Objective 1**

To describe the present scenario on extreme sea level variability along the Indian coasts.

### **Objective 2**

To study the impact of cyclones and storm surges in the coastal regions of India.

### **Objective 3**

To estimate the long term change in mean sea level along the Indian coasts.

### **Objective 4**

To analyse regional climate model data for the northern Indian Ocean for future climate.

### **Objective 5**

To estimate return periods of extreme sea level in the event of sea level rise in future.

## INTRODUCTION

Extreme sea level variability along the coast of India” is a part of the Indo-UK project on “Impacts of Climate Change in India”. The impacts of climate change in coastal regions can occur mainly due to (i) an increase in mean sea level and (ii) an increase in the extreme sea level events (storm surges) due to a possible increase in the occurrence of tropical cyclones. The present project mainly dealt with the latter aspect. It is of particular concern to India in view of the damages that occur along the east coast of India from the cyclones that form in the Bay of Bengal. Any increase in the frequency or intensity of tropical disturbances in future will cause increased damages to life and property in the coastal regions.

Recent studies on the occurrence of cyclones in the Bay of Bengal has shown no increase in the trend of occurrence of tropical cyclones in the last century, rather shows a slight decrease (Rupa Kumar et al., 2002; Bhaskar Rao et al., 2001). However, on a global scale, Haarsma et al. (1993) examined tropical disturbances in a GCM with  $2.5^{\circ} \times 3.75^{\circ}$  grid resolution. They showed that in spite of the coarse resolution, GCM could reveal essential features of the tropical cyclones, and found that the effect of doubling of  $\text{CO}_2$  in global climate model simulations showed an increase in the number of tropical disturbances, particularly intense events. In the present work, we examined the frequency distribution of cyclones in future climate by analysing the results of a regional model for the northern Indian Ocean (HadRM2).

In India, studies on storm surges had been mainly based on numerical modelling. These studies started in the 1970's (Das, 1972) and later more sophisticated models were



employed (see Murty et al., 1986; Dube and Gaur, 1995) to simulate storm surges using the input of cyclone parameters such as the track of the cyclone and core pressure, besides the bathymetry of the region. However, little effort has gone into analysis of tide gauge records for studying these events along the Indian coasts. Observations of surges will be very useful in validating the present models to improve their prediction capabilities. In the present project, we analyse the past tide gauge records to identify and quantify the extreme sea level events. Though there are instances of break-down of tide gauges during the occurrence of severe cyclonic events, there do exist sufficient data during the analysis period in order to identify surges during many severe cyclonic events. In the present work, we analysed the hourly tide gauge data of 15 years duration to identify extreme sea level events and use statistical methods to determine their return periods (Task 1).

The above analysis covered both west and east coasts of India. The descriptive part of the study and the study of impacts were covered for both the coasts. However, the statistical analysis for estimating the return periods was made to the east coast only. This is mainly because the occurrence of extreme sea level events is much more along the east coast than the west coast. Moreover, the number of extreme events in the stations along the west coast during the period of analysis is not enough to carry out a statistical analysis.

Studies on impact of extreme sea level in the coastal regions form a part of the present project. In the event of an onslaught of a cyclone into a coastal region, the maximum damage is created by storm surges. In the present study, the damages of

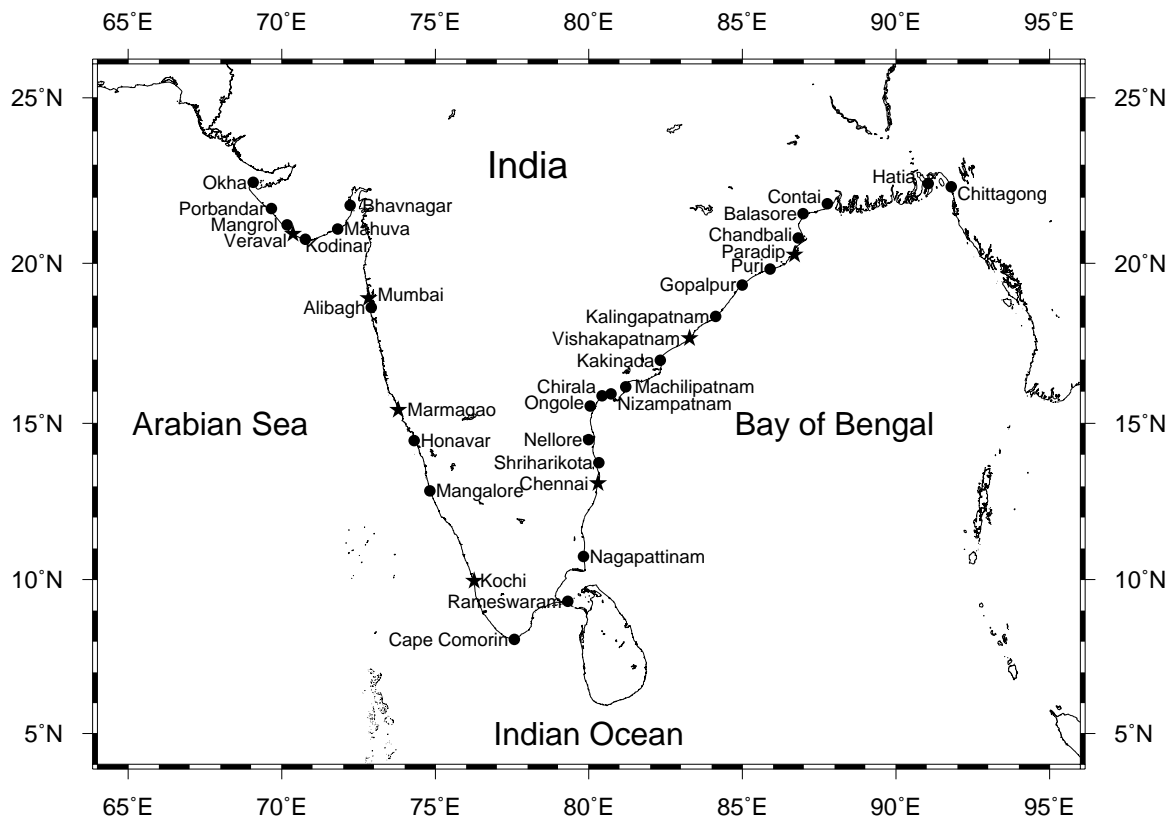


Figure 1. The location map. The stars indicate tide gauge stations.

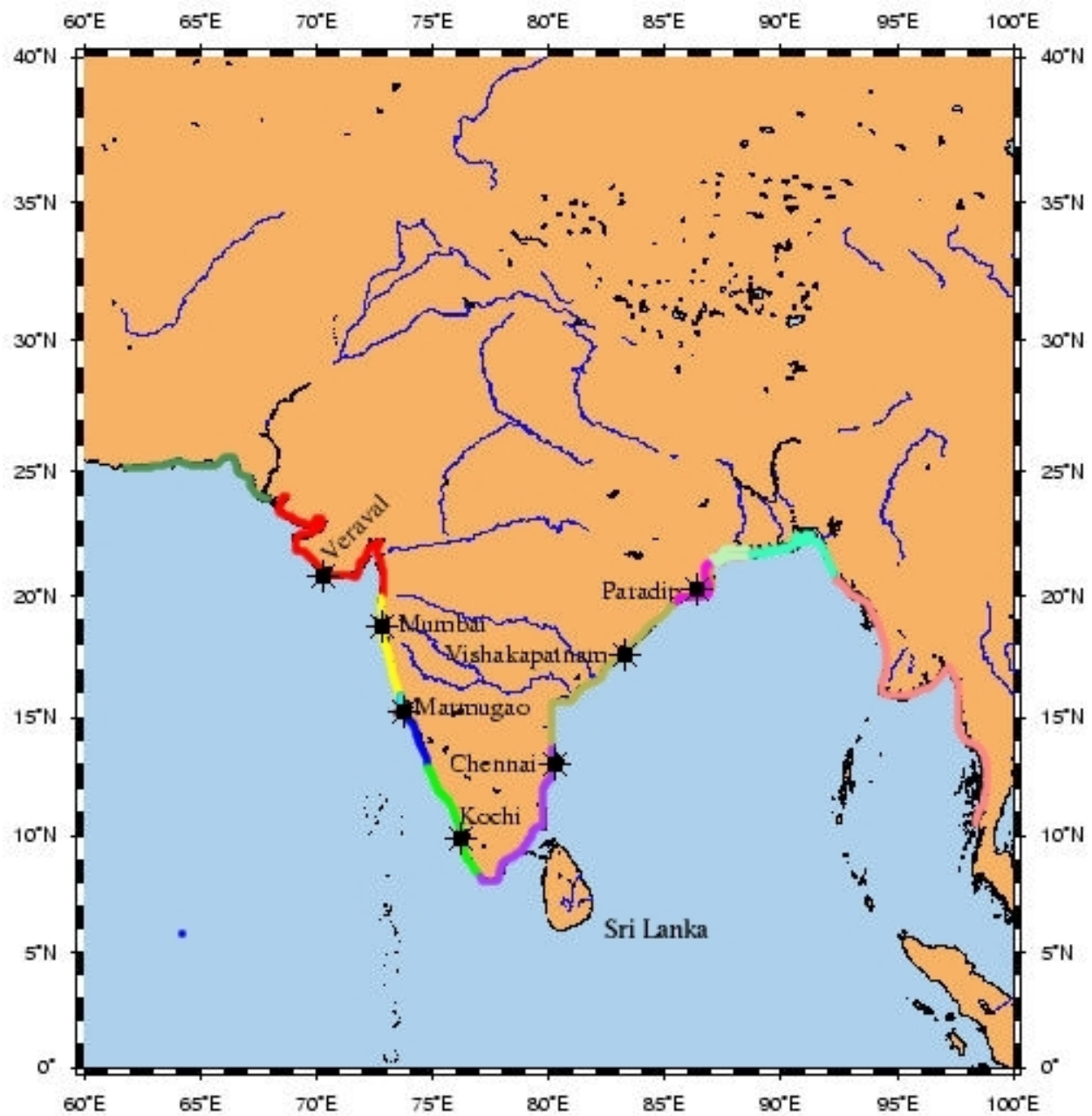


Fig. 2: Coast line of the States of India and adjoining countries, viz., Pakistan, Bangladesh and Myanmar (Burma).

cyclones and storm surges in coastal regions along the Indian coasts during past 50 years were documented (Task 2).

Global warming is expected to cause increase in sea level. Increase in sea level will cause increased risks associated with storm surges, even if the frequency and intensity of storms will remain unchanged. Though the main theme of the present project is on analysis of extreme sea level, we also estimated the mean sea level rise at selected tide gauge stations along the Indian coasts. The monthly mean sea level at selected stations were analysed to estimate long term changes in sea level (Task 3).

The impact of climate change on extreme sea level was addressed by analysing the data from the regional model for the northern Indian Ocean, HadRM2 (Task 4). The parameters analysed were sea level pressure and near surface winds, air temperature and precipitation. The results for a control run of the model and for a simulation with doubled green house gases (GHG) were analysed for the period 2041-2060.

A two-dimensional barotropic model was developed for the Bay of Bengal region for the simulation of storm surges. The model forced with HadRM2 winds were used to analyse the storm surge events in future climate.

The estimates of return periods for a future scenario of sea level rise (Task 5) were made. The estimate of the projected sea level rise for 2050 from global models (HadCM3) was used to calculate the return periods of extreme sea level in future.

## METHODOLOGY

### **Task 1: Identification of extreme sea level events from tide gauge record and estimation of their return periods**

This section deals with the analysis of tide gauge data at six locations along the coasts of India. The main objectives are (i) to identify and describe storm surge events in a record of 15 years and (ii) to estimate their return periods. This provides a qualitative and quantitative description of the present scenario on extreme sea level variability along the Indian coasts. It forms the basic information, on which variability in future climate scenario can be built.

#### *(i) Identification of extreme sea level events along the Indian coasts*

The tide gauge locations along the Indian coasts are shown in Fig.1. In Fig.2, the coastal boundary of different States of India are shown. Hourly tide gauge data (1974-1988), provided by the Geodetic and Research (G & R) Branch, Survey of India, Dehra Dun were used for the present analysis. The stations analysed are Paradip, Vishaphapatnam, Chennai (earlier known as Madras), Kochi (earlier known as Cochin), Marmugao and Mumbai (earlier known as Bombay). Though the data set contains 15 years of data, there do exist some gaps in the data due to the non functioning of the tide gauge. The details of the data gaps are provided in Annexure – I (Volume II).

A careful editing of the hourly tide gauge data was done. One problem that is often encountered is what is known as quasi-tidal oscillations, in which there is a leakage of energy from non-tidal signal to tidal frequencies. These kinds of oscillations were reported elsewhere, for example, along the British coasts (Dixon and Tawn, 1994). In the present records, there are a few instances of these oscillations, and data pertaining to

them were removed for further analysis. There are also a few cases of datum shifts, which are mentioned in the data records of the Survey of India and these shifts have been incorporated.

Observed sea level consists of tides and ‘residuals’. Tides are deterministic and can be predicted. Based on the harmonic constants that are available for the concerned port, the sea level variation due to tides at any location can be computed from

$$H = h_{\text{mean}} + \sum H_n f_n \cos [\sigma_n t - g_n + (V_n + u_n)] \quad (1)$$

Where  $n$  varies from 1 to  $N$ .  $h_{\text{mean}}$  is the mean sea level at a location,  $t$  is the time,  $n$  refers to the tidal constituent and  $\sigma_n$ ,  $H_n$  and  $g_n$  are the frequency, amplitude and the phase of the constituent  $n$ .  $(V_n + u_n)$  adjusts the phases to allow for astronomical conditions at the time of origin of the data.  $f_n$  is the node factor, which varies from year to year. We used  $N=58$  for our analysis. The analysis of data from a location consisted of using a year long time series of hourly sea level. The data were fitted to the above equation using a least-square technique. The smooth fitted curve was then subtracted from the data to determine the residuals. This was done by using the software package, TASK (Anonymous, 1996).

Residuals, determined by removing the predicted tides from the observed sea level, are mostly due to surges. Sundar et al. (1999) identified three typical storm surge events along the east coast of India from the tide gauge records and studied the evolution of these events along with the corresponding meteorological fields of surface pressure and winds. This preliminary analysis motivated us to look into the entire data set spanning 15 years to make a statistical analysis.

The extreme events identified during this period are presented in the form of tables in the first report called “Report on Scenario ” (Anonymous, 2002a). They are also presented in Annexure - II (Volume II). In these tables, the parameters listed are the observed maximum sea level during the event, the maximum surge value and a brief description of the meteorological event, such as the track of the cyclone and the core pressure (IDWR and Mausam, 1974 - 1988) that occurred during the surge event.

*(ii) Statistical analysis of hourly tide gauge data*

The preliminary analysis, in which three storm surges were identified and described by Sundar et al. (1999), motivated us to look into the entire data set and make a statistical analysis. The statistical analysis is primarily meant for determining the probabilities of occurrence of extreme sea level and estimating their return periods. This analysis was done for three stations along the east coast of India, namely, Paradip, Vishakhapatnam and Chennai (Unnikrishnan et al., 2004). Two independent methods were applied, namely, (i) annual maximum method and (ii) joint probability method. A brief description of the methods used is given below.

*Annual maximum method*

This method uses the annual maximum values in several years to fit an extreme value distribution. Based on the cumulative probability distribution, return periods of extreme events can be evaluated. A basic description of the method may be found in Bury, K. (1999). In the present work, we used the Gumbel distribution for extreme sea level analysis. In Gumbel method, cumulative probability density function  $F(x)$  can be expressed as

$$F(x; \mu, \sigma) = \exp [- \exp \{-(x-\mu)/\sigma\}] \quad (2)$$

with  $\sigma > 0$ ,  $-\infty < x, \mu < \infty$

where  $\mu$  and  $\sigma$  are the parameters of the distribution.

#### *r-largest method*

The classical annual maximum method described above for extreme sea level analysis has a disadvantage that only the highest value of sea level in a year is used and the remaining data are not considered. It is possible that more than one storm occurs in a year. Moreover, a successful application of the annual maximum method requires many years of data, say, at least 30 years (Pugh, 1987). In order to overcome this disadvantage, Smith (1986), Tawn (1988a) extended this theory for the development of *r*-largest annual maximum method, in which, ‘*r*’ values of extreme sea level are used for each year of observations. This allows incorporating more than one storm event in a year and thereby obtaining more reliable estimates of return periods using less number of years of data than the classical method. The software developed by the Proudman Oceanographic Laboratory, U.K. for *r*-largest annual maximum method was used in the present work. The details of computations are elaborated in Dixon and Tawn (1994).

#### *Joint probability distribution (JPM)*

Joint Probability Method (JPM), introduced by Pugh (1980), was modified later by Tawn and Vassie (1989). The method consists of estimating the joint probability distribution of surge and tide for the entire series. A brief outline is given below.

From the observed sea level series, tides are predicted (Equation 1) and separated. Thus, the hourly series of tides and surges are constructed from observations. Assuming that tides and surges are independent, the joint probability density function can be defined as the product of the individual probability density functions of tides and surges.



Thus, joint probability function  $p(z)$  can be expressed as

$$p(z) = \int_{-\infty}^{\infty} p(z-y) p(y) dy \quad (3)$$

where  $p(z-y)$  is the probability due to tide and  $p(y)$  is the probability due to surge.

From this, the probability that the sea level is less than  $x$  is expressed as

$$F(x) = \int_{-\infty}^x p(z) dz \quad (4)$$

The return period is defined as the expected time between independent exceedences of the level  $x$ . Based on the previous analysis for British coasts, return period in years may be taken as the inverse of probability (Pugh, 1987).

$$T(x) = [N (1-F(x))]^{-1} \quad (5)$$

where  $T(x)$  is the return period,  $N$  is the total number of hourly observations per year ( $N=8766$  for a non-leap year).

#### *Revised Joint Probability method (RJPM)*

Tawn and Vassie (1989) introduced the revised joint probability method by modifying the JPM. They introduced a parameter called extremal index ( $\theta$ ) and included an approximation for the tail of the surge distribution by parametric method. If  $Y_1, Y_2, \dots, Y_n$  are the sea level in a series of  $n$  values,

$$P \{ \max(Y_1, \dots, Y_n) < x \} = F^{n \theta(x)}(x) \quad (6)$$

$\theta(x)$  is the extremal index, defined as the expected number of hourly observations of the process above the threshold  $x$  on each independent excursion above  $x$ .

The return periods in RJPM will be

$$T(x) = [N \theta(x) (1-F(x))]^{-1} \quad (7)$$

*Approximating the tail of the surge distribution*

Information of probabilities and return periods may be often required for the extreme sea levels that are beyond the observed values. In RJPM, to determine these probabilities, the tail of the surge distribution is estimated by a parametric method (Tawn and Vassie, 1989). A probability distribution for surges is constructed based on the r-largest method.

The Gumbel distribution  $H(x)$  can be expressed as

$$H(x) = \exp [-(\exp-(x-\mu)/\sigma)] \quad (8)$$

The parameters can be determined from

$$\sigma = r^{-1} \Sigma (X_i - X_r) \quad (9)$$

$$\mu = \sigma \log (r) + X_r \quad (10)$$

where  $X_1 > X_2 > \dots > X_r$

The Gumbel distribution  $H(x)$  is related to  $F_s(x)$  by

$$H(x) = F_s^{Nm \theta_s}(x) \quad (11)$$

$$F_s(x) = H^{1/(Nm \theta_s)}(x) \quad (12)$$

where  $\theta_s$  is the extremal index for surges and  $m$  is the total number of years. A probability density distribution for surges is constructed for the tail of the surge distribution based on the r-largest method (Tawn and Vassie, 1989) and for the tail of the distribution  $F_s(x)$  is calculated, as

$$F_s(x) = (\sigma N m \theta_s)^{-1} \exp [-(x-\mu)/\sigma] \quad (13)$$

To summarise, a non-parametric approach is used for determining the joint distribution, except for the tail of the distribution, where a parametric method is used. From the estimated tail of the distribution, computation of joint probability is repeated.

For the RJPM, the software was prepared in the institute based on the theory described above. For Gumbel analysis, the software developed in the Proudman Oceanographic Laboratory was used.

## **Task 2: Impacts of cyclones and storm surges along the Indian coasts**

### *(i) Source of information*

As part of the present project, the information on the damages caused by Lows, Depressions, Cyclones, which are collectively called Low Pressure Systems (LPS), during the period from 1949 to 2000 were assembled into a data base (Annexure –III, Volume II). The source of this information is the journal “Mausam” published by the India Meteorological Department, New Delhi. This journal was started in 1950 and was called “Indian Journal of Meteorology and Geophysics” up to 1974. It was renamed as “Indian Journal of Meteorology, Hydrology and Geophysics” in 1975 and was renamed again in 1979 and since then has been called as “Mausam”.

Initially the journal has not been furnishing much information on the low pressure systems. Only events like very heavy rainfall, breach of rail and road links, telecommunication failure and similar were listed. Up to 1959 even this information was only a part of a column called “notes and events”. In 1960, an exclusive column called “weather” was started. One could get comprehensive report on summer, monsoon, post monsoon and winter from that column. It was giving the rainfall, low pressure systems, upper air data, etc. In 1973, another feature was started in the journal called “cyclones and depressions”, which gives information on the formation, advancement and landfall of the depressions and cyclones and their impacts.

Most of the tide gauges along the coast of India, which are installed by Survey of India and maintained by the respective port trusts, are of the Stilling well-Float type. Through a procedure called the “Zero measurement”, the observed sea levels are verified periodically on a routine basis. The clock mechanism in this type of gauge is a mechanical one. During the passage of severe LPS, sometimes the tide gauges collapse or malfunction due to the onslaught of the event. Installation of the acoustic type gauges has started recently and is still on an experimental basis. These new gauges give better data in terms of frequency and accuracy of values. But most of the present gauges render no useful data during the catastrophic events. The necessity of commissioning of robust tide gauges, which are capable of recording the sea levels even at the extreme weather, is often felt while studying the storm surges. During some of the severe cyclones, the instruments in the meteorological observatories break down leading to non-availability of the data during that period.

A Severe Cyclone Storm with a Core of Hurricane winds crossed the Andhra coast near Nizampatnam on 19<sup>th</sup> November, 1977 and during the landfall even the anemometer of the meteorological observatory in the vicinity was blown off. During another event, a Severe Cyclonic Storm crossed near Sriharikota on 14<sup>th</sup> November 1984 and the nearest tide gauge at Chennai broke down for several days. It has always been a tough task to get all the information at one place for analysis. Hence better instrumentation support along the east coast, which faces more frequent attacks of the Low Pressure Systems, is essential to get good meteorological and sea level data.

*(ii) Salient features of the data base*

In this section, the norms followed while assembling the data base and the structure of the data base are mentioned. The changes in terminology used and other features of the data base of past five decades are given below.

As the present study is on the impact of the LPS along the coastal regions of India, the damages caused in the proximity of the area of landfall alone are accounted here. For example, a cyclonic storm crossed Sundarbans on 18<sup>th</sup> May 1958, weakened to a Depression and due to which there was heavy rainfall in Assam leading to dislocation of normal life and rail and road link was cut-off. Brahmaputra was in spate and many buildings collapsed. But no damage in the landfall area is reported in Mausam. Hence this document reports no damages caused by this low pressure system.

In the present report, LPS which did not cross the coast are not mentioned. However, severe LPS events like Cyclonic Storm and of higher severity are reported here as they had caused considerable damages to the nearby coast. The LPS events that formed and diffused over the land do not figure in this report.

*(iii) Structure of the data base*

The first column of the report gives the date on which the landfall of the LPS had taken place. The regions mentioned in the data base may be found in Fig.1 & 2. The LPS events that formed and diffused over the land do not figure in this report. The second column gives the description of the event. While describing the event, the formation, development and the landfall details are given. If the system had diffused over the sea itself before landfall, then the details of the diffusion are given with the location of the event. In case of a LPS, which formed and diffused over the sea itself before landfall, the

date on which the LPS attained its maximum severity is given. Loss of human lives and livestock are given in the third and fourth columns respectively. The third column gives the details of the number of the injured persons also. The details of the cattle loss do not figure in the Mausam journal mostly unless the LPS event was a grand one and has caused a big havoc. The fifth column gives the details of the infrastructural damages like collapse of the buildings and telecommunication, disruption of rail and road links, industry damages, harbour damages, etc. The sixth column gives the details of the agricultural losses alone, like loss due to inundation of the crops, loss due to saline water intrusion, sand cast, etc. The financial loss shown in figures in the present document is the same as that is mentioned in Mausam and is based on the estimates at the time of loss. These values need to be normalized for comparison. The seventh column is the remarks column, which gives details such as the surge height, the minimum barometric pressure estimated or observed, the maximum wind speed estimated or observed.

#### *Miscellaneous information*

The information contained in this document were compiled from issues printed over a long span of 50 years, during which period not only the format of the journal had changed, but the units of the parameters measured also. We decided to give the figures in the same units as they are found in Mausam. Hence one may find the distance of a LPS from the coast mentioned in “miles” initially and in the later part of the document in “kilometers”. Similarly, wind speed was given in “miles per hour” and changed later to “knots”. Atmospheric pressure is mentioned in “millibar” (mb) and later in “hPa”. Rainfall in “inches” is changed to “cm”. The surge levels are found in “feet” and later in “meters”.

The figures “lakhs” and “crores” are equivalent to “hundred thousands” and “ten millions” respectively.

We have followed the following abbreviations to mention the Low Pressure Systems, which itself is abbreviated as LPS.

LP	Low Pressure
D	Depression
DD	Deep Depression
CS	Cyclonic Storm
SCS	Severe Cyclonic Storm
SCH/ VSCS	Severe Cyclonic Storm with a core of Hurricane winds/ Very Severe Cyclonic Storm
SUCS	Super Cyclonic Storm

The span of 50 years brings changes in political boundaries and names also. After 1971, the part of the world called East Pakistan is mentioned as Bangladesh. Similarly the names Madras state and Tamilnadu state mean the same place. Madras and Chennai are one and the same. At some places in the document, Tamilnadu and West Bengal are abbreviated as TN and WB respectively.

For the period June to December 1971, the details of impact from Mausam could not be obtained fully and hence the information furnished for the above said period is vague and superficial.

### **Task 3: Estimates of sea level rise along the Indian coasts**

One of the methods to get regional estimates of sea level rise is by analysing the past tide gauge data at different ports. Even though the rate of increase in sea level in the past century need not be the same as the rate of increase in the present century, these

estimates do serve as indicators of the long term changes in sea level. However, changes in sea level can also occur due to vertical movement of land; these effects have to be included while estimating a net increase in sea level.

Estimation of sea level rise along the Indian coasts is not fully resolved. Some of the coastal regions are known to be tectonically active and measurements on the land subsidence rates are not available in these regions. So a net sea level rise can be estimated only when the rates of vertical movement of land become available.

#### *Analysis of tide gauge data*

Emery and Aubrey (1988) analysed the tide gauge data along the Indian coasts. Their analysis included all the stations. However, they considered only five stations for determining the sea level rise, since the results in some stations did not have statistical significance. Moreover, in some stations, which lie in the northern side of the east coast, the occurrence of storm surge events affected the monthly mean sea level data. Excluding these stations, Emery and Aubrey considered only five stations, where the estimates could be considered as indicators of sea level rise. Even for these stations, the problem of estimating a net sea level rise is not resolved. Some of the coastal regions are known to be tectonically active and the land subsidence rates are not available for these regions. So a net sea level rise can be estimated only when the rates of vertical land movement become available.



### *Present analysis*

In the above analysis, the tide gauge data upto the year 1982 were considered. We included the recent data upto the year 1996 and carried out the analysis for a few selected stations. This has been useful for some stations, in particular, where the data record was short in the earlier analysis.

The monthly mean sea level data upto the year 1996 was downloaded from the website of Permanent Service for Mean Sea Level. A five-point moving average was applied to the data and a least square fit was made (Fig. 8).

### **Task 4: Analysis of regional climate model (HadRM2) data**

In the present study, the results of the regional model HadRM2 were analysed to determine the frequency and intensity of tropical disturbances in the northern Indian Ocean. The HadRM2 model output for the northern Indian Ocean region was provided by the Indian Institute of Tropical Meteorology, Pune (Rupa Kumar et al., personal communication). The region of analysis extends from 58.54 °E to 101.4625 °E and 3.273 °N to 36.018 °N and the data are available for each day during 2041-2060. The grid resolution of the model is  $0.4425 \times 0.4425$  with a total of  $98 \times 76$  grid points. Two model simulations are available, one for the control run and another for a run with doubled green house gases (GHG). These two results were compared in order to study the possible effects of climate change. The parameters analysed are the sea level pressure, winds at 850 hPa and air temperature (1.5 m.). We also analysed the total precipitation data at some selected coastal stations.

*(i) Surface pressure fields*

The surface pressure distribution was viewed using ferret (<http://ferret.wrc.noaa.gov>) for each day and the number of cyclones and depressions found were documented for the entire period 2041-2060. During the period of the evolution of each storm, the minimum sea level pressure in the system and the maximum wind speeds were noted and tabulated. Based on these values, the maximum wind speed and minimum pressure associated with each cyclone were tabulated.

The disturbances identified were classified into Lows, Depressions, Cyclones etc. based on the classification norms of the India Meteorological Department. This information is used to determine the frequency distribution of cyclones in the control run and doubled GHG run.

*(ii) Simulation of storm surges using HadRM2 winds*

A storm surge model was developed for the Bay of Bengal for simulating the surges forced by HadRM2 winds. The model was developed from the basic code of the barotropic model, developed earlier in the institute (Unnikrishnan et al., 1999) for the simulation of tides and tidal currents. The model uses vertically integrated equations of momentum and the equation of continuity in Cartesian co-ordinate system. This original code, developed for the propagation of barotropic tides in shallow water, was modified by incorporating the wind stress terms in the momentum equations and making use of a radiation boundary condition along the open boundary. The radiation boundary condition used is the same as that given in Flather (1994). The model results for three simulations were tested with observations (not presented in this report). The sea surface elevations simulated by the model were compared with observed sea level during these events at

Paradip and Vishakhapatnam and found that the model reproduced the observed surges fairly well. This prompted us to use the model for the simulation of storm surges forced by HadRM2 winds.

The vertically integrated equation of continuity (14) and equations of momentum (15, 16) in Cartesian co-ordinates x and y can be written as

$$\frac{\partial \eta}{\partial t} + \frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = 0 \quad (14)$$

$$\begin{aligned} \frac{\partial U}{\partial t} + \frac{\partial(uU)}{\partial x} + \frac{\partial(vU)}{\partial y} - fV = -g(h+\eta) \frac{\partial \eta}{\partial x} \\ + \frac{\tau_{sx}}{\rho_0} - g U \frac{(U^2 + V^2)^{1/2}}{C^2 H} \end{aligned} \quad (15)$$

$$\begin{aligned} \frac{\partial V}{\partial t} + \frac{\partial(uV)}{\partial x} + \frac{\partial(vV)}{\partial y} + fU = -g(h+\eta) \frac{\partial \eta}{\partial y} \\ + \frac{\tau_{sy}}{\rho_0} - g V \frac{(U^2 + V^2)^{1/2}}{C^2 H} \end{aligned} \quad (16)$$

Where  $\eta$  is the surface elevation with reference to the undisturbed water level; u,v are depth averaged velocity components in x and y directions and U and V are the corresponding transports.  $H=h+\eta$ , where h is still water depth.  $\tau_{sx}$  and  $\tau_{sy}$  are the wind stress components in x and y directions. C is the Chezy coefficient and g is the acceleration due to gravity.  $\rho_0$  is the density of water.

## **Task 5: Return period estimates in future scenario**

This section deals with the flood risks associated with sea level rise. We estimated the changes in return periods of extreme sea level that could occur in future in the event of sea level rise.

For evaluating the impacts of sea level rise on the return period estimates, we made calculations of return periods assuming that an increase of sea level, say, 24.1 cm, occurs by 2050, obtained from HadCM2 and HadCM3 projections of sea level rise (see Fig.7). As a first approximation, assuming that the occurrence of cyclones remains the same in future, the r-largest analysis described (Task 2) was performed again by adding this uniform increase of sea level to all values. In this calculation, we did not incorporate the trends from year to year. Fig.20 shows a comparison of the return period estimates for Paradip, Vishakhapatnam and Chennai respectively during the present scenario and for the year 2050.

The impacts associated with flood risks was studied by Nicholls et al. (1999) by estimating a term called flood envelope, defined as  $E_{\text{flood}} = H_{1000} - H_1$ , where  $H_{1000}$  and  $H_1$  are the return levels for 1000 year and 1 year return periods respectively. Nicholls et al. (1999) noted that for most coastal regions,  $E_{\text{flood}}$  is less than 1 m. An increase in sea level of similar magnitude will imply that an extreme event occurring once in 1000 year at present will occur once in 1 year after the sea level rise.

## KEY RESULTS

### **Task 1: Identification of extreme sea level events from tide gauge record and estimation of their return periods**

#### *(i) Identification of extreme sea level events*

The extreme events identified during the period (1974-1988) are presented in the form of tables in the first report called “Report on Scenario ” (Anonymous, 2002a). They are also presented in Annexure- II (Volume II) of this report. In these tables, the parameters listed are the observed maximum sea level during the event, the maximum surge value and a brief description of the corresponding meteorological event, such as the track of the cyclone and the core pressure (IDWR and Mausam, 1974-1988) that occurred during the surge event.

A typical storm surge event and the corresponding meteorological fields are shown in Fig.3a, b & c. Fig.3a shows the track of the cyclone and Fig.3b shows the evolution of surface meteorological fields during this period from the NCEP/NCAR reanalysis data. When a severe cyclone crossed the coast of Orissa at Puri, south of Paradip on 7 August, 1981, the signatures of surges are seen not only in Paradip, but at Vishakhapatnam as well, with Chennai record showing insignificant magnitudes. The maximum magnitudes of surges at Paradip and Vishakhapatnam are 95.0 cm and 30.0 cm respectively. However, for all the events identified during this period, some do not have signatures at more than one station. For example, in the cyclone during June 1982 (Fig.4a,b), the surges occurred in Paradip only with practically no signatures found in Vishakhapatnam (Fig.4c).

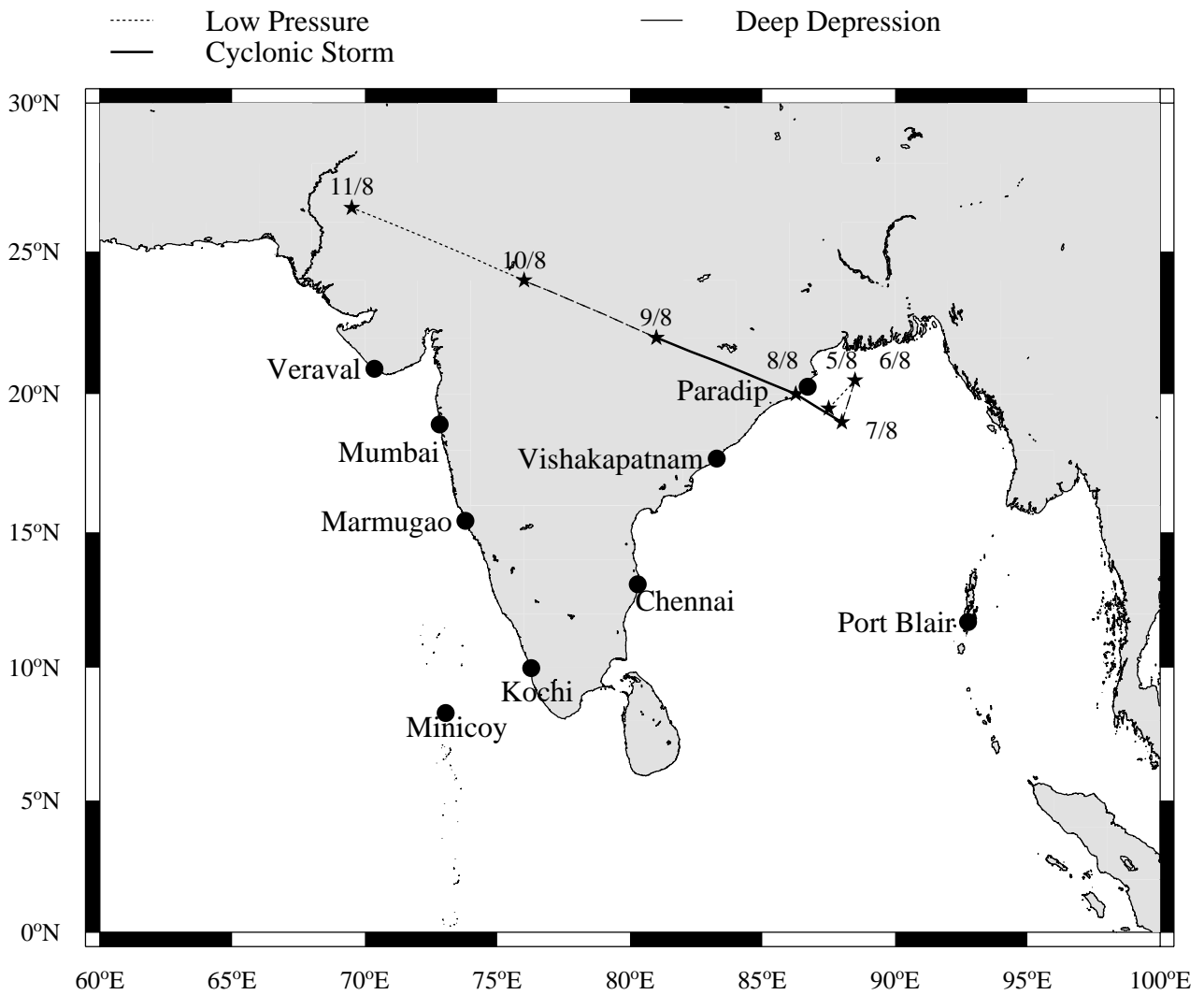


Fig. 3a. The track of the Cyclonic Storm which had the landfall near Puri on 7-8-1981.

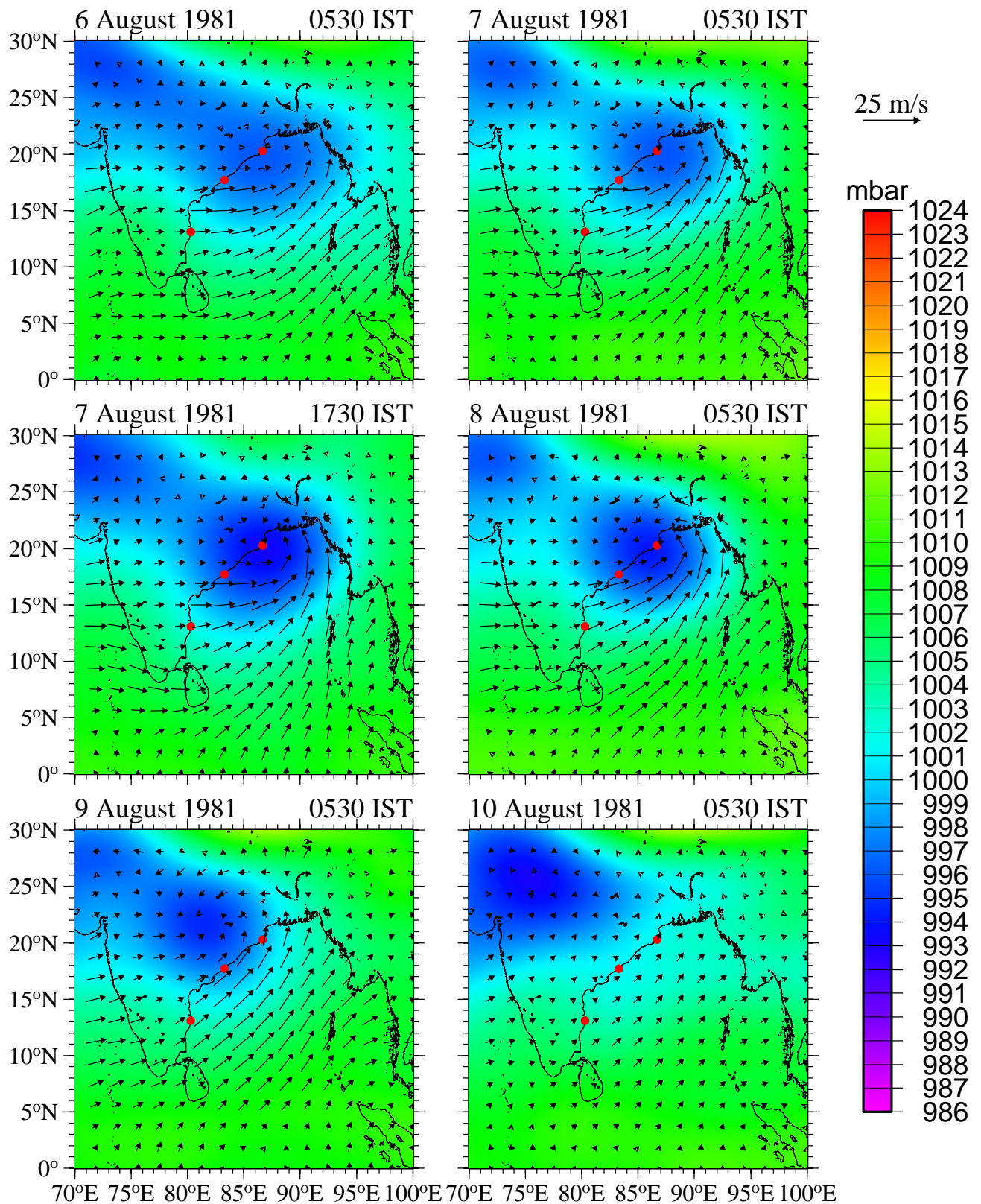


Fig. 3b. Atmospheric pressure at mean sea level and winds at 10m (NCEP/NCAR Reanalysis Data) during the period of landfall of Cyclonic Storm near Puri on 7-8-1981.

## Observed Sea Level & Residuals-1981

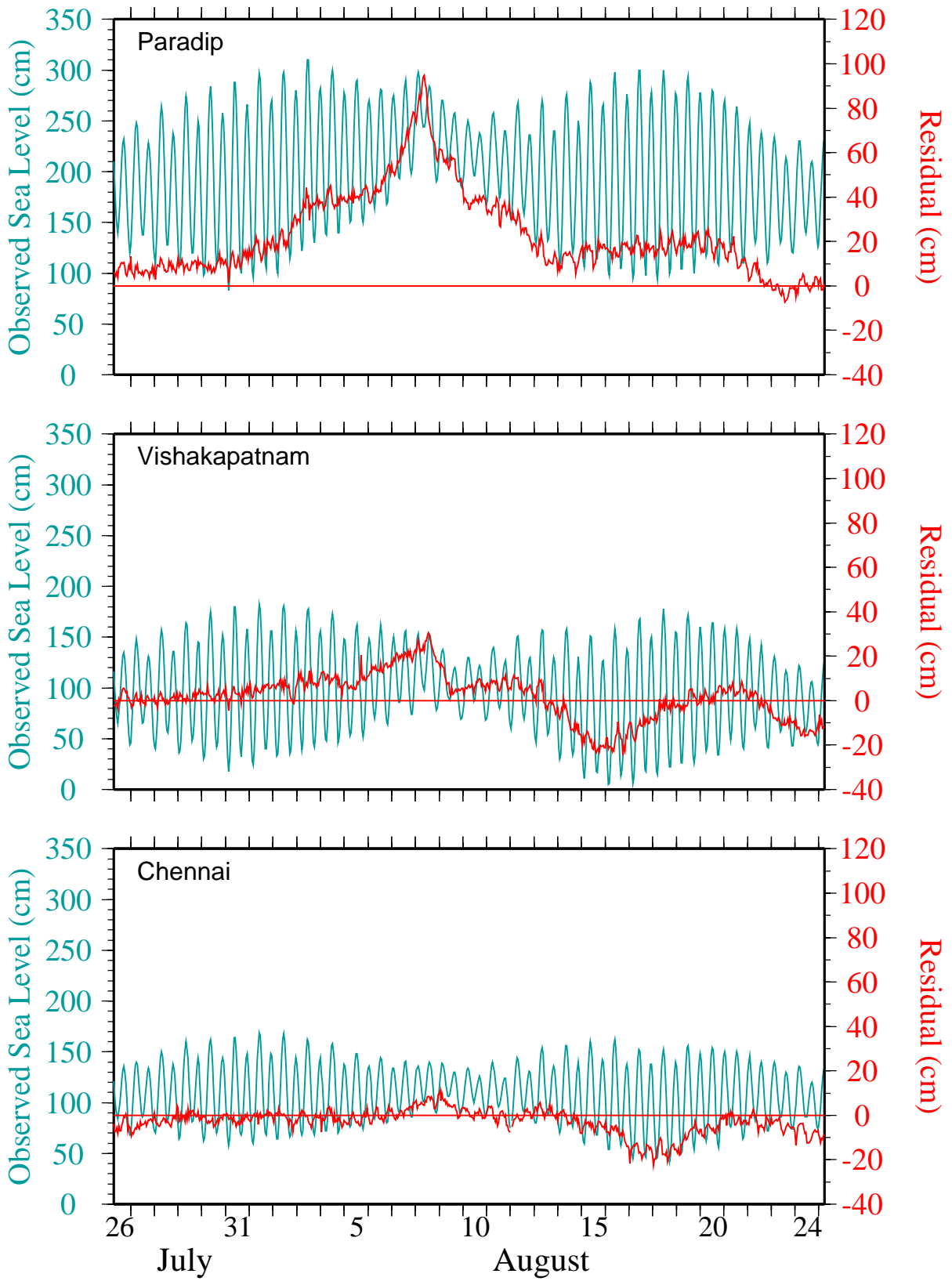


Fig. 3c. Observed Sea Level and Residual at the three stations on the east coast during the Cyclonic Storm which had landfall near Puri on 7-8-1981.



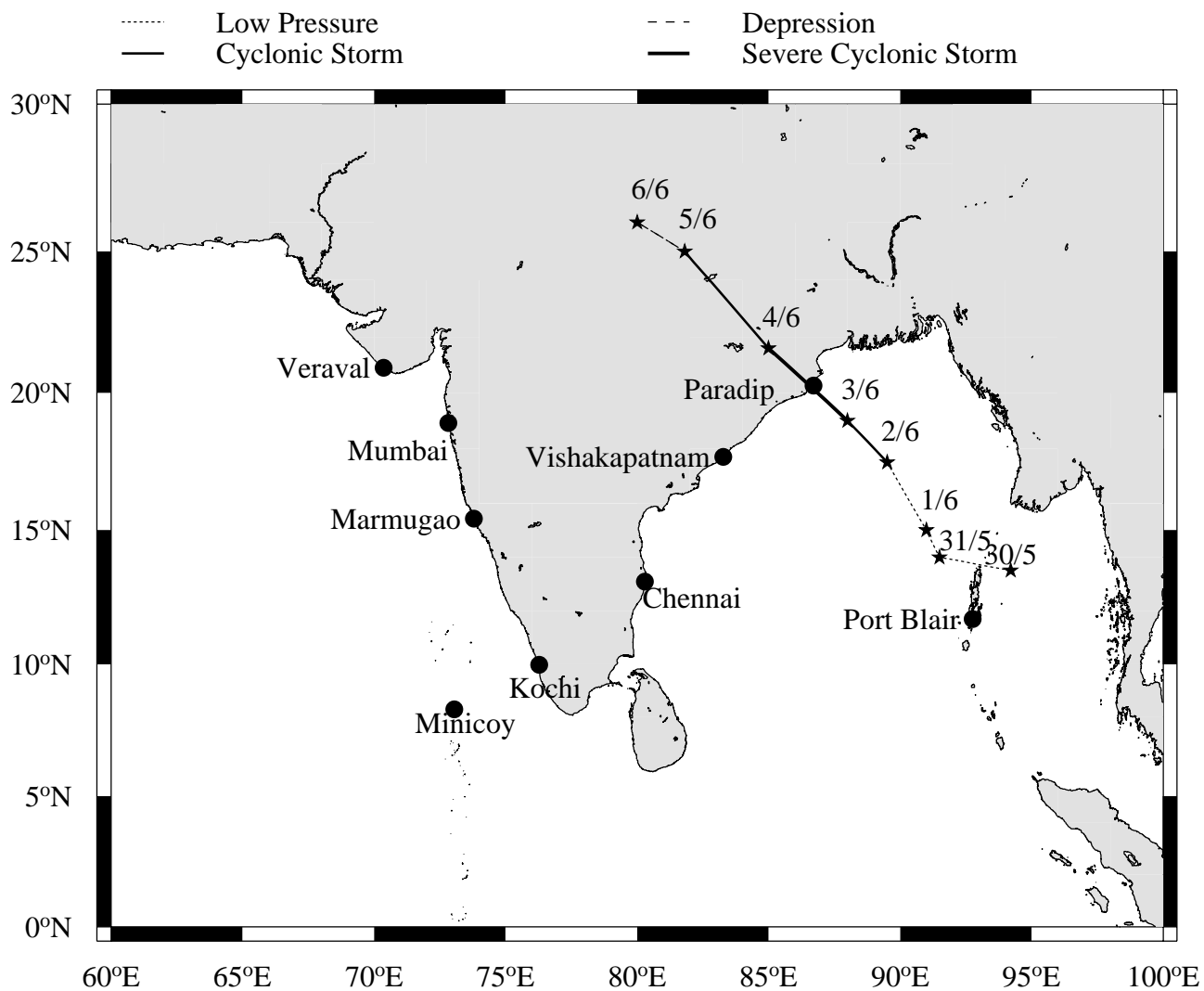


Fig. 4a. The track of the Severe Cyclonic Storm which had the landfall near Paradip on 3-6-1982.

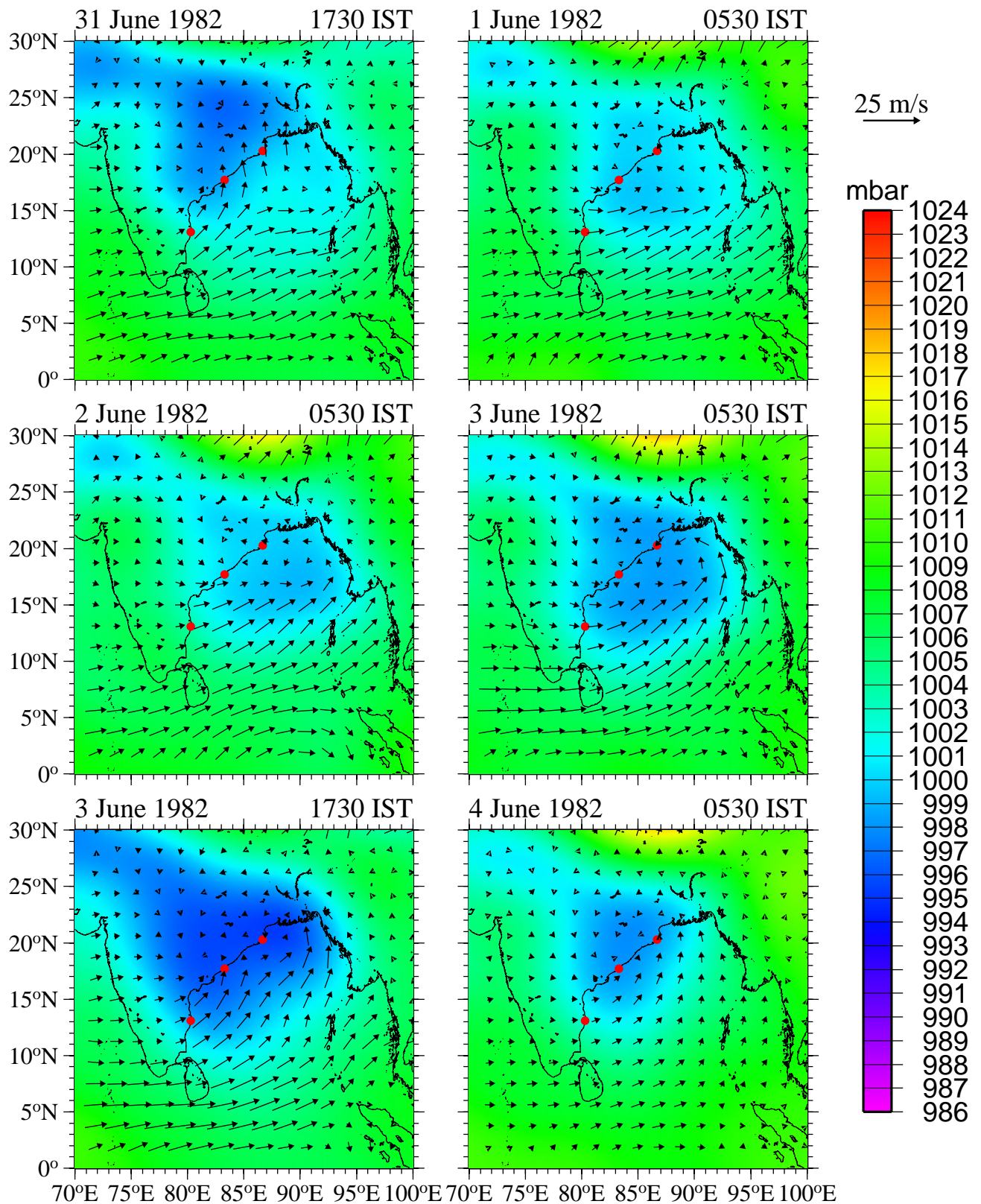


Fig. 4b. Atmospheric pressure at mean sea level and winds at 10m (NCEP/NCAR Reanalysis Data) during the period of landfall of Severe Cyclonic Storm near Paradip on 3-6-1982.

## Observed Sea Level & Residuals-1982

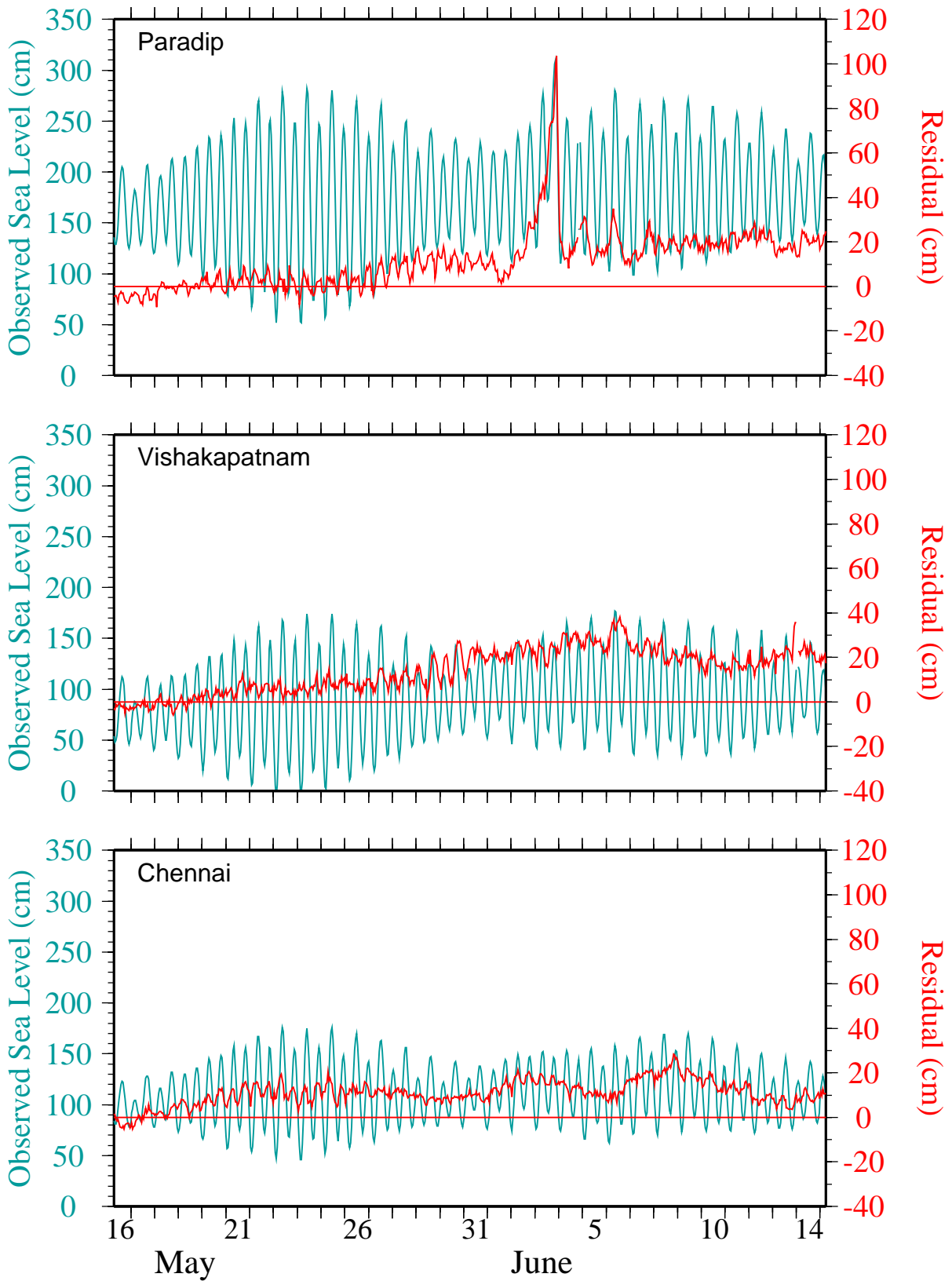


Fig. 4c. Observed Sea Level and Residual at the three stations on the east coast during the Severe Cyclonic Storm which had landfall near Paradip on 3-6-1982.

One of the problems associated with the identification of very high surges from long term records is that in some cases, during the crossing of cyclones to the land, the tide gauge becomes non-functional. There are instances of break-down of tide gauges during catastrophic cyclones. However, we believe that long records of tide gauges do have sufficient number of events for making a qualitative and statistical analysis.

*(ii) Statistical analysis of tide gauge data - Application to the east coast of India*

The maximum values of observed sea level and surges during storm surge events are given in Annexure –II (Volume II). In the present application, we considered three stations for the analysis. (i) Paradip (ii) Vishakhapatnam and (iii) Chennai. The station Marmugao has only 4 years of data during this period. At Kochi, there are only about 11 events during this period, in which 4 of them show negative surges. The number of surge events at Mumbai also is relatively low. Since there is no sufficient number of observed events during the available data, the statistical analysis was not performed for these stations. It should be noted that these stations lie on the west coast, where the probability of occurrence of a storm is rather small. So, only the stations along the east coast were considered for the statistical analysis.

*Application of r-largest method*

In the present work, for the r-largest analysis, Gumbel distribution was chosen for the sake of simplicity. Moreover, we examined the validity of the Gumbel fit by plotting the values of annual maxima plotted against  $-\ln(-\ln P)$  for the three stations and found that there was no significant departure from the linearity, thereby justifying its application. The software prepared in the Proudman Oceanographic Laboratory, U.K. for r-largest annual maximum method was used.

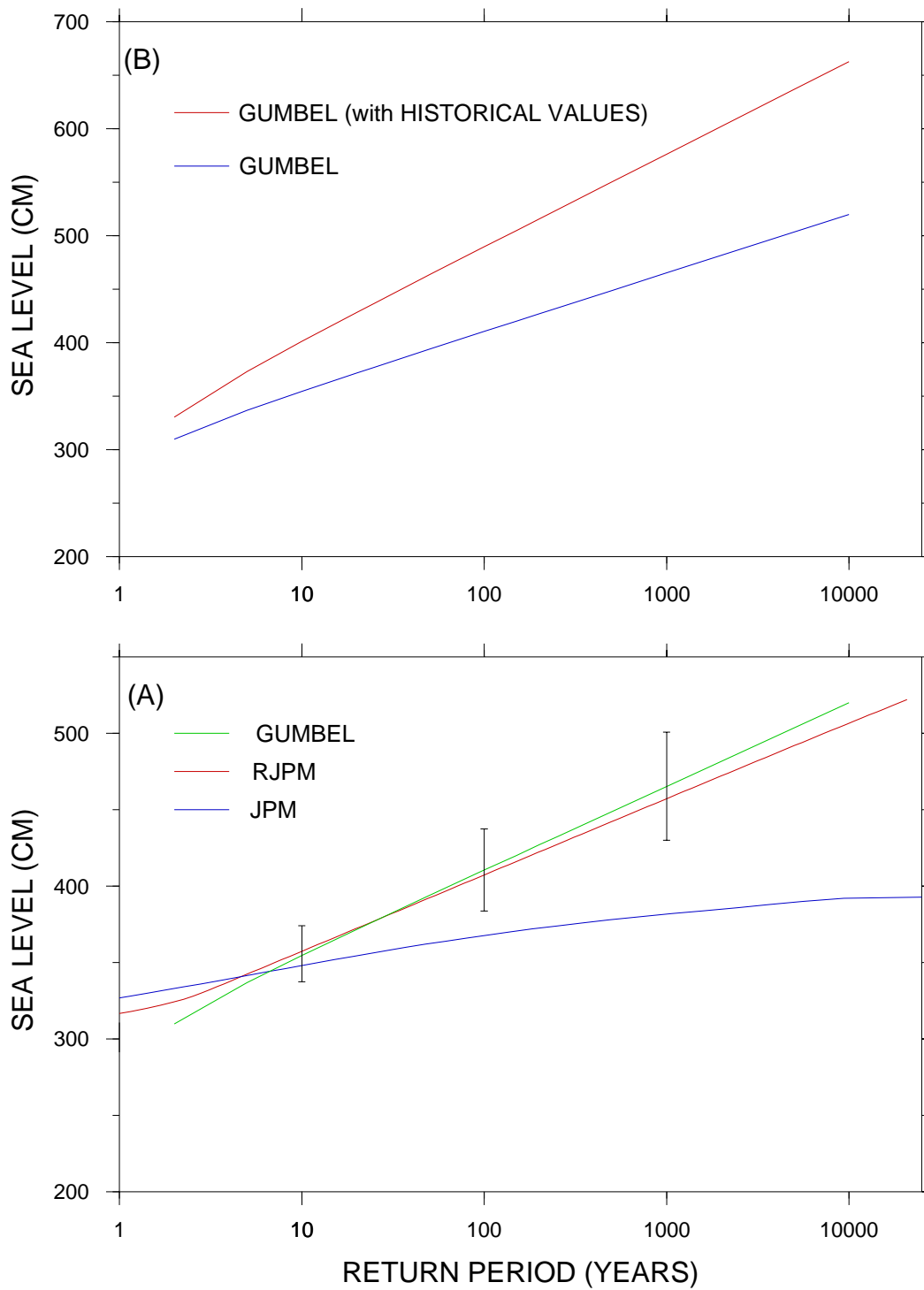


Fig. 5: Return period estimates at Paradip (A) without historical values (B) with historical values included.

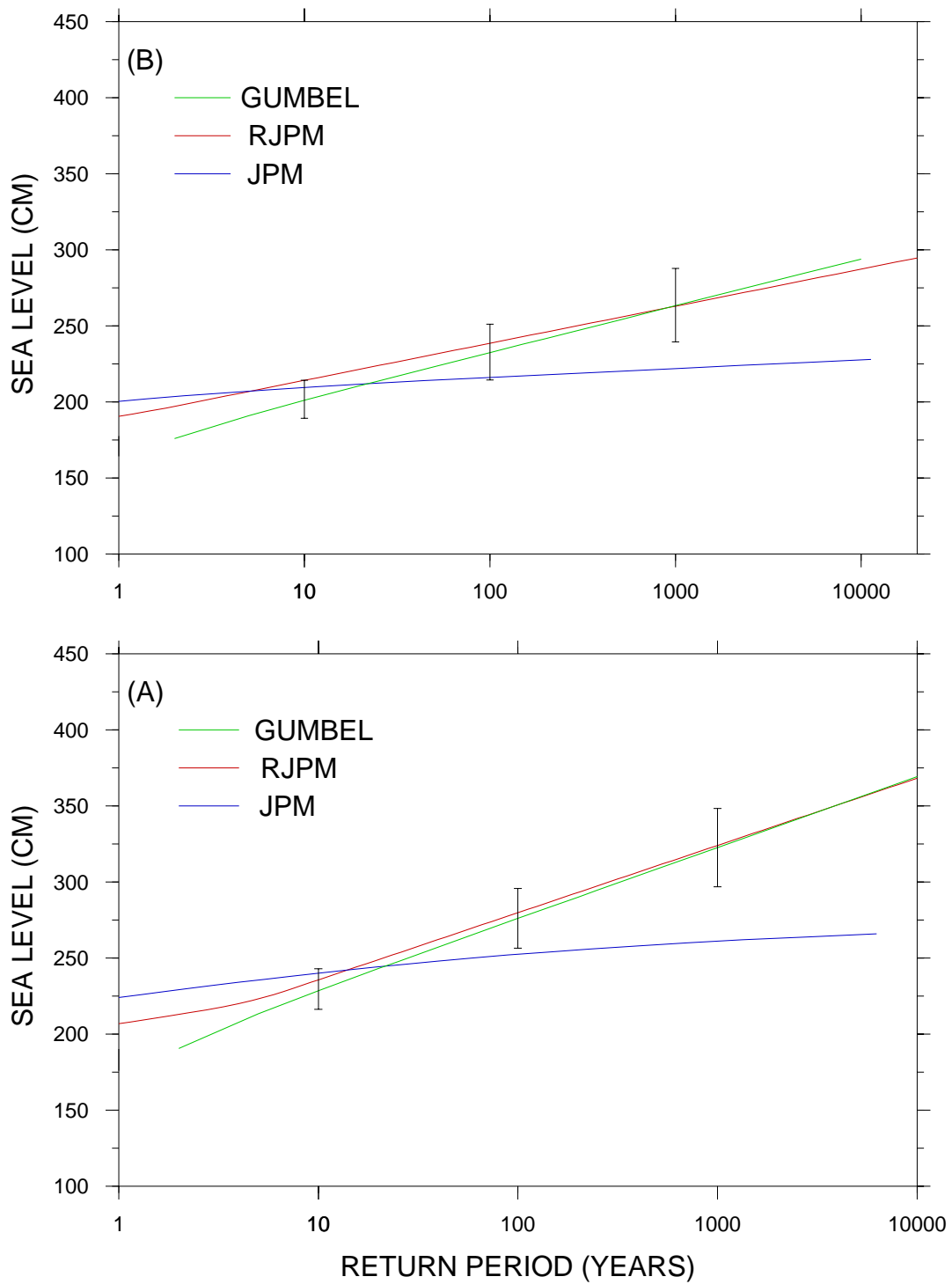


Fig. 6: Return period estimates at (A) Vishakhapatnam (B) Chennai.

r-largest values for each year were chosen by examining the entire series of hourly data along with the corresponding meteorological events. It was found that, the number of storm surge events at each station varied between 2 to 4 in different years. While picking up extreme values, care was taken not to include the highest spring tides, which are not associated with any meteorological events and could be mistaken as storm surge events. Among the observed surge events at Paradip, two events that occurred in May and October, 1985 (Annexure –II, Volume II) have observed sea levels of 2.26 and 2.28 m. During these events, the observed surges have magnitudes of 42 cm and 55 cm respectively. Since these events do not fall in the tail of the distribution, they were not considered for the r-largest analysis. Tawn and Vassie (1989), while fitting r-largest Gumbel fit to the observed surge distribution, observed that the choice of ‘ r ’ must be such that there are sufficient values to obtain a reasonable estimate of the fitted parameters and that the lowest value remains in the extreme tail of the distribution. In the present application, ‘ r ’ varies from 2 to 4. For Vishakhapatnam, no values were rejected, while for Chennai, two events that occurred in November, 1987 with observed sea levels of 1.36 m and 1.24 m and surges of 37 cm and 27 cm were not considered for the r-largest analysis.

Along the east coast of India, tidal range increases towards north, in general. Among the three stations, Paradip has the highest tidal ranges, followed by Vishakhapatnam and least in Chennai. The mean spring tidal ranges at Paradip, Vishakhapatnam and Chennai are about 2.0, 1.5 and 1.0 m respectively. The surges that were identified during this period also show the highest values (60 - 105 cm) in Paradip, followed by about 30 to 75 cm in Vishakhapatnam and 30 to 65 cm in Chennai. Here,

one word of caution is needed. Extremely rare events do occur, for instance, the super cyclone of October 1999, which produced about 300 cm of surge at Paradip. This kind of an event did not fall in the present analysis period. However, the r-largest method allows to use historical values and inclusion of this event in the present analysis is discussed in the next section. At Paradip, during the analysis period, at least, two events in a year are present with some years having 3 events. In the Gumbel analysis performed, the standard errors for  $\mu$  and  $\sigma$  are 0.063 and 0.042 respectively. Vishakhapatnam has the maximum number of surge events;  $r = 3$  was taken for most of the years and  $r = 4$  for two years. Since the software allows using of variable number of  $r$  for different years, it does not pose a problem in including as many as possible. For Vishakhapatnam, the estimated standard errors are 0.037 and 0.023 for  $\mu$  and  $\sigma$  respectively. In Chennai, the highest recorded sea level is about 2.0 m only during this period. The tidal ranges are low in Chennai (between 0.40 and 1.0 m approximately) and the observed surges during this period are of about 30 and 60 cm. The standard errors in the r-largest method are 0.047 and 0.033 for  $\mu$  and  $\sigma$  respectively. 95 % confidence intervals were determined based on the estimated parameters. The 100 year return period estimates are found to be consistent for varying '  $r$  '.

#### *JPM and RJPM*

The return period estimates for extreme sea level using the JPM for Paradip, Vishakhapatnam and Chennai are given in Fig.5a and 6a,b respectively. It is found that JPM gave an underestimate for long return periods in all the stations. This drawback was found for stations elsewhere, for instance, for the British coasts (Tawn and Vassie, 1989).



This is due to the deficiencies of the JPM, such as the assumption of the independence of sea level in the series and inadequate representation of the tail of the surge distribution.

In order to overcome this, RJPM was employed. RJPM requires extremal indices for the sea level and surge. They were determined for different values of threshold, and an average was obtained (Tawn and Vassie, 1989). For this estimation, the sea level and surge distributions in about 15 surge events were taken. For sea level, the estimated value for Paradip, Vishakhapatnam and Chennai are 1.9, 2.4 and 2.0 respectively. Similarly, for surges the estimated value for Paradip, Vishakhapatnam, and Chennai are 3.0, 3.5 and 3.5 respectively. The tail of the surge distribution was approximated by Gumbel probability distribution and joint probability was performed again. The resulting cumulative probability does not sum exactly to 1; however, Tawn and Vassie (1989) affirm this difference to be insignificant.

The return period estimates using the RJPM for Paradip, Vishakhapatnam and Chennai are shown in Fig.5a and Fig.6a,b respectively. The RJPM estimates lie within 95 % confidence intervals for all the stations.

#### *Inclusion of historical storm surge events*

The r-largest method allows inclusion of historical values in the analysis. The main difficulty lies in the fact that only visual estimates are available. We looked into available information during the last 50 years and there are two events of very severe cyclones that crossed Paradip on 30 October 1971 and 28-30 October 1999. The former caused storm surges of 4.0 m with tide of 0.9 m (Murty et al., 1986), while the latter, referred to as super cyclone, caused a surge height of 3.0 m and tide of 3.0 m resulting in a total sea level of 6.0 m. Water level was found to be about 2 m above the ground in

Paradip. Since Paradip lies 4 m above the mean sea level, the total sea level was estimated to be 6 m (Paradip Port Trust, 1999). When Gumbel analysis was performed again by including these events (Fig. 5b), it is found that the 100 year return period is increased by about 79 cm. In addition to the present data, Vishakhapatnam had one incidence of storm surges in 1969, when a cyclone crossed Kakinada, when historical values were considered in the last 50 years. This storm surge event had a total sea level of 2.6 m (Murty et al., 1986). The r-largest analysis performed again by including this value did not show any significant difference in the return levels.

## **Task 2: Impact of cyclones and storm surges along the Indian coasts**

The impacts associated with Low pressure systems (LPS) along the Indian coasts during the period 1950-2000 were documented in this report (Annexure –III). Each LPS is unique in terms of its impact. It need not have to be an explosive event to cause great damage; sometimes, even a mild depression, if sustained for a long time can cause heavy damage by incessant prolonged rainfall or if it has hit the right area at the right time can cause heavy loss due to storm surge at high water. For instance, if the damage caused by the Severe Cyclonic Storm (24-11-'79), which crossed near Sriharikota is compared with the damage caused by the Deep Depression (17-9-'80) that crossed near Puri, we find that the latter caused more damages than the former. Even a Depression which crossed the Bangladesh coast (4-10-'80) caused more damages than the SCS mentioned above. A Low Pressure became a DD and crossed Saurashtra coast (20-6-'83). This caused very severe damage because the heavy rainfall associated with the DD resulted in overflowing of rivers and dams inundating vast area. A Depression that

crossed the Andhra coast near Kakinada (23-8-2000) caused the damage to the tune of 776 crores. The intensity of the damages is not directly proportional to the severity of the LPS alone but many other factors also.

*Some LPS events of very high severity*

As mentioned above, the details of the impacts caused by all the LPS events are described in Annexure – III (Volume II). In this section, impact created by three LPS events of very high severity, which had caused great destruction at the landfall point, are discussed.

*(i) Severe Cyclonic Storm with a core of Hurricane Winds in the Bay of Bengal (23-30 November 1988)*

This meteorological system originated from South China Sea, moved westwards and entered into the south Andaman Sea as a Low Pressure area on 22<sup>nd</sup> November. The system became intensified to a Depression on 23<sup>rd</sup> evening, moved in a northerly direction for next 24 hours and thereafter took a westerly course until 26<sup>th</sup> morning. From 26<sup>th</sup> morning onwards, it took a northerly course and headed towards West Bengal, Bangladesh coast. The system was intensified to a Cyclone on 25<sup>th</sup> morning, and became a Severe Cyclonic Storm at noon. During the northerly course, it further intensified into a Severe Cyclonic Storm with a core of Hurricane winds on 27<sup>th</sup> morning. It crossed West Bengal – Bangladesh coast around 1730 hrs. IST of 29<sup>th</sup> November.

During the landfall, wind speed observed at Sandheads and Calcutta was 40 and 30 knots respectively. The lowest estimated central pressure was 942 hPa at 1730 hrs. IST on 29<sup>th</sup> November. As per the reports, maximum winds of 150 to 180 kmph. were reported.

As per the government reports, the storm affected a population of 28.29 lakhs in 3893 villages in North and South 24 Parganas of several districts of West Bengal. It took a toll of 532 human lives and perished 57,600 cattle heads. It also damaged about 3,45,530 houses and crops in 1,93,780 hectares of land. The estimated cost of damage to crops and properties in West Bengal was Rs. 137.77 crores. About 794 fishermen were missing. The storm sank the ship M.V. Punneri of Singapore with 19 crew onboard. Drowned two launches of the forest department and a light vessel with 18 persons was missing.

In Bangladesh, over two thousand people were killed and 6,000 were missing. About 15,000 deer, 9 Royal Bengal tigers were killed and about 65,000 cattle heads were perished. The estimated cost of crops damaged in Bangladesh was worth about 9,400 million taka.

*(ii) Very Severe Cyclonic Storm in the Arabian Sea (4-10 June 1998)*

A Low Pressure area formed over southeast Arabian Sea and Lakshadweep area on 2<sup>nd</sup> June evening and became well marked on 4<sup>th</sup>. The system was intensified to a depression at 1430 hrs. IST on the same day and further intensified to a deep depression at 1730 hrs. It became a cyclonic storm in the evening of 5<sup>th</sup> and further intensified into a severe cyclonic storm at 1430 hrs. IST of 6<sup>th</sup>. It turned into a Very Severe Cyclonic Storm on 7<sup>th</sup> at 1730 hrs. IST and crossed the coast of Gujarat near Porbandar on 9<sup>th</sup> morning. The estimated core pressure was 962 hPa and a maximum wind speed of 98 knots was recorded at Jamnagar.

The government of Gujarat reported a death toll of 1173 persons and reported that 1774 persons were missing. More than 2.5 lakhs of houses were destroyed. The total estimate of loss as per the government was Rs.190 crores.

*(iii) Super Cyclonic Storm in the Bay of Bengal ( 25-31 October 1999)*

A well marked low pressure area from Gulf of Siam became a depression in the Andaman Sea and intensified into a cyclonic storm on 26<sup>th</sup>. It further intensified to a Severe cyclonic storm on 27<sup>th</sup> and became a Very Severe Cyclonic Storm in the evening. It turned in to a Super Cyclonic Storm at 2330 hrs. of IST of 28<sup>th</sup>. It crossed the Orissa coast on 29<sup>th</sup> October in between 0930 hrs. and 1200 hrs. IST.

The maximum wind of 80 knots was recorded at 0930 hrs. on 29<sup>th</sup> at Paradip and since then the instrument was out of order. A wind speed of 95 knots was estimated at Puri at 1230 hrs. on 29<sup>th</sup>. According to the Port Authorities, a total sea level of 6 m. was reported at Paradip. Storm surge penetrated into the land and a tidal inundation up to 35 km. from the coast was observed.

The system was of unprecedented intensity and it caused very heavy damage and devastation along the coastal districts of Orissa and adjoining districts of West Bengal. Very heavy rainfall was recorded at the coastal districts of Orissa and West Bengal on 29<sup>th</sup> to 31<sup>st</sup> October. As per the government of Orissa, the loss is given as follows.

Population affected	: 129.22 lakhs
Villages affected	: 14643
Blocks affected	: 97
Crop area affected	: 18.42 lakhs hectares
Houses	: 16.49 lakhs

Loss of life	: 9887
Persons missing	: 40
Persons injured	: 2507
Lives stock perished	: 4.44 lakhs
Fishing boats lost	: 9085
Fishing nets lost	: 22143

According to the press reports the damage caused in West Bengal is as follows.

Chandipur district	: 10,000 people affected
South 24 Paraganas district	: 100 houses damaged, two children died
Tamluk & Kontai	: 250 fishermen missing, who later on returned.
Miniport district	: Many houses damaged, 50 persons injured

### Task 3: Mean sea level rise along the Indian coasts

#### (i) Global sea level rise

One of the ways of examining long term variations of mean sea level is by analysing the past tide gauge records. The estimates obtained from tide gauges along with the data on vertical land movements in those locations can be used to get the net sea level changes. Though the tide gauge estimates can be considered as indicators of sea level rise in the last century, the projected sea level rise in the current century is much higher than these estimates (Fig. 7). It is believed that even if the emission of green house gases stabilises, sea level will continue to rise for a long term.

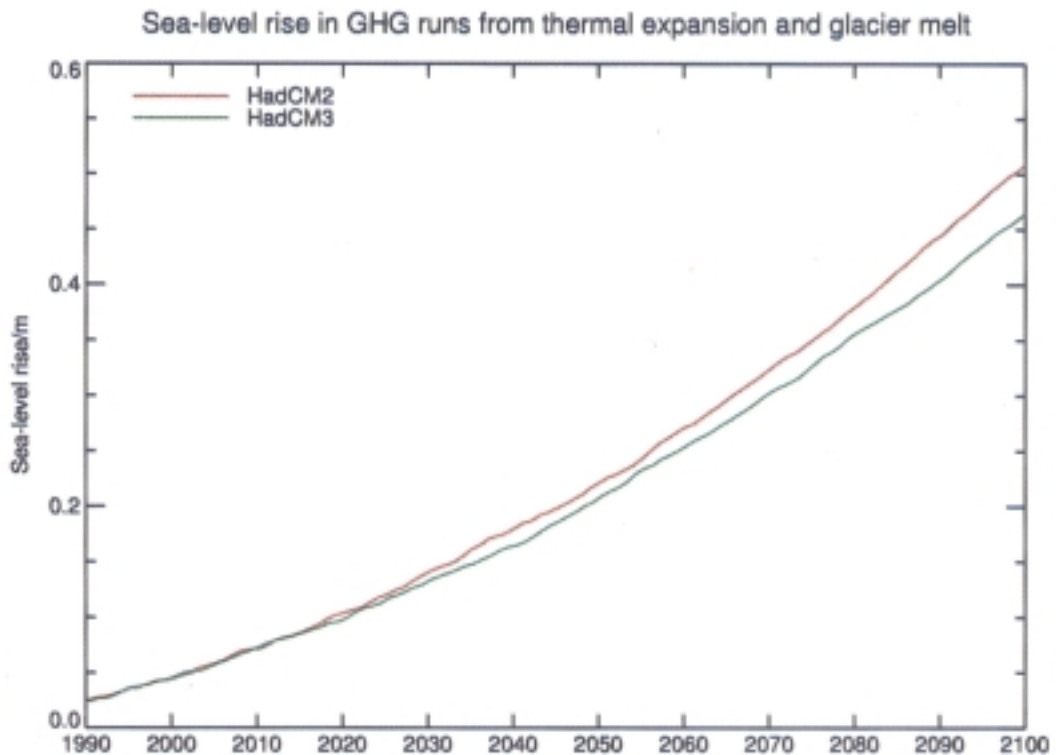


Fig. 7: Sea level rise (m) from the models HadCM2 (red) and HadCM3 (green)

*(ii) Regional estimates of sea level rise*

One of the methods to get regional estimates of sea level rise is by analysing the past tide gauge data at different ports. There are only very few ports in the world such as Mumbai, where records of more than 100 years are available. Even though the rate of increase in sea level in the past century need not be the same as the rate of increase in the present century, these estimates do serve as indicators of the long term changes in the sea level. However, changes in sea level can also occur due to vertical movement of land. These effects have to be included while estimating a net increase in sea level.

Estimation of sea level rise along the Indian coasts is not fully resolved. Some of the coastal regions are known to be tectonically active and the land subsidence rates are not available in these regions. A net sea level rise can be estimated only when the rates of vertical movement of land become available.

*(iii) Analysis of tide gauge data along the Indian coasts*

Emery and Aubrey (1988) analysed the tide gauge data along the Indian coasts. Their analysis included all the stations. However, they considered only five stations for determining the sea level rise, since the results in some stations did not have statistical significance. Moreover, in some stations, which lie in the northern side of the east coast, the occurrence of storm surge events affected the monthly mean sea level data. Excluding these stations, Emery and Aubrey considered only five stations, where the estimates could be considered as indicators of sea level rise. Even for these stations, the problem of estimating a net sea level rise is not resolved. Some of the coastal regions are known to be tectonically active and the land subsidence rates are not available for these regions. So



a net sea level rise can be estimated only when the rates of vertical land movement become available.

The stations considered were Mumbai, Mangalore, Kochi, Chennai and Vishakhapatnam. The estimated sea level rise for these stations are -0.9, 1.3, -2.1, -0.4 and -0.7 mm/year with negative sign indicating a sea level rise, as Emery and Aubrey preferred to attribute the changes to vertical land movements.

*(iv) Present analysis*

In the above analysis, the tide gauge data upto the year 1982 were considered. We included the recent data upto the year 1996 and carried out the analysis only for a few selected stations. This has been useful for some stations, in particular, where the data record was short in the earlier analysis.

The monthly mean sea level data upto the year 1996 was downloaded from the website of Permanent Service for Mean Sea Level. A five-point moving average was applied to the data and a least square fit was made (Fig. 8). The results are shown only for some selected stations, namely, Mumbai, Kochi, Chennai and Vishakhapatnam. The duration of data length and the estimates of sea level rise obtained are given in Table 1.

Station	Number of years of data used	Sea level rise (mm/year)
Mumbai	111.5	0.78
Kochi	52.917	1.14
Chennai	75.5	-0.98
Vishakhapatnam	54.334	0.75

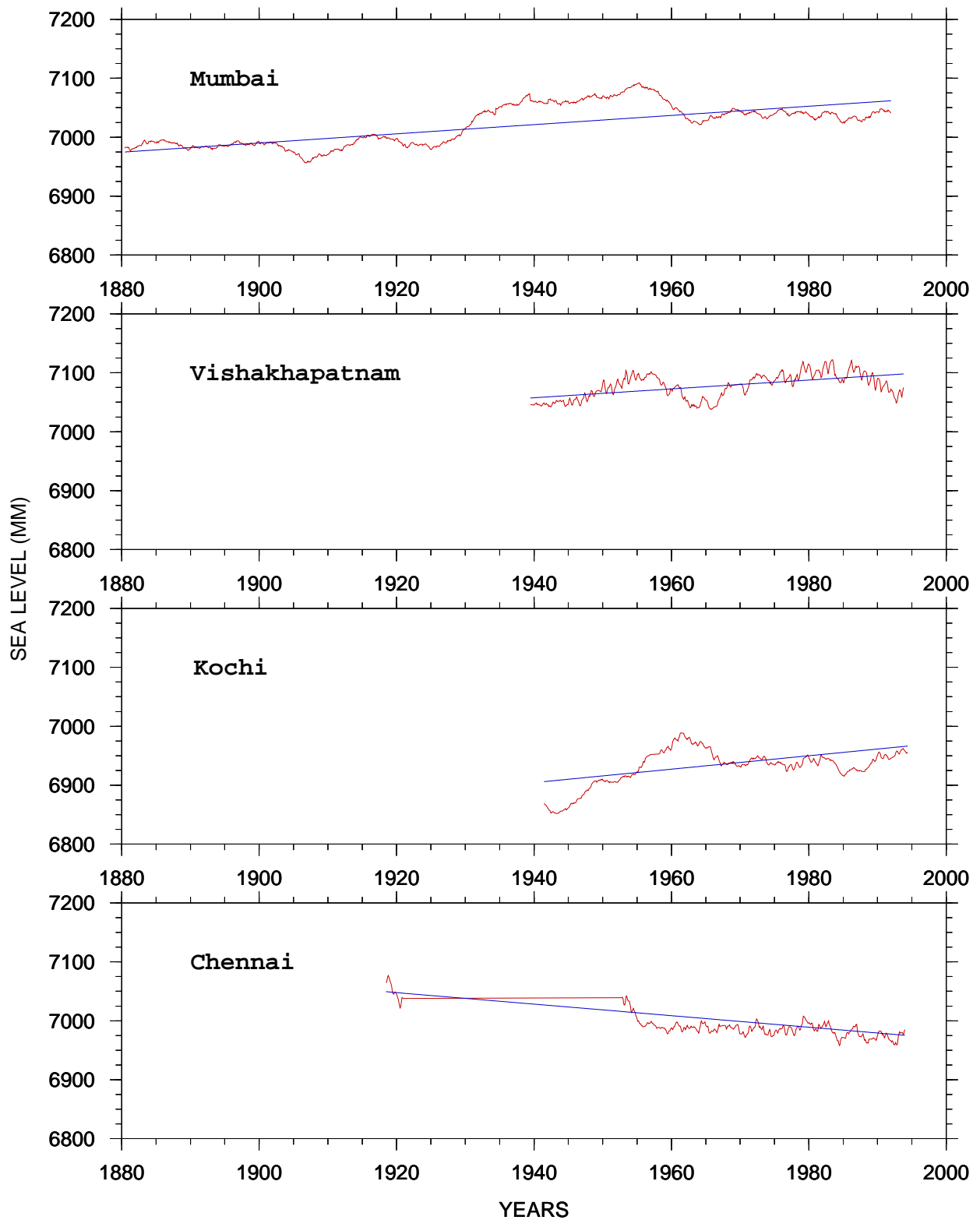


Fig. 8: Estimates of sea level rise (mm) at selected stations along the coast of India.

Table 1: Estimated sea level rise at selected stations along the Indian coast (positive sign indicates increase in sea level)

Out of the four stations chosen, rate of increase of sea level in three stations indicate about 1 mm/year or slightly less, with one station indicating a rate of decrease of sea level. Since the land subsidence measurements are not available, it is difficult to derive final conclusions from these estimates. Out of these four stations, three, namely, having the longest records of more than 50 years indicate a sea level rise of slightly less than about 1 mm/year. Mumbai, has a particularly the longest record of above 100 years duration, which shows a sea level rise of less than 1 mm/year.

The analysis provides the estimates of about 1 mm/year, which is observed elsewhere. However, in this part of the globe, the coastal region is not tectonically stable pointing out the fact that the changes found (rise in sea level) could be associated with either a sinking of the land or rise in sea level due to global warming. Another problem is that along the east coast of India, particularly northern side, there are many extreme events caused by storm surges. The monthly mean data could be affected by these signals and the estimates obtained for these stations may not be real indicators of the long term changes in sea level. So, the stations along the northeast coast of India were not considered for the present analysis.

## **Task 4: Analysis of regional climate model (HadRM2) data**

### *(i) Surface pressure distribution*

The surface pressure distribution from the HadRM2 model output was viewed using Ferret (<http://ferret.wrc.noaa.gov>) for each day to identify low pressure systems. During the period of the evolution of each storm, the minimum sea level pressure in the system and the maximum wind speeds were noted and tabulated.

The disturbances identified were classified into Lows, Depressions, Cyclones etc. based on the classification norms of the India Meteorological Department. This information was used to determine the frequency distribution of cyclones in the control run and doubled GHG run. A typical cyclone identified during the doubled GHG run is shown in Fig. 9.

Fig.10 and Fig.11 indicate the frequency distribution diagram for the Arabian Sea and the Bay of Bengal respectively for the tropical disturbances (T.D.) by including all the disturbances from Depressions to severe cyclones for the Arabian Sea and the Bay of Bengal respectively. Fig.10 shows a decrease in the number of TD s in the Arabian Sea from April to August during the doubled GHG run and the number of TD s remain nearly the same from September to December in both cases. In Fig.11, there is no appreciable change in the number of TD s between the control run and the doubled GHG run, except for a marginal increase for the latter from the beginning of June to mid July.

Figs.12 and 13 show the frequency distribution (2041-2060) of the number of cyclones in the Arabian Sea and the Bay of Bengal respectively for both the model runs. Fig.13 shows that for the doubled GHG run, there is a sharp increase in the number of cyclones from mid September to mid October and a marginal decrease in the number

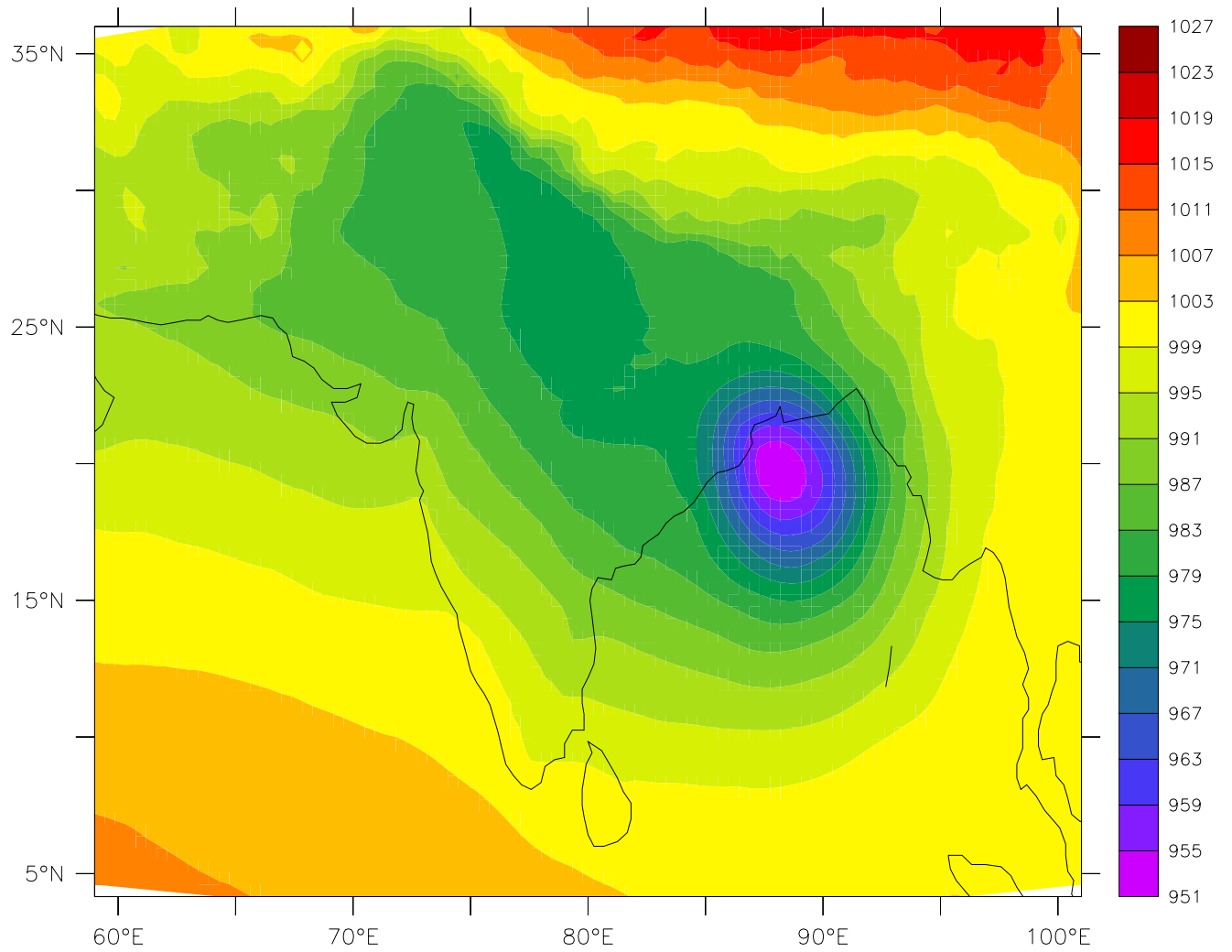


Fig. 9: A typical cyclone crossing the land on June 3, 2051 from HadRM2 simulation of double GHG scenario

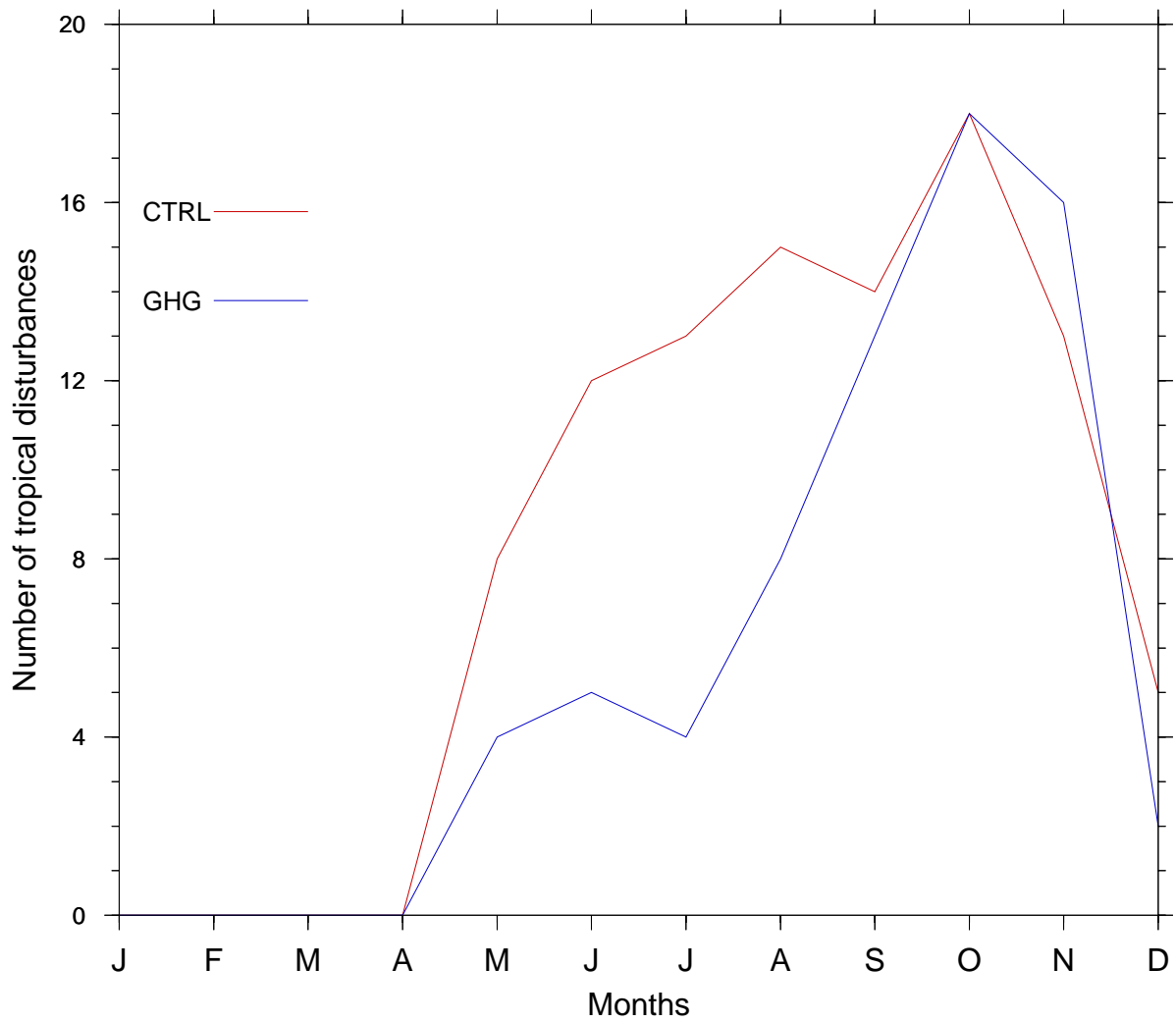


Fig. 10: Frequency distribution of depressions and cyclones in the Arabian sea for a period of 20 years (2041-2060) for the HadRM2 model run. Red line shows CTRL simulation and blue line shows doubled GHG simulation.

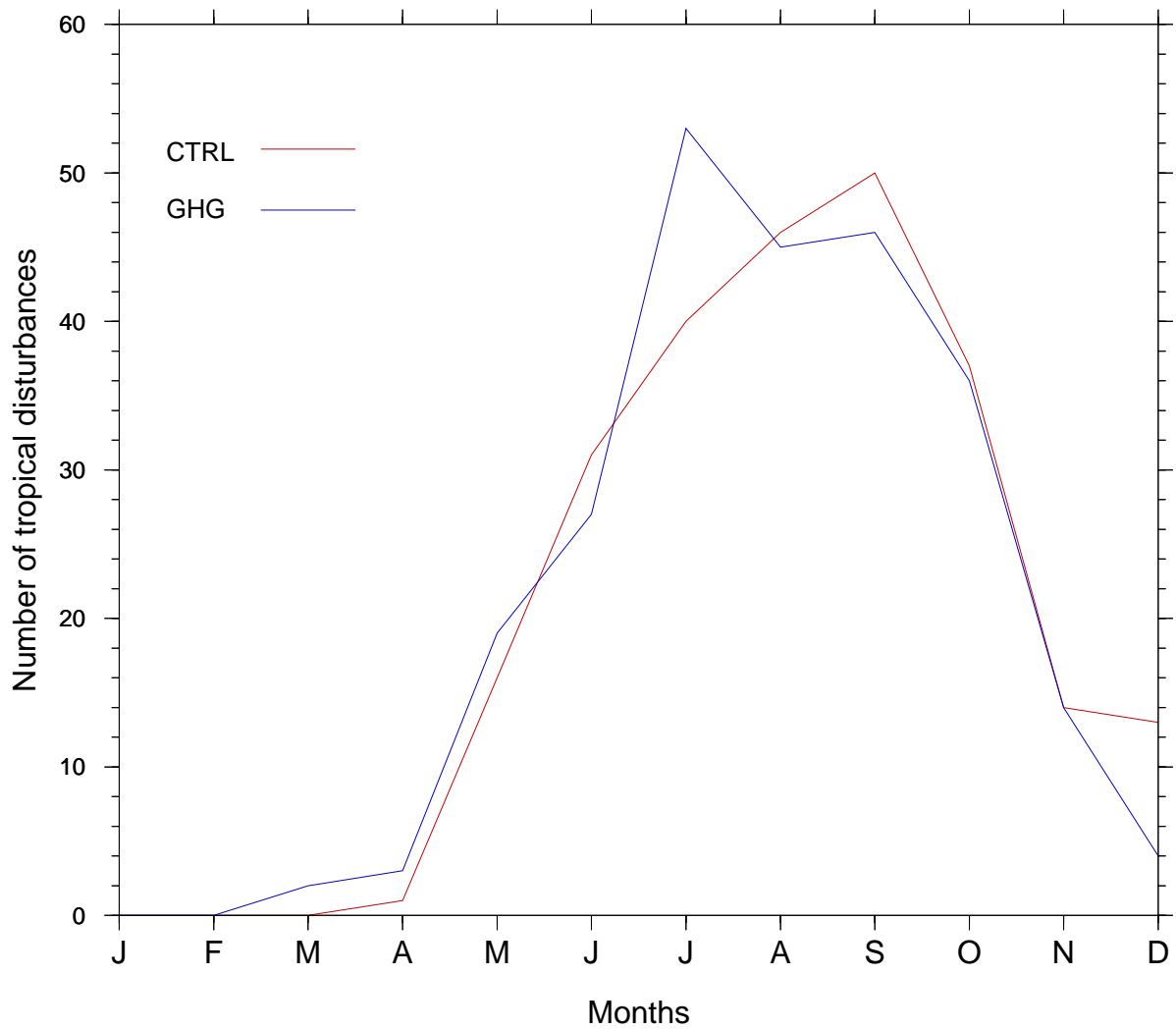


Fig. 11: Frequency distribution of depressions and cyclones in the Bay of Bengal for a period of 20 years (2041-2060) for the HadRM2 model run. Red line shows CTRL simulation and blue line shows doubled GHG simulation.

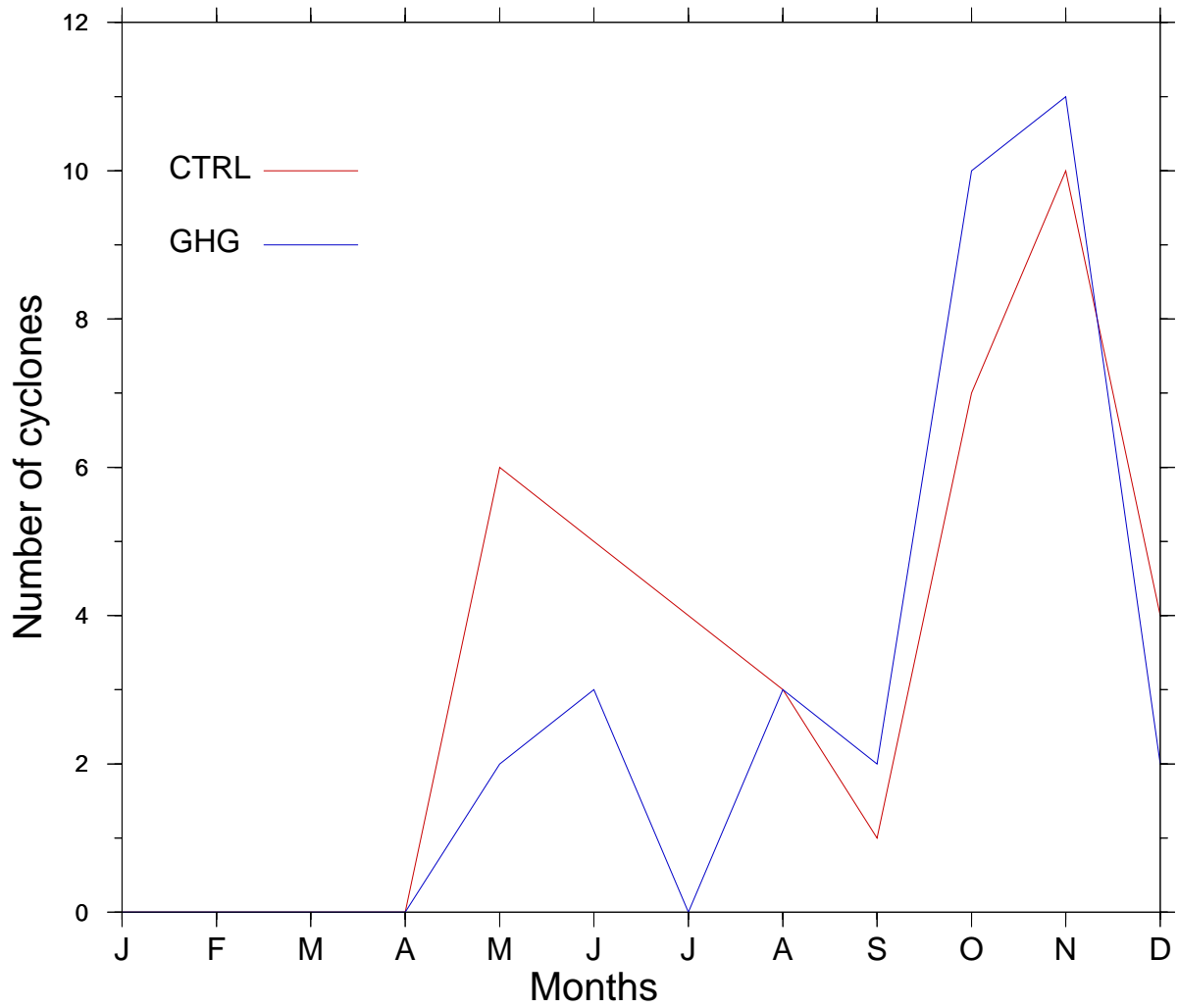


Fig. 12: Frequency distribution of cyclones in the Arabian Sea for a period of 20 years (2041-2060) for the HadRM2 model run. Red line shows CTRL simulation and blue line shows doubled GHG simulation.



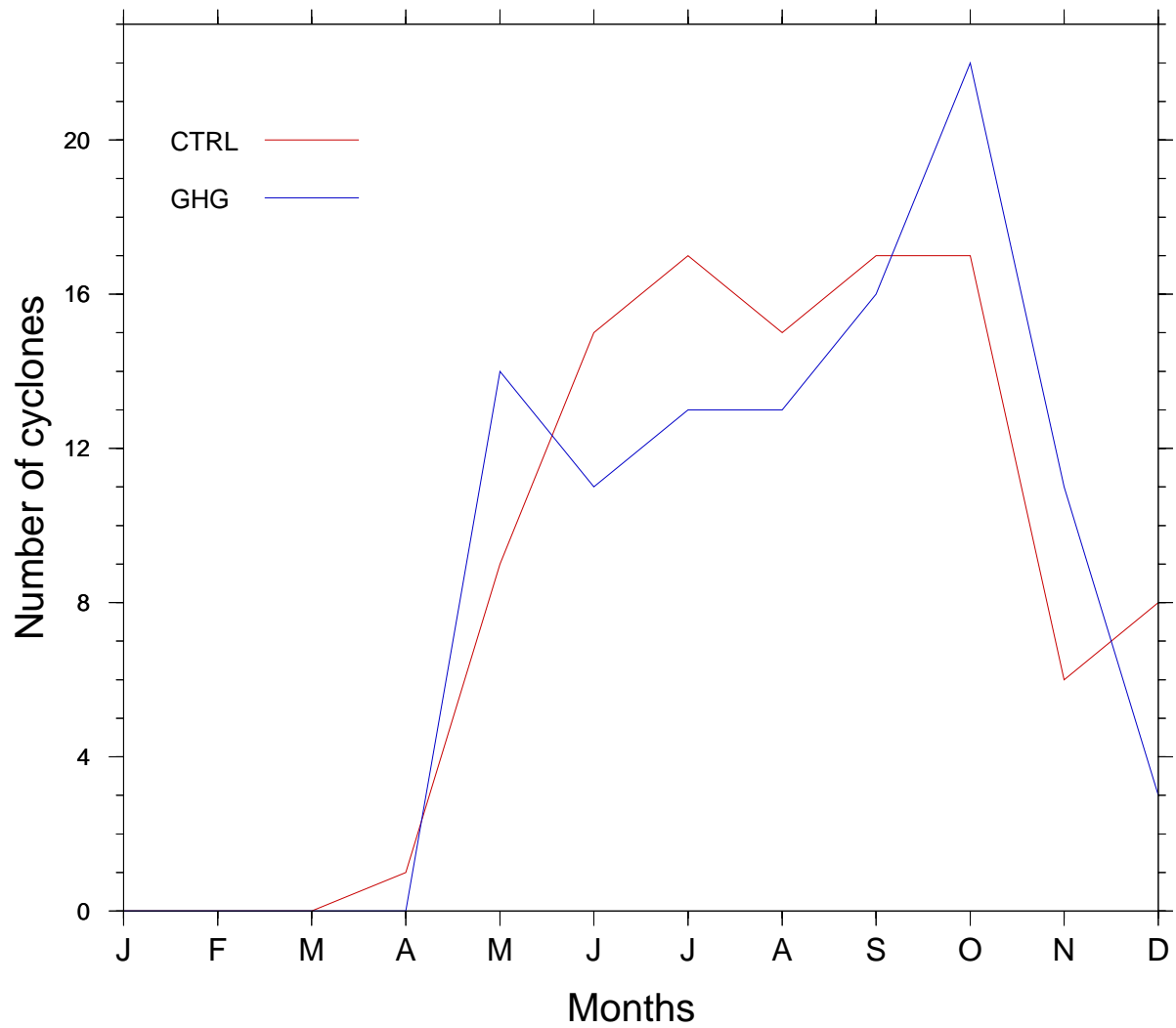


Fig. 13: Frequency distribution of cyclones in the Bay of Bengal for a period of 20 years (2041-2060) for the HadRM2 model run. Red line shows CTRL simulation and blue line shows doubled GHG simulation.

from mid May to middle of August when compared to the control run. Fig 12 shows an increase in the number of cyclones from middle of September to November in doubled GHG run. There is also a decrease in the number of cyclones from April to July.

The number of intense events, such as cyclones, shows an increase in the Bay of Bengal during the post monsoon season, with a peak in October (Fig. 13), indicating that though the number of total disturbances may not vary much due to increased greenhouse gases, the number of intense events may increase. In the case of the Arabian Sea, no such changes are noticed.

*(ii) Wind fields*

The track of the cyclones for a five year period (2041-'45) is shown in Fig 14a,b for the control simulation and the doubled GHG simulation respectively. The simulated tracks between the two runs does not show any significant difference. The maximum wind speeds associated with each storm were compiled and the ensemble of all during the 20 year period is presented in Fig 15. The frequency of cyclones having maximum wind speed, particularly in the range of (30-35 m/sec), is much higher in the doubled GHG run than in the control run.

*(iii) Simulation of storm surges using HadRM2 winds*

The domain of the storm surge model, developed for the Bay of Bengal, is shown in Fig.16. The grid resolution is about 18 km and the time step used is 30 seconds. The open boundary is along  $6.58^{\circ}\text{N}$  on the southern side. The HadRM2 winds were interpolated to the model grid using a two-dimensional linear interpolation method. Since the winds are on a daily time scale, the wind field is kept constant for 24 hours and made to change after every 24 hours. The storm surge model was run for a period of 20 years

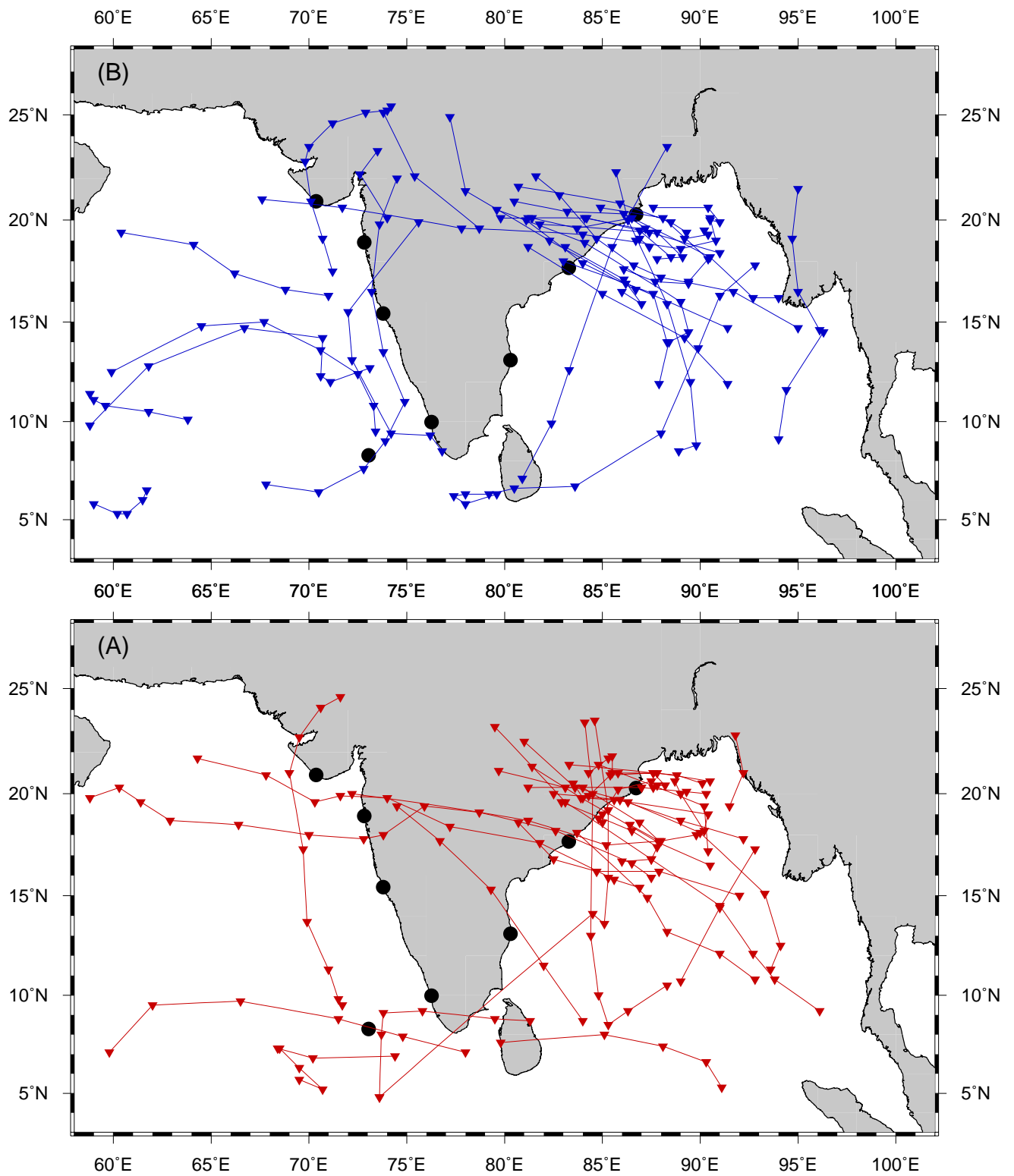


Fig. 14: Composite track of cyclones (2041-2045). (A) control run and (B) doubled GHG run of HadRM2.

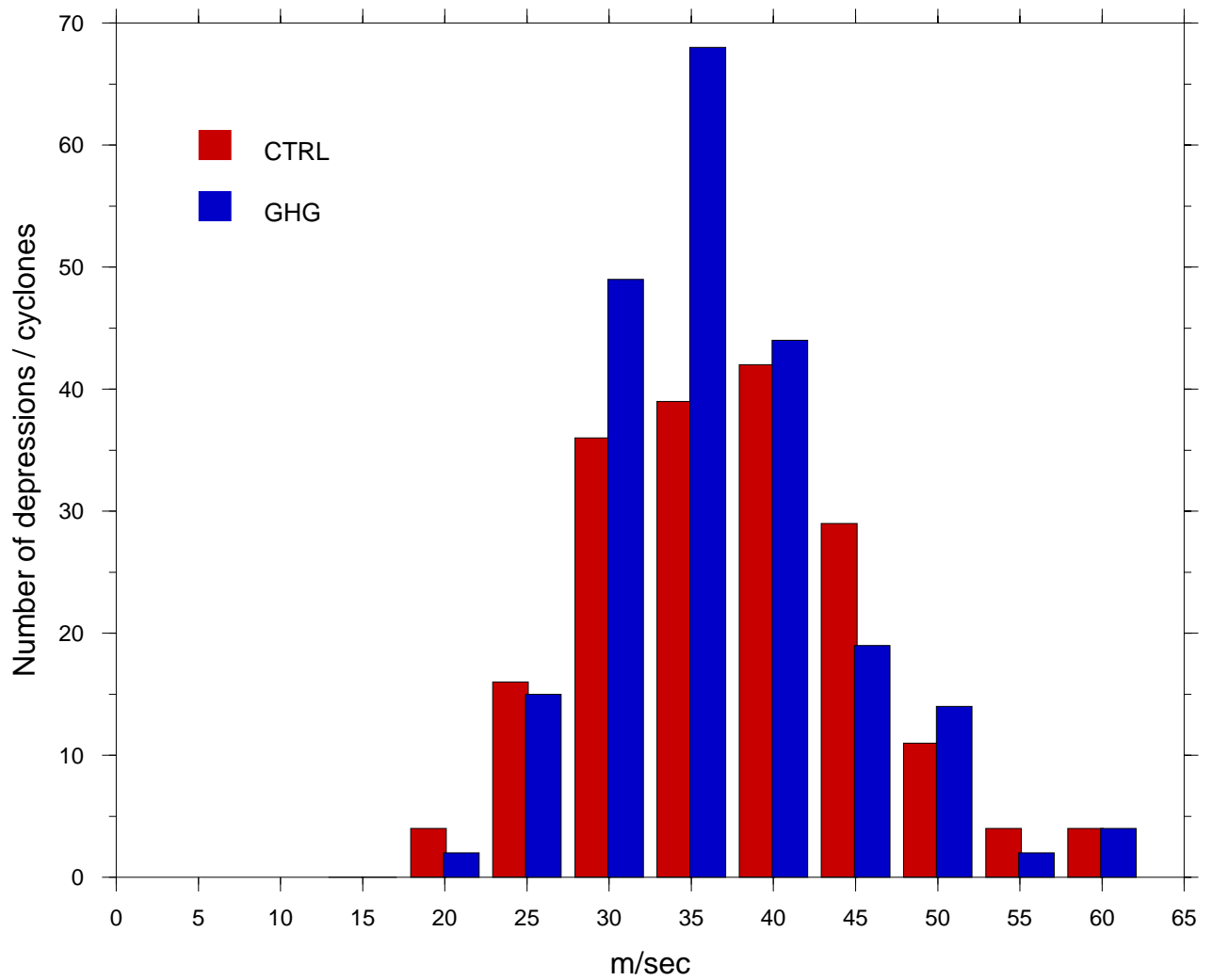


Fig. 15: Frequency distribution of maximum wind speeds associated with cyclones in the control run and doubled GHG run of HadRM2 (2041-2060).

by forcing the model with winds from HadRM2 for the (i) control run and (ii) doubled GHG run.

Along the open boundary, tides were prescribed using the global tidal model output (Le Provost et al., 1994). Surface elevations at five equidistant points from 82 °E to 99 °E along the southern open boundary (6.58 °N) were extracted from the global model at each model time step (30 second) for the 20 year period. These values were linearly interpolated to different grid points along the open boundary.

A typical example of the storm surges generated by the storm surge model is shown in Fig.17. The storm surges generated by the cyclone, which crossed the land north of Paradip (Fig.9), are shown for two stations Paradip and Sagar. The simulated sea levels are with respect to mean sea level and they were adjusted with respect to the chart datum (Fig.17). As the crossing of the cyclone is north of Paradip, negative surges are found at Paradip, where as high surges are found at Sagar.

The maximum value of simulated sea level during a storm surge event for each grid point along the coastline was compiled for all the events in the 20 year simulation. These values were picked up by defining a window, which consists of 48 hours before and 48 hours after the crossing of the cyclone over the land. Thus, for each storm, one highest value was chosen and this information was compiled for the 20 years. The number of storm events varied between in the control run and doubled GHG run. While picking up the highest sea level during a storm surge event, care was taken not to include the highest spring tides, which could be mistaken as storm surges. Since the model results are over the mean sea level, the results presented in Fig.18 are with respect to the mean sea level. The level of chart datum has to added to the simulated sea level to obtain the

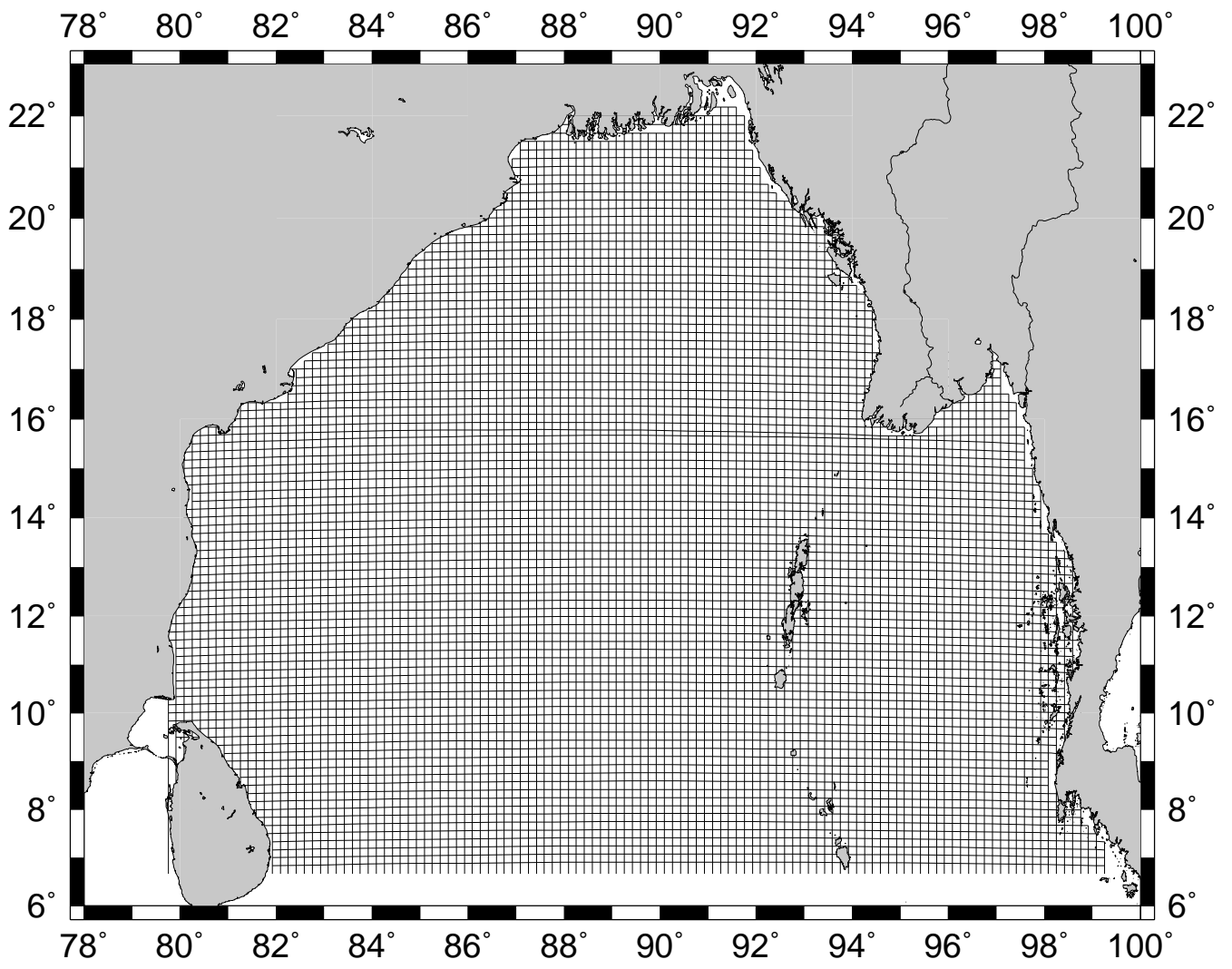


Fig. 16: The domain of storm surge model

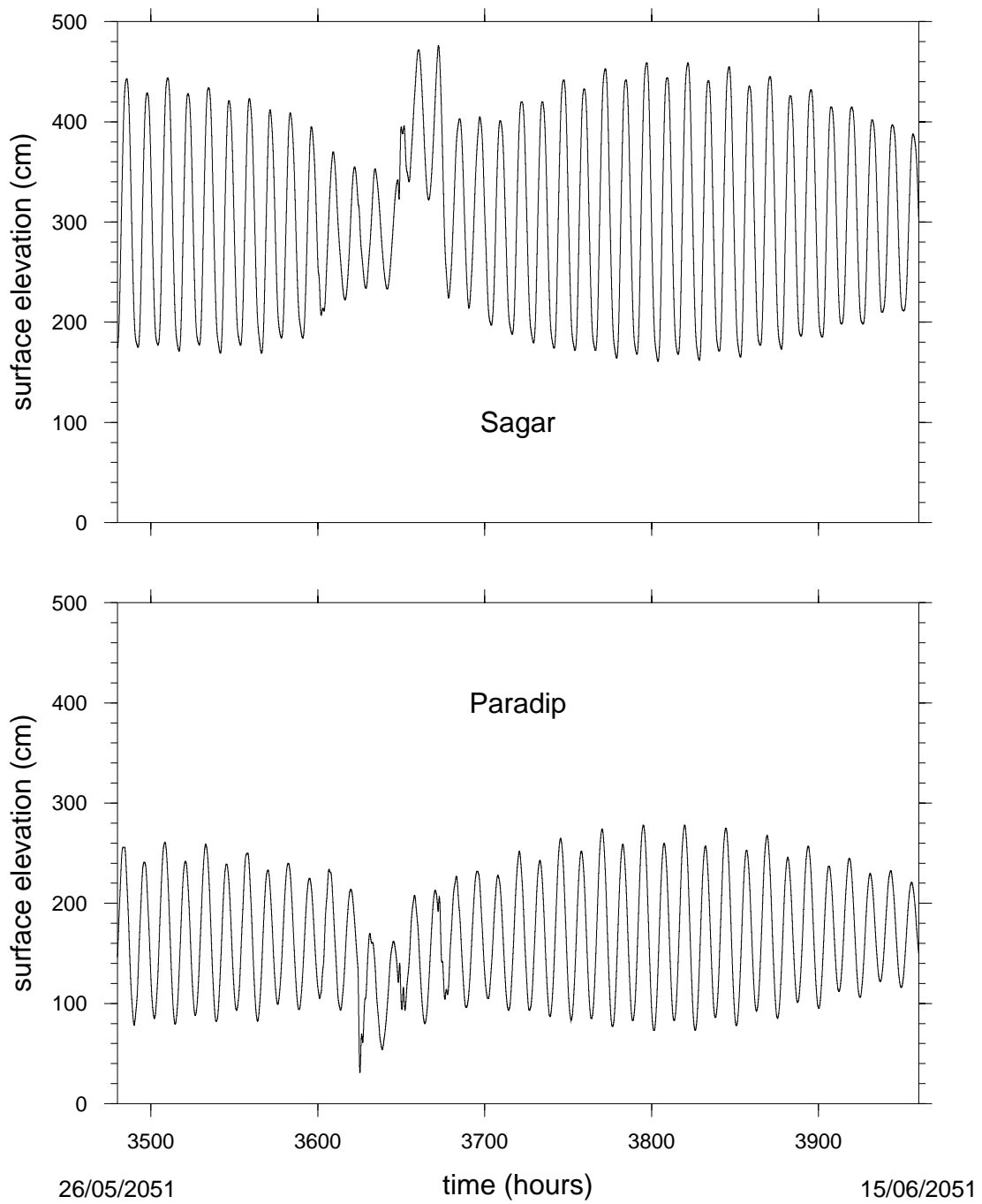


Fig. 17: Sea surface elevation simulated by storm surge model associated with the cyclone of June 3, 2051 (doubled GHG run of HadRM2).

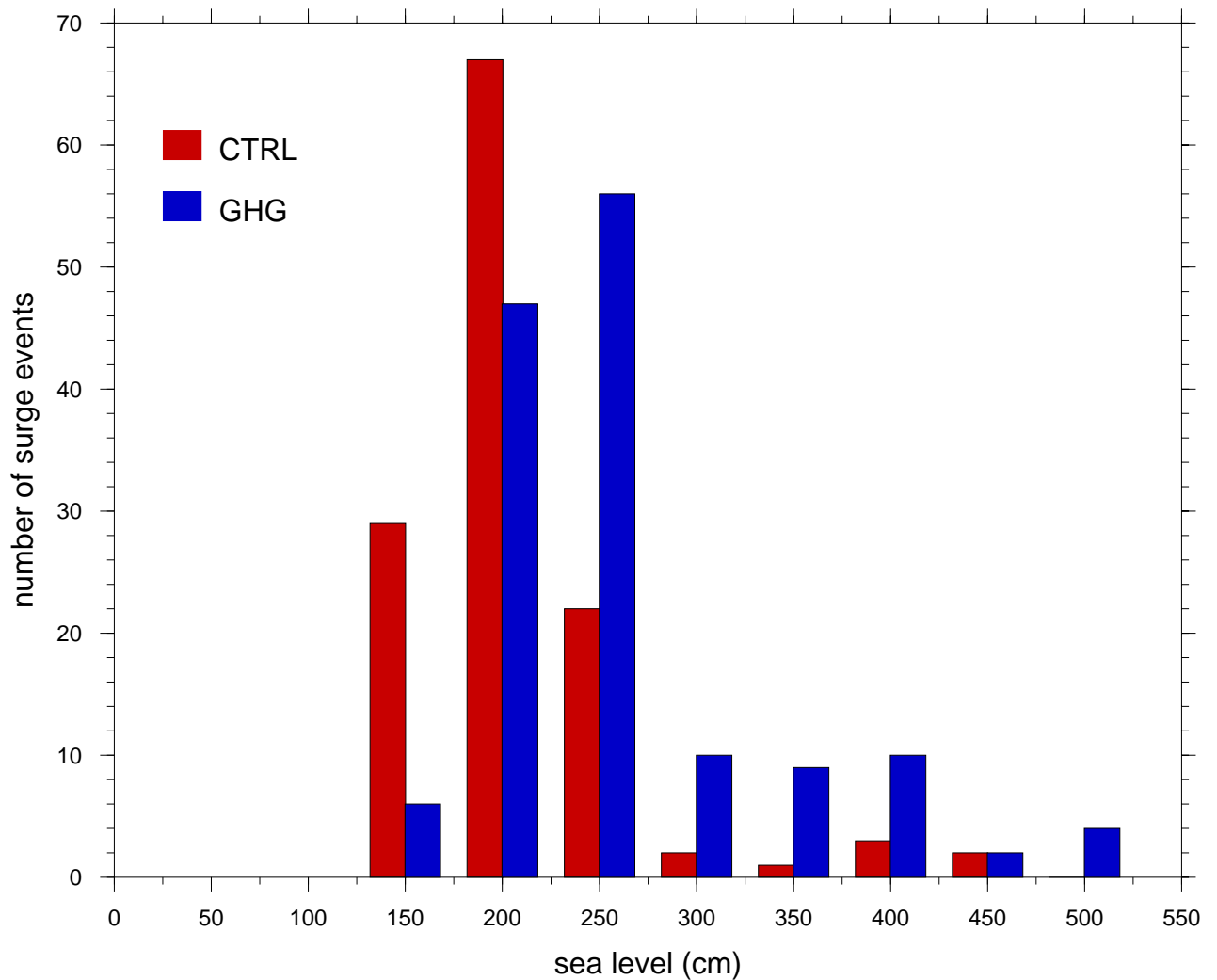


Fig. 18: Frequency distribution of maximum surges (2041-2060) associated with the storm surges simulated by winds in the control run and doubled GHG run. The surface elevations are with respect to the mean sea level.



actual sea level in that location. This is not very critical as far as the interpretation of this result is concerned (Fig 18), as it is intended to make a comparison between the two model simulations. Occurrence of highest sea levels is found to be more in the storm surge simulations forced by winds from doubled GHG than in the simulation forced by winds from the control run. This is consistent with the frequency distribution of maximum wind speeds associated with cyclones (Fig. 15).

*(iv) Precipitation*

Extreme rainfall events occur in the coastal regions in association with the crossing of cyclones over the land. The daily rainfall data from HadRM2 were analysed using Gumbel extreme value distribution to estimate the return periods of extreme rainfall events. Results are shown for six selected points along the east coast (Fig.19 A,B,C,D,E &F). It is found that the return levels for different periods are higher in doubled GHG estimates than those in the control run. This is particularly conspicuous for the points, which lie in the northernmost part of the coast. The tracks of the cyclones indicate (Fig. 14) that most of the cyclones cross the land in this region. As discussed in the previous section, in HadRM2 simulations, the frequency of cyclones in the Bay of Bengal are found to be higher in the doubled GHG run than in the control run, particularly in the post monsoon season. For the points which lie in the southern side (Fig. 19F), the return levels of intense rainfall are lower and there is no significant difference between the control run and doubled GHG run. For these points, the 100 year return period of intense rainfall is slightly less than 300 mm. This compares well with the estimates made by Mukherji et al. (1991), in which the authors performed Gumbel extreme value analysis for different points along the coast of India and estimated the 100 year rainfall to be about 250 to 350

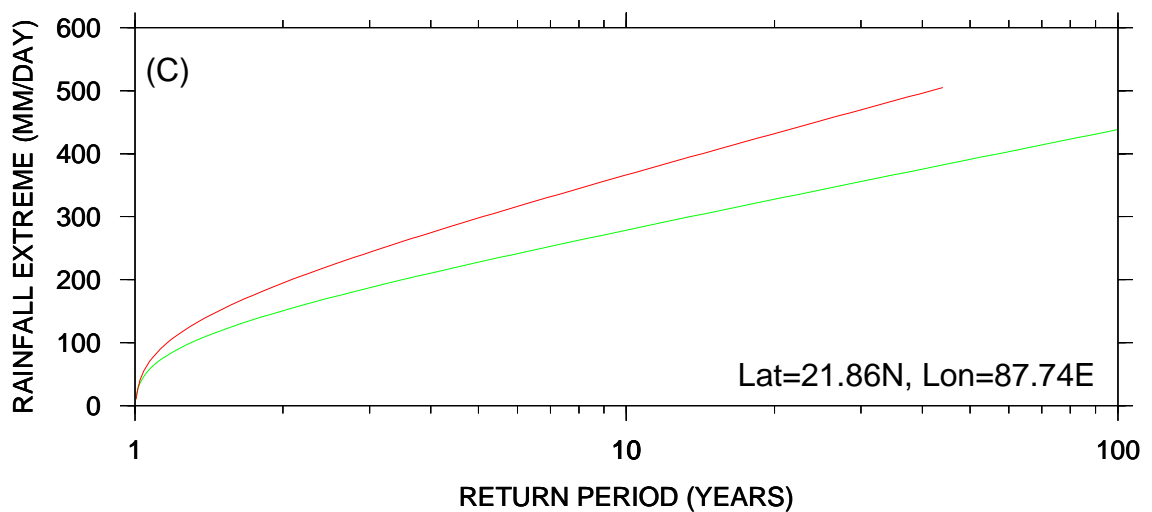
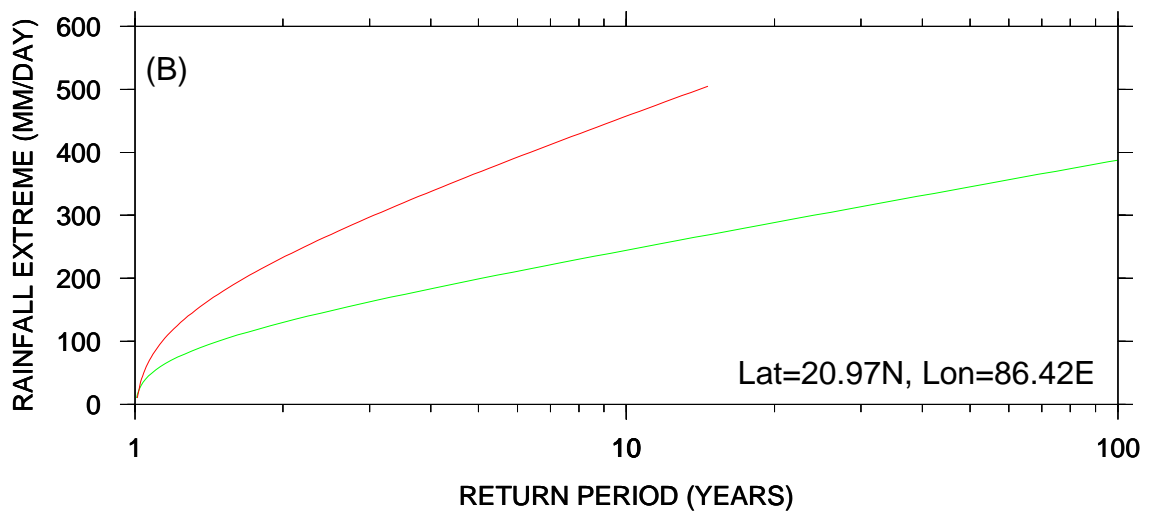
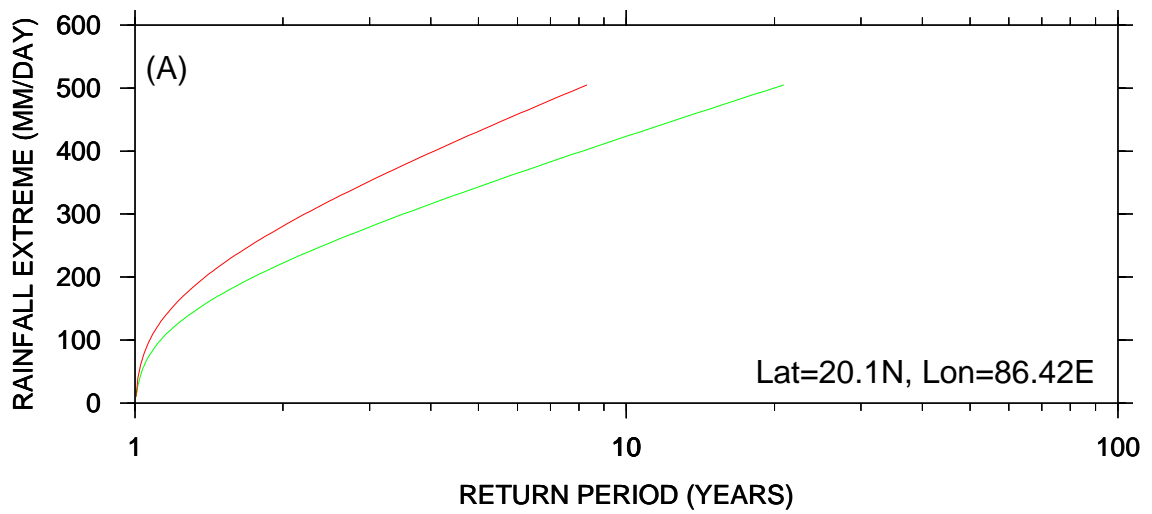


Fig. 19(A,B,C): The return period of Extreme daily Rain fall at different locations along the coast of India for HadRM2 data. Red line indicates double GHG run, Green line indicates Control run.

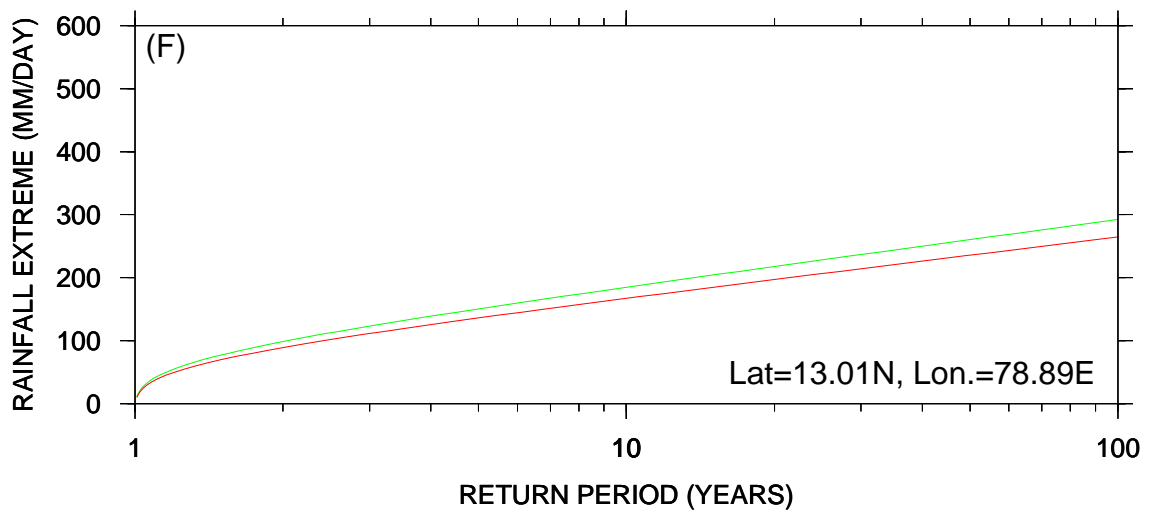
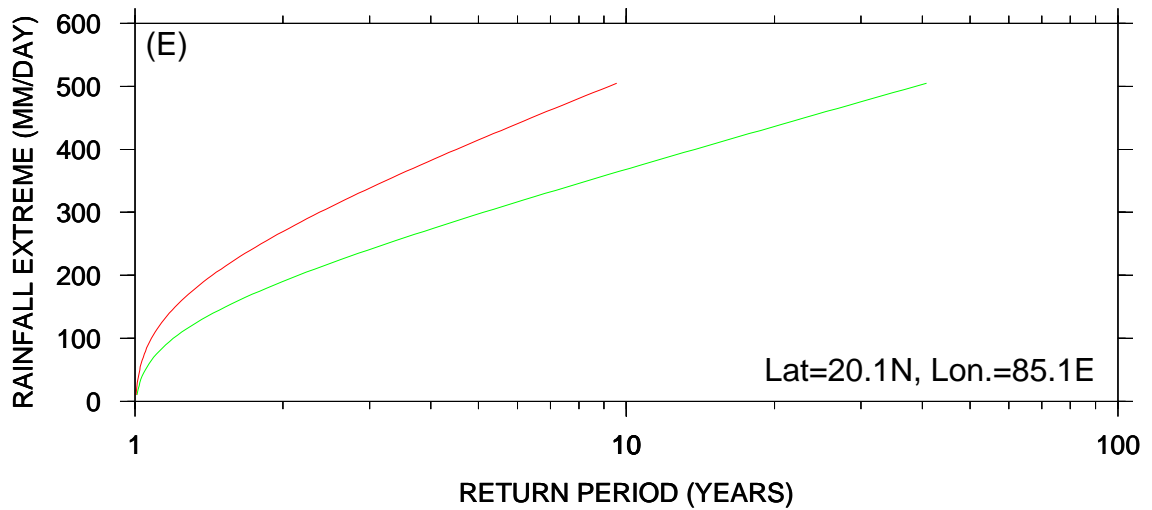
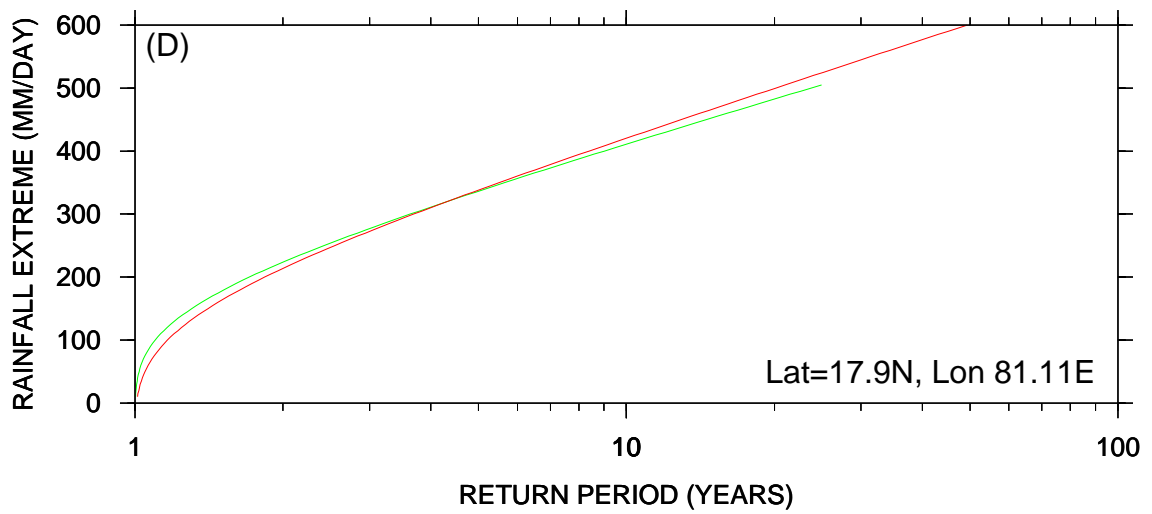


Fig. 19(D,E,F): The return period of Extreme daily Rain fall at different locations along the coast of India for HadRM2 data. Red line indicates double GHG run, Green line indicates Control run.

mm. This value is comparable to the estimates for the points lying in the southern part of the coast. However, for the points along the northern part of the coast, the 100 year return levels of rainfall are higher, varying between 400 to 500 mm.

## **Task 5: Return periods of extreme sea level in a future sea level rise scenario**

### *(i) Flood risks associated with sea level rise*

In this section, we estimated the changes in return periods of extreme sea level that could occur in future in the event of future sea level rise. For evaluating the impacts of sea level rise on the return period estimates, we made calculations of return periods assuming that an increase of sea level, say, 24.1 cm, occurs by 2050, obtained from HadCM2 and HadCM3 estimates of sea level rise for the year 2050 (see Fig.7). As a first approximation, assuming that the occurrence of cyclones remains the same in future, the r-largest analysis described in Task 2, was performed again by adding this uniform increase of sea level to all values. In this calculation, we did not incorporate the trends from year to year. Fig. 20 shows a comparison of the return period estimates between the present scenario and the for the year 2050 for Paradip, Vishakhapatnam and Chennai.

The impacts associated with flood risks was studied by Nicholls et al. (1999) by estimating a term called flood envelope, defined as  $E_{\text{flood}} = H_{1000} - H_1$ , where  $H_{1000}$  and  $H_1$  are the return levels for 1000 year and 1 year return periods respectively. Nicholls et al. (1999) noted that for most coastal regions,  $E_{\text{flood}}$  is less than 1 m. A sea level rise of similar magnitude as that of  $E_{\text{flood}}$  will imply that an extreme event occurring once in 1000 year at present will occur once in 1 year after the sea level rise.

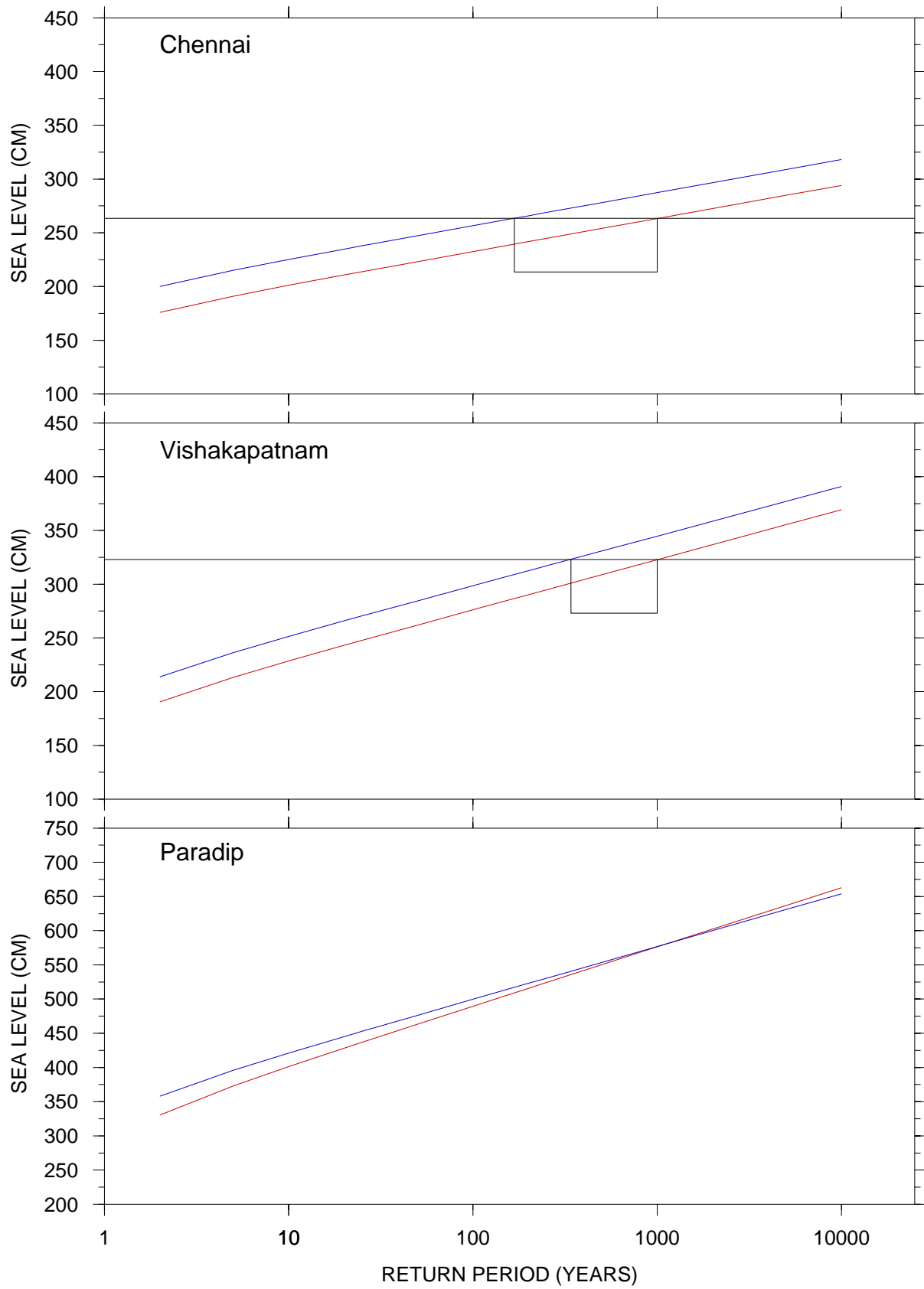


Fig. 20: Return period estimates, red indicates the present scenario and blue indicates the sea level rise scenario for 2050.

We calculated the parameter flood envelope for Paradip, Vishakhapatnam and Chennai. They are approximately 1.56, 1.32 and 0.88 m respectively. The characteristics of the return period curves, which are also known as port diagram curves, are important. Fig. 20 shows a steep curve for Paradip, followed by Vishakhapatnam and for Chennai, it is flatter. If the return period curve is relatively flat, then the value of  $E_{\text{flood}}$  decreases and it becomes comparable to the projected sea level rise by the turn of the century. This is the case for Chennai and the effect of sea level rise is maximum felt at Chennai and least in Paradip, as far as the occurrence of floods due to storm surges are concerned.

*(ii) Sea level rise and tidal ranges along the Indian coasts*

Along the Indian coasts, the tidal range increases in general, gradually from south to north. Along the west coast of India, the mean spring tide tidal ranges at Kochi, Marmugao and Mumbai are about 0.6, 1.7 and 3.7 m. respectively (Indian Tide Tables, 2004). Along the east coast, the mean spring tidal ranges at Chennai, Vishakhapatnam, and Paradip are 1.0, 1.4 and 1.9 m respectively. In the regions where the tidal ranges are low, say less than 1 m., the increase in sea level projected by the turn of the century, becomes comparable to the magnitudes of tidal ranges. Thus, flood risks will be greater in a region where the tidal ranges are lower than in regions of higher tidal ranges.

*(iii) Sea level rise and mangrove distribution along the Indian coasts*

When the tidal ranges are low and become comparable to the sea level rise, the impacts will be more. A project conducted by the National Institute of Oceanography (Anonymous, 2002b) studied the mangrove distribution along the west coast of India and found it to be sensitive to sea level rise. Along the coast of Kerala, the tidal ranges are low ( $\sim 1\text{m}$ ). An increase in sea level coupled with limitations in landward margins in this

region may cause severe damage to the mangrove ecosystem (Jagtap et al., 2004, communicated).

## CONCLUSION

Extreme sea level analysis using tide gauge data is new to the Indian coasts. The estimates of return periods of storm surge events are useful for the design of sea walls, offshore structures and for planning an optimal tide gauge network. The statistical analysis of tide gauge data is complimentary to the existing work on storm surge modelling in the country.

For studying the impacts of surges in the coastal zone, a database on the damage and destruction caused by cyclones and storm surges along the Indian coasts was created for the period 1950-2000.

The analysis of regional climate model of the Hadley Centre, HadRM2 provided indications of the possible changes that could occur in future due to an increase in green house gases. A comparison between the results of two simulations, namely, the control run and a run with doubled green house gas showed (i) an increased occurrence of cyclones in the Bay of Bengal, particularly in the post-monsoon period (ii) increased maximum wind speeds associated with cyclones and (iii) a decrease in the return period of intense rainfall events along the north east part of the coast.

The storm surge model for the Bay of Bengal region, developed during the present study, was run using the winds from HadRM2 model. The simulations showed greater number of high surges in the doubled GHG run than in the control run.

Impact of flood risk associated with storm surges was estimated for the year 2050, assuming that the occurrence of cyclones will remain the same, as a first approximation. Gumbel analysis was performed for the extreme sea levels for the present scenario and



for the year 2050 assuming a sea level rise of 24.1 cm (Fig. 7). The results indicated that the regions where the return period curves are steep, for example, for Paradip (Fig 20), the impact will be minimum and vice versa for Chennai, where the return period curve is relatively flat.

Estimates of sea level rise along the Indian coast were made for selected tide gauge stations. The analysis for the stations, Mumbai, Vishakhapatnam and Kochi showed a sea level rise of less than 1mm/year; however, the analysis for Chennai showing a rate of decrease. However, these estimates need to be corrected by subtracting the vertical land movements in order to get the net sea level rise. When the data on vertical land movements become available, the trend in sea level rise along the Indian coasts can be understood.

## **PUBLICATIONS**

Unnikrishnan, A.S., D. Sundar and D.Blackman (2004) Analysis of extreme sea level along the east coast of India. Journal of Geophysical Research – Oceans, 109, C06023, doi:10.129/2003JC002217.

## **MANPOWER TRAINING**

In the present project, dissertation works for the fulfillment of Masters Degree were carried out by two students. The references are given below.

(i) Sundar, D. (2001) Sea level variability along the Indian coast during storms. M.Sc. dissertation, Goa University, 29 p., 25 figs.

(ii) Mony, M.V. (2004) Climate Change – A future perspective of the northern Indian Ocean. M.Tech thesis, submitted to the Department of Future Studies, University of Kerala.

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As far as the scientific aspects of the project are concerned, the present project involved associations with many organisations. Firstly, we thank the Geodetic &

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NIO/TR-6/2004

**JOINT INDO-UK PROGRAMME**

**MoEF India and DEFRA UK**

# Extreme sea level variability along the coast of India

**Volume II**

**28 October 2004**



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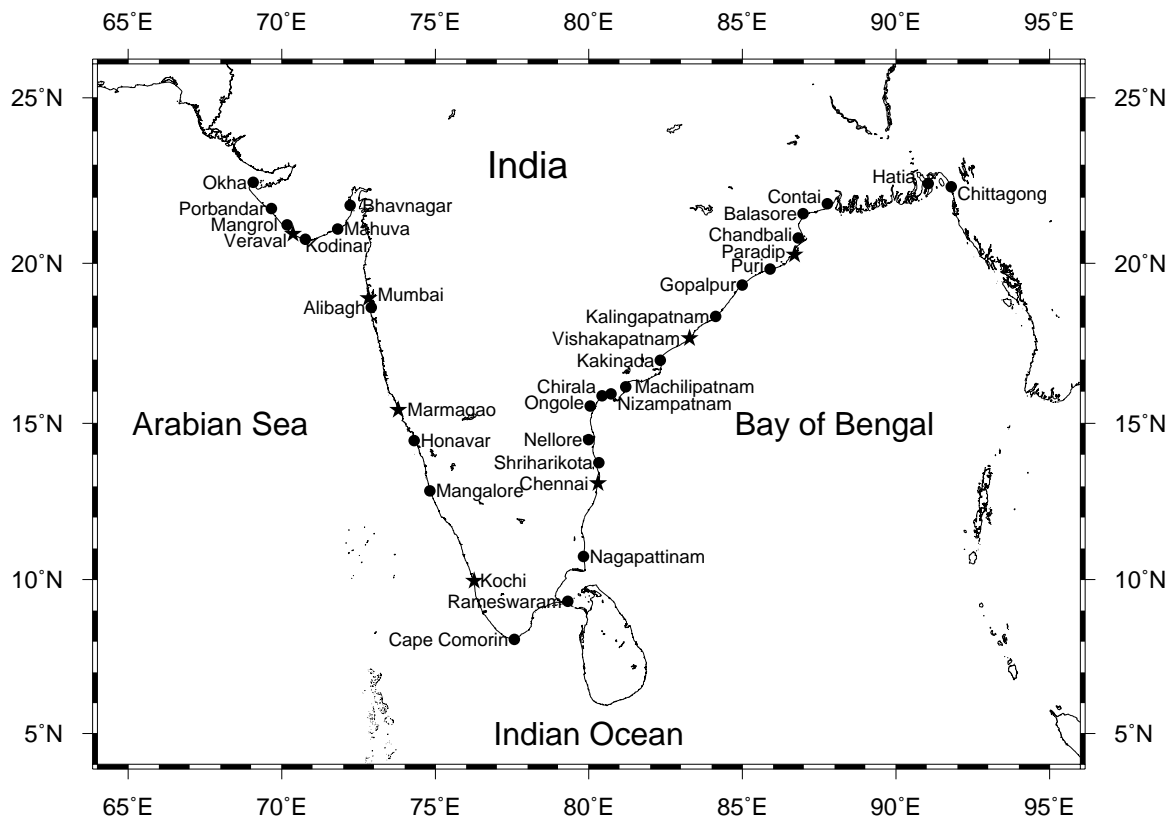


Figure 1. The location map. The stars indicate tide gauge stations.

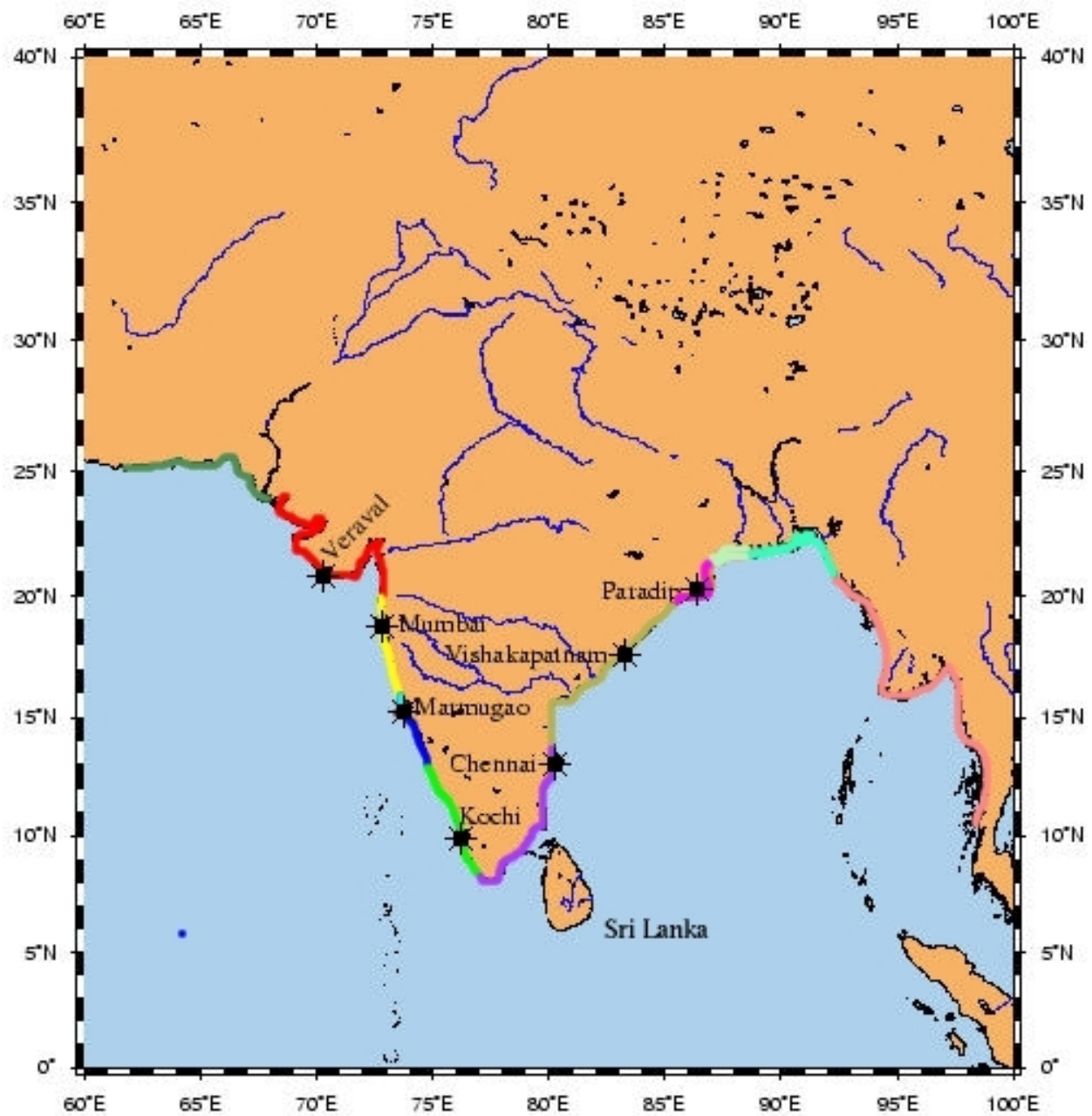


Fig. 2: Coast line of the States of India and adjoining countries, viz., Pakistan, Bangladesh and Myanmar (Burma).

## ANNEXURE - I

For the recently concluded project at the National Institute of Oceanography on “ Sea-level variability in the coastal region of India ”, the Survey of India, Dehra Dun made available 15 years (1974- '88) of hourly tide gauge data for six stations along the coast of India. (See Fig.1), namely, Paradip, Vishakhapatnam, Chennai, Kochi, Marmagoa and Mumbai. These data were in the digital form and were fed into the computer during this project. Thus a computer accessible data set was prepared during this project. This data set does contain some gaps. These gaps are listed below.

The years listed in parentheses against the name of each station are those for which the Survey of India supplied data. When months are listed, data are missing for the listed months; if only the year is listed, data are missing for the entire year; when a year is missing in the list below, data are available for all months in that year.

- Paradip (1974-1988)

Feb 1974; Feb-Jun, Sep-Nov 1975; 1976; 1977; Feb 1978; Nov 1982; Aug 1988.

- Vishakhapatnam (1974-1988)

Dec 1978; Mar-Apr 1981; Feb, Apr 1987.

- Chennai (1974-1988)

Apr-May 1977; Feb 1980; Sep 1984; Jan-Feb, Dec 1985; 1986; Sep 1987; Nov-Dec 1988.

- Kochi (1974-1988)

Nov-Dec 1978; May-Jul 1979; May 1982

- Marmugao (1974-1988)

Jan-Mar 1974; May-Dec 1979; Jun-Dec 1980; 1981; 1982; 1983; 1984; 1985;

1986; Sep-Dec 1987; Nov-Dec 1988.

- Mumbai (1974-1988)

May 1983.

## ANNEXURE –II

Paradip

20° 16' N 86° 42' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
28 September, 1974	304.0	69.1	CS (core pressure < 992 hPa) crossed Orissa coast, south off Paradip on 28 September evening. Details: 24 Sep LP Andaman Sea 25 Sep LP Southeast Bay 26 Sep DD 16.0 N / 92.0 E < 1002 27 Sep CS 17.5 N / 88.5 E < 1000 28 Sep CS 19.0 N / 87.5 E < 998	
28 November, 1974	312.0	52.4	SCH (core pressure < 996 hPa) crossed Bangladesh near Chittagong on 28 November noon and weakened rapidly. Details: 22 Nov LP Southwest bay 24 Nov DD 11.5 N / 87.0 E < 1000 25 Nov SCS 12.5 N / 85.0 E 26 Nov SCS 13.5 N / 87.0 E < 998 27 Nov SCS 17.5 N / 88.0 E < 996 28 Nov SCH 21.5 N / 91.0 E < 996	
6 August, 1975	262.0	26.2	D (core pressure < 994 hPa) crossed Orissa between Balasore and Chandbali on 6 August afternoon. Details: 3 Aug LP South Orissa, north Andhra Coast 4 Aug LP 18.5 N / 87.8 E < 998 5 Aug D 19.5 N / 87.5 E < 994 6 Aug D 21.2 N / 87.2 E < 996 7 Aug LP 23.5 N / 82.5 E < 998	

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
15 May, 1978	254.0	33.9	<p>SCH (core pressure &lt; 992 hPa) crossed Burma coast near Akyab on 17 May at night.</p> <p>Details:</p> <p>13 May LP Southeast Bay.</p> <p>14 May DD 10.0 N / 89.0 E &lt; 1000</p> <p>15 May CS 13.5 N / 91.2 E &lt; 994</p> <p>16 May CS 16.1 N / 92.0 E &lt; 992</p> <p>17 May SCH 18.2 N / 92.2 E &lt; 992</p> <p>18 May D Over North Burma</p>	
12 July, 1978	266.0	34.6	<p>DD (core pressure &lt; 995 hPa) crossed Orissa coast near Bhubaneswar in early hours of 12 July.</p> <p>Details:</p> <p>10 Jul LP 19.0 N / 87.0 E &lt; 1000</p> <p>11 Jul LP 18.5 N / 87.0 E &lt; 998</p> <p>12 Jul DD 20.3 N / 85.5 E &lt; 995</p> <p>13 Jul DD Near Mandla (U.P) &lt; 998</p>	
15 August, 1978	312.0	65.3	<p>DD (core pressure &lt; 988 hPa) crossed Orissa coast between Gopalpur and Puri on 15 May afternoon.</p> <p>Details:</p> <p>12 Aug LP 21.0 N / 89.4 E &lt; 997</p> <p>13 Aug D 19.5 N / 89.0 E &lt; 994</p> <p>14 Aug DD 19.2 N / 87.7 E &lt; 992</p> <p>15 Aug DD 19.2 N / 87.2 E &lt; 988</p> <p>16 Aug DD Near Mandla (U.P) &lt; 994</p>	

Paradip

20° 16' N 86° 42' E

8

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
23 June, 1979	308.0	50.1	DD (core pressure < 990 hPa) crossed Orissa coast near Cuttack on 24 June evening. Details: 22 Jun LP 19.0 N / 88.5 E < 998 23 Jun D 19.5 N / 88.5 E < 994 24 Jun DD 19.5 N / 87.5 E < 990 25 Jun DD Over M.P < 992	
8 July, 1979	300.0	44.5	D (core pressure < 994 hPa) crossed Orissa coast in the early morning of 8 July. Details: 6 Jul LP 21.2 N / 89.5 E < 998 7 Jul D 19.5 N / 90.0 E < 994 8 Jul D 20.5 N / 86.2 E < 996 9 Jul LP Over M.P < 998	
7 August, 1979	280.0	-5.77	SCS (core pressure < 980 hPa) crossed Orissa coast near Balasore in the early night of 7 August. Details: 5 Aug LP 22.1 N / 90.0 E < 996 6 Aug D 21.0 N / 90.0 E < 990 7 Aug SCS 21.5 N / 87.5 E < 980 8 Aug SCS 22.3 N / 85.0 E < 984	A negative surge. Balasore recorded the lowest MSL pressure of 970 hPa at 2100 hrs of 7 August.



Paradip

20° 16' N 86° 42' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
17 September, 1980	272.0	51.6	DD (core pressure < 998 hPa) crossed Orissa coast between Puri and Gopalpur on 17 September morning. Details: 15 Sep LP 19.6 N / 88.5 E < 1002 16 Sep D 18.0 N / 86.5 E < 1002 17 Sep DD 19.8 N / 84.8 E < 998 18 Sep DD 21.5 N / 82.3 E < 998	
17 September, 1980	272.0	51.6	DD (core pressure < 998 hPa) crossed Orissa coast between Puri and Gopalpur on 17 September morning. Details: 15 Sep LP 19.6 N / 88.5 E < 1002 16 Sep D 18.0 N / 86.5 E < 1002 17 Sep DD 19.8 N / 84.8 E < 998 18 Sep DD 21.5 N / 82.3 E < 998	
18 October, 1980	248.0	34.1	CS (core pressure < 1000 hPa) crossed Andhra Coast between Machilipatnam and Kakinada on 18 October morning. Details: 15 Oct LP 10.0 N / 88.0 E < 1009 16 Oct D 10.0 N / 88.0 E < 1006 17 Oct CS 14.5 N / 82.5 E < 1000 18 Oct CS 16.2 N / 81.7 E < 1000 19 Oct D 16.8 N / 81.5 E < 1004	This was only a border case of a cyclone. Machilipatnam reported the lowest pressure of 997.4 hPa at 0430 of 18 October.

Paradip

20° 16' N 86° 42' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
7 August, 1981	298.0	94.7	CS (core pressure < 982 hPa) crossed Orissa coast close to and North of Puri on 8 August in the Morning. Details 5 Aug LP 19.5 N / 87.5 E < 996 6 Aug LP 20.5 N / 88.5 E < 996 7 Aug DD 19.0 N / 88.0 E < 992 8 Aug CS 20.0 N / 86.0 E < 982 9 Aug CS 22.0 N / 81.2 E < 990	
26 September, 1981	344.0	89.4	SCS (core pressure < 992 hPa) crossed Orissa coast near Puri on the early morning of 26 September. Details: 24 Sep LP 17.0 N / 91.0 E < 1002 25 Sep CS 18.0 N / 88.5 E < 994 26 Sep SCS 20.5 N / 85.5 E < 992 27 Sep DD 22.8 N / 80.5 E < 998	Puri reported the lowest pressure of 983.1 hPa at 0530 hrs of 26 September.
3 June, 1982	310.0	103.5	SCS (core pressure < 986 hPa) crossed Orissa Coast close to and North of Paradip around 2200 IST on 3 June. Details: 31 May LP 13.0 N / 91.5 E < 1002 1 Jun D 15.0 N / 91.0 E < 994 2 Jun CS 17.5 N / 89.5 E < 994 3 Jun SCS 19.0 N / 88.0 E < 986 4 Jun CS 21.5 N / 85.5 E < 990 5 Jun D 25.0 N / 82.0 E < 998	Ship M.V Renusagar anchored at Paradip port recorded the lowest pressure 952.0 hPa and northerly wind of 120 Knots.

Paradip

20° 16' N 86° 42' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
19 July, 1982	296.0	34.0	DD (core pressure < 992 hPa) crossed Orissa coast between Gopalpur and Puri by early night on 19 July. Details: 17 Jul LP 16.6 N / 89.8 E < 998 18 Jul D 18.4 N / 88.5 E < 992 19 Jul DD 18.7 N / 86.5 E < 994 20 Jul D 21.0 N / 83.3 E <996	
28 August, 1982	236.0	43.4	D (core pressure < 996 hPa) crossed Orissa coast near Balasore on 28 August night. Details: 26 Aug LP 20.5 N / 88.5 E < 1000 27 Aug D 19.0 N / 88.5 E < 998 28 Aug D 21.0 N / 87.5 E < 996 29 Aug D 22.0 N / 86.0 E < 996	
10 September, 1982	276.0	31.1	D (core pressure < 998 hPa) crossed Orissa coast near Puri on 10 morning. Details: 8 Sep LP 18.0 N / 88.0 E < 1002 9 Sep D 18.0 N / 89.0 E < 998 10 Sep D 20.3 N / 85.0 E < 998	

Paradip

20° 16' N 86° 42' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
24 June, 1983	294.00	40.4	DD (core pressure < 994 hPa) crossed south Orissa coast near Gopalpur on the forenoon of 25 June. Details: 23 Jun LP 18.5 N / 87.5 E < 999 24 Jun DD 18.0 N / 85.6 E < 996 25 Jun DD 19.0 N / 85.4 E < 994 26 Jun D 20.3 N / 84.0 E < 994	
9 November, 1983	310.0	44.8	SCH (core pressure < 996 hPa) crossed Bangladesh coast near Cox's Bazaar on 9 evening. Details: 6 Nov LP 12.5 N / 89.0 E < 1008 7 Nov CS 15.0 N / 89.0 E < 1000 8 Nov SCS 17.0 N / 89.5 E < 996 9 Nov SCH 20.0 N / 90.5 E < 996 10 Nov D 24.0 N / 95.0 E < 1006	The system did not affect the weather over India.
1 August, 1984	346.0	68.4	DD (core pressure < 992 hPa) crossed Orissa coast between Puri and Paradip on 1 August. Details: 30 Jul LP 19.5 N / 88.5 E < 998 31 Jul D 19.8 N / 88.0 E < 996 1 Aug DD 20.5 N / 84.0 E < 992	

Paradip

20° 16' N 86° 42' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
15 August, 1984	300.0	36.2	DD (core pressure < 992 hPa) crossed North Orissa coast near Balasore on 16 morning. Details: 13 Aug LP 19.5 N / 90.5 E < 998 14 Aug LP 20.0 N / 90.0 E < 996 15 Aug D 20.0 N / 90.0 E < 992 16 Aug DD 21.5 N / 87.0 E < 992 17 Aug DD 23.0 N / 84.0 E < 994	Balasore reported a MSL pressure of 989.6 hPa at the time of landfall.
14 October, 1984	314.0	61.8	SCH (core pressure < 1000 hPa) crossed Orissa coast near Chandbali on the forenoon of 14 October. Details: 11 Oct LP 18.0 N / 88.5 E < 1006 12 Oct LP 19.0 N / 88.5 E < 1006 13 Oct SCS 19.5 N / 88.0 E < 1000 14 Oct SCH 20.7 N / 86.8 E < 1000 15 Oct DD 22.5 N / 85.0 E < 1006	This system very rapidly intensified into a hurricane from a stage of Depression within twelve hours.
25 May, 1985	226.0	42.3	SCS (core pressure < 980 hPa) crossed Bangladesh coast near Hatia in the early hours of 25 May. Details: 22 May D 15.5 N / 88.0 E < 998 23 May DD 16.5 N / 87.5 E < 994 24 May SCS 19.0 N / 89.0 E < 980 25 May SCS 23.0 N / 91.5 E < 986 1 Aug D 20.0 N / 88.0 E < 996 2 Aug LP 22.5 N / 83.0 E < 998	Caused tidal waves of 4.5 meters.

Paradip

20° 16' N 86° 42' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
20 September, 1985	228.0	55.0	CS (core pressure < 998 hPa) crossed Orissa coast near Puri in the evening of 20 September. Details: 19 Sep LP 18.5 N / 90.0 E <1004 20 Sep CS 19.5 N / 87.0 E < 998 21 Sep D 21.5 N / 82.5 E < 1004	
16 October, 1985	296.0	65.1	SCS (core pressure < 994 hPa) crossed Orissa coast near Balasore in the early hours of 16 October. Details: 13 Oct LP 14.0 N / 95.0 E < 1006 14 Oct DD 16.0 N / 89.5 E < 1002 15 Oct SCS 19.5 N / 87.5 E < 994 16 Oct CS 21.2 N / 87.0 E < 996 17 Oct CS 24.5 N / 85.5 E < 998	Lowest Pressure at Balasore 987.8 hPa at 0330 hours of 16 October.
12 August, 1986	303.0	46.0	DD (core pressure < 992 hPa) crossed North Andhra coast near Kalingapatnam in the night of 12 August. Details: 9 Aug LP 18.5 N / 85.0 E <1000 10 Aug LP 17.5 N / 87.5 E < 998 11 Aug DD 18.0 N / 86.5 E < 994 12 Aug DD 18.0 N / 84.5 E < 992 13 Aug DD 19.5 N / 83.5 E < 992	

Paradip

20° 16' N 86° 42' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
20 August, 1986	304.0	40.8	D (core pressure < 998 hPa) crossed Orissa coast in the early hours of 20 August. Details: 18 Aug LP 21.0 N / 88.5 E <1000 19 Aug LP 20.0 N / 88.5 E < 998 20 Aug D 21.5 N / 86.0 E < 998 21 Aug LP 23.0 N / 85.0 E < 1000	
25 September, 1986	265.0	36.8	D (core pressure < 1004 hPa) crossed Orissa coast near Balasore before noon of 25 September. Details: 23 Sep LP 18.4 N / 85.5 E <1008 24 Sep LP 19.6 N / 87.5 E <1006 25 Sep D 21.4 N / 86.5 E <1004 26 Sep D 21.7 N / 87.0 E <1002	Lowest pressure recorded at Balasore was 1000 hPa at 1730 hours of 25 September.
3 November, 1987	226.0	-17.3	SCS (core pressure < 996 hPa) crossed south Andhra coast just North of Nellore in the early hours of 3 November. Details: 31 Oct D 11.5 N / 86.0 E < 1006 1 Nov CS 14.0 N / 84.5 E < 1002 2 Nov SCS 13.5 N / 82.0 E < 996 3 Nov CS 14.9 N / 79.5 E < 1000 4 Nov LP 15.0 N / 76.5 E < 1000	

Paradip

20° 16' N 86° 42' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
13 November, 1987	250.0	46.8	SCS (core pressure <1000 hPa) crossed South Andhra coast just south of Machilipatnam in the early hours of 13 November.  Details: 9 Nov LP 10.0 N / 94.0 E < 1008 10 Nov LP 12.0 N / 90.0 E < 1006 11 Nov DD 13.0 N / 92.0 E < 1006 12 Nov CS 14.5 N / 84.5 E < 1000 13 Nov DD 16.0 N / 80.6 E < 1002	Became SCS at 1730 hours of 12 November and after crossing the coast weakened to DD.
17 July, 1988	302.0	46.3	D (core pressure < 993 hPa) crossed Orissa coast near Gopalpur in the night of 17 July.  Details: 15 Jul LP 19.0 N / 86.5 E < 1002 16 Jul LP 18.5 N / 87.0 E < 1000 17 Jul D 18.0 N / 86.0 E < 994 18 Jul D 19.5 N / 83.5 E < 993	
18 November, 1988	309.0	40.9	SCS (core pressure < 996 hPa) dissipated over North East and adjoining East Central Bay of Arakan coast by the midnight of 18 November.  Details: 14 Nov LP 07.0 N / 88.5 E < 1009 15 Nov D 08.0 N / 87.0 E < 1008 16 Nov CS 10.5 N / 89.0 E < 1002 17 Nov SCS 16.0 N / 90.5 E < 1000 18 Nov SCS 19.0 N / 93.0 E < 996 19 Nov LP 22.0 N / 93.0 E < 1012	



Paradip

20° 16' N 86° 42' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks																																				
28 November, 1988	289.0	34.8	<p>SCH (core pressure &lt; 988 hPa) crossed West Bengal and Bangladesh coast 50 kms east of Sagar islands on 29 November afternoon.</p> <p>Details:</p> <table border="0"> <tr> <td>22 Nov</td> <td>LP</td> <td>06.5 N / 98.5 E</td> <td>&lt; 1008</td> </tr> <tr> <td>23 Nov</td> <td>D</td> <td>09.8 N / 95.0 E</td> <td>&lt; 1008</td> </tr> <tr> <td>24 Nov</td> <td>DD</td> <td>10.0 N / 94.0 E</td> <td>&lt; 1008</td> </tr> <tr> <td>25 Nov</td> <td>CS</td> <td>11.5 N / 92.0 E</td> <td>&lt; 998</td> </tr> <tr> <td>26 Nov</td> <td>SCS</td> <td>12.0 N / 86.5 E</td> <td>&lt; 996</td> </tr> <tr> <td>27 Nov</td> <td>SCH</td> <td>13.5 N / 87.0 E</td> <td>&lt; 988</td> </tr> <tr> <td>28 Nov</td> <td>SCH</td> <td>16.0 N / 87.0 E</td> <td>&lt; 988</td> </tr> <tr> <td>29 Nov</td> <td>SCH</td> <td>19.5 N / 88.0 E</td> <td>&lt; 1000</td> </tr> <tr> <td>30 Nov</td> <td>LP</td> <td>Over Assam and Meghalaya</td> <td></td> </tr> </table>	22 Nov	LP	06.5 N / 98.5 E	< 1008	23 Nov	D	09.8 N / 95.0 E	< 1008	24 Nov	DD	10.0 N / 94.0 E	< 1008	25 Nov	CS	11.5 N / 92.0 E	< 998	26 Nov	SCS	12.0 N / 86.5 E	< 996	27 Nov	SCH	13.5 N / 87.0 E	< 988	28 Nov	SCH	16.0 N / 87.0 E	< 988	29 Nov	SCH	19.5 N / 88.0 E	< 1000	30 Nov	LP	Over Assam and Meghalaya		<p>This was one of the super storms that affected the Indian Coast. The lowest estimated core pressure was 942 hPa at 1730 hrs of 29 November however Sagar island lighthouse recorded 990 hPa as the lowest.</p>
22 Nov	LP	06.5 N / 98.5 E	< 1008																																					
23 Nov	D	09.8 N / 95.0 E	< 1008																																					
24 Nov	DD	10.0 N / 94.0 E	< 1008																																					
25 Nov	CS	11.5 N / 92.0 E	< 998																																					
26 Nov	SCS	12.0 N / 86.5 E	< 996																																					
27 Nov	SCH	13.5 N / 87.0 E	< 988																																					
28 Nov	SCH	16.0 N / 87.0 E	< 988																																					
29 Nov	SCH	19.5 N / 88.0 E	< 1000																																					
30 Nov	LP	Over Assam and Meghalaya																																						

## Annexure- II

Vishakhapatnam

17° 41' N 83°17' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
28 September, 1974	194.0	42.6	CS (core pressure < 992 hPa) crossed Orissa coast close to and south of Paradip on 28 evening. Details: 24 Sep LP 14.2 N / 94.7 E < 1007 25 Sep LP 13.2 N / 90.0 E < 1000 26 Sep D 16.2 N / 92.2 E < 1002 27 Sep CS 17.5 N / 88.5 E < 1000 28 Sep CS 19.0 N / 87.2 E < 998 29 Sep CS 22.2 N / 86.6 E < 994 30 Sep DD 25.0 N / 88.0 E < 1000	Paradip reported 989 hPa at 1930 hrs of 28 September.
8 October, 1974	190.0	56.6	DD (core pressure < 1004 hPa) crossed Andhra coast near Vishakhapatnam on 8 October evening. Details: 5 Oct LP 17.0 N / 87.0 E < 1006 6 Oct LP 13.5 N / 90.5 E < 1008 7 Oct DD 16.5 N / 86.0 E < 1004 8 Oct DD 17.2 N / 84.2 E < 1004 9 Oct LP 17.6 N / 79.5 E < 1004	
14 October, 1974	232.0	59.5	DD (core pressure < 1002 hPa) crossed Andhra coast between Vishakhapatnam and Kakinada during the early morning of 15 October. Details: 10 Oct LP 14.0 N / 94.0 E < 1009 11 Oct D 16.0 N / 92.0 E < 1004 12 Oct D 17.5 N / 90.5 E < 1004 13 Oct D 17.5 N / 87.5 E < 1004 14 Oct DD 17.5 N / 86.5 E < 1002 15 Oct DD 18.5 N / 81.5 E < 1004	

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
18 August, 1975	168.0	-9.2	DD (core pressure < 994 hPa) crossed west Bengal coast near Sagar islands on 18 August forenoon. Details: 16 Aug LP 20.2 N / 89.0 E < 1000 17 Aug D 20.0 N / 89.3 E < 1000 18 Aug DD 21.5 N / 87.8 E < 994 19 Aug DD 23.8 N / 86.0 E < 996	A negative surge.
9 September, 1975	202.0	7.75	D (core pressure < 996 hPa) crossed Orissa coast between Paradip and Puri on 9 September evening. Details: 7 Sep LP 21.5 N / 87.5 E < 1002 8 Sep LP 18.6 N / 86.0 E < 1000 9 Sep D 19.1 N / 86.0 E < 997 10 Sep D 21.2 N / 83.5 E < 996	
2 November, 1975	252.0	60.1	CS (core pressure < 1006 hPa) crossed Andhra coast on 3 November. Details: 30 Oct LP 12.0 N / 88.5 E < 1009 31 Oct LP 13.5 N / 87.0 E < 1006 1 Nov D 15.0 N / 84.5 E < 1008 2 Nov CS 15.5 N / 83.0 E < 1006 3 Nov LP 14.8 N / 81.5 E < 1006	The estimated pressure at the center of the storm is about 1000 hPa.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
9 November, 1975	200.0	53.5	DD (core pressure < 1004 hPa) crossed Bangladesh coast near Chittagong on 11 November night. Details: 5 Nov LP 12.0 N / 95.0 E < 1010 6 Nov LP 11.0 N / 89.5 E < 1008 7 Nov D 11.5 N / 88.5 E < 1006 8 Nov CS 13.8 N / 84.2 E < 1004 9 Nov CS 17.5 N / 84.5 E < 1004 10 Nov DD 17.0 N / 86.5 E < 1004 11 Nov DD 21.0 N / 89.5 E < 1004 12 Nov LP 22.5 N / 93.0 E < 1010	The cyclonic storm weakened into a DD by the morning of 10 November.
27 November, 1975	197.0	44.2	SCS (core pressure < 1002 hPa) passed off Tamilnadu coast during 24 November to 1 December. Details: 23 Nov LP South East Bay < 1010 24 Nov DD 09.0 N / 84.5 E < 1006 25 Nov CS 11.2 N / 82.0 E < 1002 26 Nov SCS 12.5 N / 81.0 E < 1004 27 Nov CS 14.0 N / 82.0 E < 1004 28 Nov CS 14.0 N / 84.0 E < 1004 29 Nov CS 15.5 N / 86.8 E < 1004 30 Nov D 18.0 N / 91.2 E < 1006 1 Dec D 14.0 N / 87.0 E < 1006	The SCS weakened and diffused over the central Bay.
13 August, 1976	137.0	-11.23	DD (core pressure < 994 hPa) crossed Orissa coast between Balasore and Contai on the early morning of 13 August. Details: 11 Aug LP 21.5 N / 89.5 E < 998 12 Aug D 20.5 N / 89.0 E < 996 13 Aug DD 22.1 N / 87.0 E < 994	A negative surge.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
19 October, 1976	154.0	30.4	CS (core pressure < 1000 hPa) crossed Bangladesh coast near Chittagong in the early hours of 21 October. Details: 12 Oct LP 08.5 N / 88.5 E < 1010 13 Oct D 10.5 N / 84.0 E < 1010 14 Oct DD 08.0 N / 90.0 E < 1009 15 Oct DD 09.0 N / 85.4 E < 1004 16 Oct CS 12.3 N / 83.0 E < 1000 17 Oct DD 13.5 N / 80.7 E < 1000 18 Oct CS 14.8 N / 81.0 E < 1000 19 Oct CS 16.0 N / 85.0 E < 1000 20 Oct CS 20.0 N / 88.0 E < 1000 21 Oct CS 23.0 N / 92.5 E < 1000	
4 November, 1976	170.0	40.5	SCS (core pressure < 1004 hPa) crossed coast just North of Machilipatnam around 2030 hrs on 4 November.  Details: 3 Nov D 13.0 N / 87.5 E < 1009 4 Nov DD 15.0 N / 84.0 E < 1004 5 Nov SCS 17.2 N / 79.0 E < 1006	A cyclone of narrow core (less than a degree in diameter). Lowest pressure of 985 hPa was recorded at Machilipatnam was recorded at 2100 hrs of 4 November.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
25 November, 1976	176.0	1.09	D/CS (core pressure < 996 hPa) skirted Andhra coast upto 27, then moved North eastwards to Arakan coast and weakened on 30 November morning. Details: 22 Nov LP 07.0 N / 91.5 E < 1006 23 Nov DD 09.0 N / 88.2 E < 1004 24 Nov DD 10.0 N / 84.0 E < 1000 25 Nov DD 13.6 N / 80.5 E < 996 26 Nov DD 14.0 N / 80.2 E < 1006 27 Nov CS 16.3 N / 82.2 E < 1004 28 Nov DD 18.0 N / 87.0 E 29 Nov DD North West Bay	The D seems to have become CS on 27 morning for a short time.
13 May, 1977	126.0	20.6	SCS (core pressure < 994 hPa) crossed Bangladesh coast on 13 May morning. Details: 9 May LP 08.2 N / 85.0 E < 1006 10 May D 10.2 N / 83.5 E < 1004 11 May D 15.4 N / 86.5 E < 998 12 May CS 19.5 N / 89.4 E < 994 13 May SCS 22.5 N / 90.6 E < 994	
25 July, 1977	158.0	33.4	D (core pressure < 994 hPa) crossed Orissa coast near Balasore on 24 July night. Details: 23 Jul LP 19.5 N / 87.0 E < 996 24 Jul D 20.0 N / 88.0 E < 994 25 Jul D 22.0 N / 85.5 E < 994 26 Jul D 23.6 N / 82.0 E < 994	

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
30 October, 1977	174.0	38.5	SCS crossed south Andhra coast between Nellore and Ongole around noon of 31 October. Details: 27 Oct D 13.0 N / 91.5 E 28 Oct D 29 Oct CS 30 Oct CS 31 Oct SCS 15.0 N / 81.0 E	This emerged into the Arabian sea off Maharashtra coast as a LP.
18 November, 1977	150.0	44.8	SCH (core pressure < 960 hPa) crossed coast near Nizampatnam at about 1730 hrs of 19 November.  Details: 13 Nov LP 07.0 N / 95.0 E < 1010 14 Nov DD 06.0 N / 92.0 E < 1008 15 Nov CS 06.8 N / 90.0 E < 1000 16 Nov SCH 06.6 N / 85.4 E < 1000 17 Nov SCH 10.0 N / 85.0 E < 960 18 Nov SCH 12.5 N / 82.5 E < 960 19 Nov SCH 15.2 N / 81.2 E < 970 20 Nov LP Over Telangana < 1004	Interacted with another SCS in the Arabian sea. They turned cyclonically around each other. Lowest pressure recorded in the 'eye' was 941 hPa. This is the infamous '1977 Andhra cyclone'. The tide guage at Chennai did not function after 17 November 1977.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
17 May, 1978	174.0	28.9	SCH (core pressure < 992 hPa) crossed Burma coast on 17 May in the evening. Details: 13 May LP South east Bay 14 May DD 10.5 N / 88.5 E < 1000 15 May CS 13.5 N / 91.2 E < 994 16 May CS 16.1 N / 92.0 E < 992 17 May SCH 18.2 N / 92.2 E < 992 18 May LP Over Burma	
17 June, 1978	167.0	33.2	DD (core pressure < 994 hPa) crossed coast south of Vishakhapatnam on 17 June afternoon. Details: 15 Jun LP 16.6 N / 85.6 E < 1001 16 Jun D 17.0 N / 86.0 E < 998 17 Jun DD 17.2 N / 84.2 E < 994 18 Jun LP 20.5 N / 81.5 E < 998	
15 August, 1978	171.0	37.8	DD (core pressure < 988 hPa) crossed Orissa coast between Gopalpur and Puri on 15 May afternoon. Details: 12 Aug LP 21.0 N / 89.4 E < 997 13 Aug D 19.5 N / 89.0 E < 994 14 Aug DD 19.2 N / 87.7 E < 992 15 Aug DD 19.2 N / 87.2 E < 988 16 Aug DD Near Mandla (U.P) < 994	



Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
28 August, 1978	108.0	-18.1	CS (core pressure < 990 hPa) crossed North Orissa coast between Chandbali and Balasore by about noon on 27 August.  Details: 25 Aug LP 19.8 N / 89.5 E < 1000 26 Aug DD 20.0 N / 89.0 E < 992 27 Aug CS 21.2 N / 87.5 E < 990 28 Aug DD 21.5 N / 82.8 E < 992	A negative surge. Balasore recorded 985.4 hPa at 0930 hrs on 27 August near the storm center.
18 November, 1978	160.0	35.5	SCH (core pressure < 996 hPa) crossed SriLanka coast on 23 night. Crossed Tamilnadu coast near Rameshwaram on 24 November evening.  Details: 17 Nov D 06.5 N / 92.5 E < 1008 18 Nov LP 06.5 N / 92.0 E < 1008 19 Nov LP 07.0 N / 92.0 E < 1008 20 Nov CS 08.0 N / 91.0 E < 1008 21 Nov SCH 07.5 N / 88.5 E < 1002 22 Nov SCH 07.5 N / 86.0 E < 1000 23 Nov SCH 08.0 N / 83.5 E < 998 24 Nov SCH 08.7 N / 80.5 E < 996 25 Nov DD 11.5 N / 75.0 E < 1006	Pamban observatory reported lowest pressure of 993.4 hPa at 0345 hrs on 25 November. Emerged into the Arabian sea off Kerala coast as DD on 25 November morning.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
12 May, 1979	180.0	24.9	SCS crossed Andhra coast south of Ongole by the evening of 12 May.	This is the first time during the last 100 yrs that in the month of May an SCH formed at such a low latitude and also very heavy rain along and to the left of it's track is noteworthy. Nellore recorded the lowest pressure of about 980 hPa on 12 May evening.
			No details available.	
2 July, 1979	112.0	-15.5	DD (core pressure < 986 hPa) crossed Bangladesh coast on 28 June at night. Details: 28 Jun     D            21.5 N / 90.0 E            < 992 29 Jun     D            22.5 N / 89.8 E            < 988 30 Jun     DD            24.0 N / 90.2 E            < 986 01 Jul     DD            25.0 N / 91.0 E            < 988	A negative surge.
7 August, 1979	148.0	-30.4	SCS (core pressure < 980 hPa) crossed Orissa coast near Balasore in the early night of 7 August.  Details: 5 Aug     LP            22.1 N / 90.0 E            < 996 6 Aug     D            21.0 N / 90.0 E            < 990 7 Aug     SCS          21.5 N / 87.5 E            < 980 8 Aug     SCS          22.3 N / 85.0 E            < 984	A negative surge. Balasore recorded the lowest MSL pressure of 970 hPa at 2100 hrs of 7 August.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
18 October, 1980	164.0	46.4	CS (core pressure < 1000 hPa) crossed Andhra Coast between Machilipatnam and Kakinada on 18 October morning.  Details: 15 Oct LP 10.0 N / 88.0 E < 1009 16 Oct D 10.0 N / 88.0 E < 1006 17 Oct CS 14.5 N / 82.5 E < 1000 18 Oct CS 16.2 N / 81.7 E < 1000 19 Oct D 16.8 N / 81.5 E < 1004	This was only a border case of a cyclone. Machilipatnam reported the lowest pressure of 997.4 hPa at 0430 of 18 October.
7 August, 1981	153.0	30.4	CS (core pressure < 982 hPa) crossed Orissa coast close to and North of Puri on 8 August in the Morning. Details 5 Aug LP 19.5 N / 87.5 E < 996 6 Aug LP 20.5 N / 88.5 E < 996 7 Aug DD 19.0 N / 88.0 E < 992 8 Aug CS 20.0 N / 86.0 E < 982 9 Aug CS 22.0 N / 81.2 E < 990	
20 November, 1981	178.0	40.8	SCS (core pressure < 994 hPa) weakened into a D by 20 November evening and dissipated <i>in situ</i> the next day. Details: 16 Nov D 11.0 N / 93.0 E < 1009 17 Nov DD 12.0 N / 91.5 E < 1002 18 Nov CS 13.5 N / 90.0 E < 1000 19 Nov SCS 16.0 N / 90.5 E < 994 20 Nov SCS 19.0 N / 92.0 E < 998 21 Nov LP 17.5 N / 92.0 E < 1010	The estimated lowest pressure at the core of the storm is 983 hPa.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks																																				
10 December, 1981	187.0	27.9	<p>SCH (core pressure &lt; 992 hPa) crossed west Bengal coast near Sagar island around 1830 hrs of 10 December.</p> <p>Details:</p> <table> <tr> <td>3 Dec</td> <td>LP</td> <td>07.0 N / 90.0 E</td> <td>&lt; 1010</td> </tr> <tr> <td>4 Dec</td> <td>D</td> <td>09.0 N / 92.0 E</td> <td>&lt; 1011</td> </tr> <tr> <td>5 Dec</td> <td>DD</td> <td>10.0 N / 88.0 E</td> <td>&lt; 1008</td> </tr> <tr> <td>6 Dec</td> <td>DD</td> <td>11.0 N / 88.0 E</td> <td>&lt; 1004</td> </tr> <tr> <td>7 Dec</td> <td>CS</td> <td>12.0 N / 85.2 E</td> <td>&lt; 992</td> </tr> <tr> <td>8 Dec</td> <td>SCS</td> <td>13.5 N / 86.0 E</td> <td>&lt; 992</td> </tr> <tr> <td>9 Dec</td> <td>SCH</td> <td>16.0 N / 86.4 E</td> <td>&lt; 992</td> </tr> <tr> <td>10 Dec</td> <td>SCH</td> <td>19.5 N / 97.0 E</td> <td>&lt; 994</td> </tr> <tr> <td>11 Dec</td> <td>D</td> <td>24.2 N / 90.4 E</td> <td>&lt; 1008</td> </tr> </table>	3 Dec	LP	07.0 N / 90.0 E	< 1010	4 Dec	D	09.0 N / 92.0 E	< 1011	5 Dec	DD	10.0 N / 88.0 E	< 1008	6 Dec	DD	11.0 N / 88.0 E	< 1004	7 Dec	CS	12.0 N / 85.2 E	< 992	8 Dec	SCS	13.5 N / 86.0 E	< 992	9 Dec	SCH	16.0 N / 86.4 E	< 992	10 Dec	SCH	19.5 N / 97.0 E	< 994	11 Dec	D	24.2 N / 90.4 E	< 1008	The lowest pressure recorded at Sagar was 983.5 hPa at 1745 hrs on 10 August.
3 Dec	LP	07.0 N / 90.0 E	< 1010																																					
4 Dec	D	09.0 N / 92.0 E	< 1011																																					
5 Dec	DD	10.0 N / 88.0 E	< 1008																																					
6 Dec	DD	11.0 N / 88.0 E	< 1004																																					
7 Dec	CS	12.0 N / 85.2 E	< 992																																					
8 Dec	SCS	13.5 N / 86.0 E	< 992																																					
9 Dec	SCH	16.0 N / 86.4 E	< 992																																					
10 Dec	SCH	19.5 N / 97.0 E	< 994																																					
11 Dec	D	24.2 N / 90.4 E	< 1008																																					
2 May, 1982	113	-7.5	<p>SCH (core pressure &lt; 994 hPa) crossed Arakan coast around midnight of 4 May.</p> <p>Details:</p> <table> <tr> <td>1 May</td> <td>D</td> <td>14.0 N / 82.5 E</td> <td>&lt; 1009</td> </tr> <tr> <td>2 May</td> <td>CS</td> <td>16.5 N / 83.5 E</td> <td>&lt; 1004</td> </tr> <tr> <td>3 May</td> <td>SCH</td> <td>17.5 N / 86.5 E</td> <td>&lt; 996</td> </tr> <tr> <td>4 May</td> <td>SCH</td> <td>18.5 N / 91.5 E</td> <td>&lt; 994</td> </tr> <tr> <td>5 May</td> <td>D</td> <td>Over Thailand</td> <td></td> </tr> </table>	1 May	D	14.0 N / 82.5 E	< 1009	2 May	CS	16.5 N / 83.5 E	< 1004	3 May	SCH	17.5 N / 86.5 E	< 996	4 May	SCH	18.5 N / 91.5 E	< 994	5 May	D	Over Thailand		A negative surge.																
1 May	D	14.0 N / 82.5 E	< 1009																																					
2 May	CS	16.5 N / 83.5 E	< 1004																																					
3 May	SCH	17.5 N / 86.5 E	< 996																																					
4 May	SCH	18.5 N / 91.5 E	< 994																																					
5 May	D	Over Thailand																																						
19 July, 1982	176.0	25.1	<p>DD (core pressure &lt; 992 hPa) crossed Orissa coast between Gopalpur and Puri by early night on 19 July.</p> <p>Details:</p> <table> <tr> <td>17 Jul</td> <td>LP</td> <td>16.6 N / 89.8 E</td> <td>&lt; 998</td> </tr> <tr> <td>18 Jul</td> <td>D</td> <td>18.4 N / 88.5 E</td> <td>&lt; 992</td> </tr> <tr> <td>19 Jul</td> <td>DD</td> <td>18.7 N / 86.5 E</td> <td>&lt; 994</td> </tr> <tr> <td>20 Jul</td> <td>D</td> <td>21.0 N / 83.3 E</td> <td>&lt; 996</td> </tr> </table>	17 Jul	LP	16.6 N / 89.8 E	< 998	18 Jul	D	18.4 N / 88.5 E	< 992	19 Jul	DD	18.7 N / 86.5 E	< 994	20 Jul	D	21.0 N / 83.3 E	< 996																					
17 Jul	LP	16.6 N / 89.8 E	< 998																																					
18 Jul	D	18.4 N / 88.5 E	< 992																																					
19 Jul	DD	18.7 N / 86.5 E	< 994																																					
20 Jul	D	21.0 N / 83.3 E	< 996																																					

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
10 September, 1982	166.0	40.0	D (core pressure < 998 hPa) crossed Orissa coast near Puri on 10 morning. Details: 8 Sep LP 18.0 N / 88.0 E < 1002 9 Sep D 18.0 N / 89.0 E < 998 10 Sep D 20.3 N / 85.0 E < 998	
*16 October, 1982 and **18 October, 1982	186.0	36.5	*LP crossed North Andhra coast just south of Kakinada in the early morning of 17 October. **SCS (core pressure < 1004 hPa) crossed south Andhra coast near Sriharikota around 2200 hrs of 18 October.  Details: *14 Oct LP 13.0 N / 91.5 E < 1012 *15 Oct DD 15.5 N / 86.5 E < 1008 *16 Oct SCS 16.0 N / 83.0 E < 1002 *17 Oct LP 16.0 N / 78.5 E < 1008 **17 Oct D 11.0 N / 84.0 E < 1008 **18 Oct SCS 13.1 N / 81.2 E < 1002 **19 Oct DD 14.8 N / 79.0 E < 1005	Two events around the same period of Surge. *A narrow core system. SCS weakened to a LP. **Lowest pressure of 982.8 hPa was recorded at Sriharikota at 2000 hrs on 18 October. A narrow core system.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
25 June, 1983	166.0	23.5	DD (core pressure < 994 hPa) crossed south Orissa coast near Gopalpur on the forenoon of 25 June. Details: 23 Jun LP 18.5 N / 87.5 E < 999 24 Jun DD 18.0 N / 85.6 E < 996 25 Jun DD 19.0 N / 85.4 E < 994 26 Jun D 20.3 N / 84.0 E < 994	
4 October, 1983	198.0	53.1	CS (core pressure < 996 hPa) crossed north Andhra coast around 0100 hrs of 4 October. Details: 1 Oct LP 17.5 N / 88.0 E < 1004 2 Oct D 19.5 N / 86.5E < 998 3 Oct CS 18.0 N / 84.0 E < 996 4 Oct CS 17.8 N / 83.0 E < 996 5 Oct LP 17.5 N / 80.5 E < 998	Lowest pressure recorded at Vishakhapatnam was 989.5 hPa at 2000 hrs.
15 August, 1984	176.0	19.4	DD (core pressure < 992 hPa) crossed North Orissa coast near Balasore on 16 morning. Details: 13 Aug LP 19.5 N / 90.5 E < 998 14 Aug LP 20.0 N / 90.0 E < 996 15 Aug D 20.0 N / 90.0 E < 992 16 Aug DD 21.5 N / 87.0 E < 992 17 Aug DD 23.0 N / 84.0 E < 994	Balasore reported a MSL pressure of 989.6 hPa at the time of landfall.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks																				
14 October, 1984	183.0	40.6	<p>SCH (core pressure &lt; 1000 hPa) crossed Orissa coast near Chandbali on the forenoon of 14 October.</p> <p>Details:</p> <table> <tr> <td>11 Oct</td> <td>LP</td> <td>18.0 N / 88.5 E</td> <td>&lt; 1006</td> </tr> <tr> <td>12 Oct</td> <td>LP</td> <td>19.0 N / 88.5 E</td> <td>&lt; 1006</td> </tr> <tr> <td>13 Oct</td> <td>SCS</td> <td>19.5 N / 88.0 E</td> <td>&lt; 1000</td> </tr> <tr> <td>14 Oct</td> <td>SCH</td> <td>20.7 N / 86.8 E</td> <td>&lt; 1000</td> </tr> <tr> <td>15 Oct</td> <td>DD</td> <td>22.5 N / 85.0 E</td> <td>&lt; 1006</td> </tr> </table>	11 Oct	LP	18.0 N / 88.5 E	< 1006	12 Oct	LP	19.0 N / 88.5 E	< 1006	13 Oct	SCS	19.5 N / 88.0 E	< 1000	14 Oct	SCH	20.7 N / 86.8 E	< 1000	15 Oct	DD	22.5 N / 85.0 E	< 1006	This system very rapidly intensified into a hurricane from Depression stage within twelve hours. Paradip reported a pressure of 996.1 hPa at 0830 hrs on 14 October.
11 Oct	LP	18.0 N / 88.5 E	< 1006																					
12 Oct	LP	19.0 N / 88.5 E	< 1006																					
13 Oct	SCS	19.5 N / 88.0 E	< 1000																					
14 Oct	SCH	20.7 N / 86.8 E	< 1000																					
15 Oct	DD	22.5 N / 85.0 E	< 1006																					
25 May, 1985	166.0	33.0	<p>SCS (core pressure &lt; 980 hPa) crossed Bangladesh coast near Hatia in the early hours of 25 May.</p> <p>Details:</p> <table> <tr> <td>22 May</td> <td>D</td> <td>15.5 N / 88.0 E</td> <td>&lt; 998</td> </tr> <tr> <td>23 May</td> <td>DD</td> <td>16.5 N / 87.5 E</td> <td>&lt; 994</td> </tr> <tr> <td>24 May</td> <td>SCS</td> <td>19.0 N / 89.0 E</td> <td>&lt; 980</td> </tr> <tr> <td>25 May</td> <td>SCS</td> <td>23.0 N / 91.5 E</td> <td>&lt; 986</td> </tr> </table>	22 May	D	15.5 N / 88.0 E	< 998	23 May	DD	16.5 N / 87.5 E	< 994	24 May	SCS	19.0 N / 89.0 E	< 980	25 May	SCS	23.0 N / 91.5 E	< 986	Caused high tidal waves of 4.5 meters.				
22 May	D	15.5 N / 88.0 E	< 998																					
23 May	DD	16.5 N / 87.5 E	< 994																					
24 May	SCS	19.0 N / 89.0 E	< 980																					
25 May	SCS	23.0 N / 91.5 E	< 986																					
6 August, 1985	120.0	-15.1	<p>D (core pressure &lt; 994 hPa) crossed west Bengal coast near Sagar Island around noon on 6 August.</p> <p>Details:</p> <table> <tr> <td>4 Aug</td> <td>LP</td> <td>22.5 N / 89.5 E</td> <td>&lt; 1004</td> </tr> <tr> <td>5 Aug</td> <td>LP</td> <td>21.5 N / 88.5 E</td> <td>&lt; 1000</td> </tr> <tr> <td>6 Aug</td> <td>D</td> <td>21.0 N / 88.0 E</td> <td>&lt; 996</td> </tr> <tr> <td>7 Aug</td> <td>D</td> <td>22.5 N / 84.0 E</td> <td>&lt; 994</td> </tr> </table>	4 Aug	LP	22.5 N / 89.5 E	< 1004	5 Aug	LP	21.5 N / 88.5 E	< 1000	6 Aug	D	21.0 N / 88.0 E	< 996	7 Aug	D	22.5 N / 84.0 E	< 994	A negative surge.				
4 Aug	LP	22.5 N / 89.5 E	< 1004																					
5 Aug	LP	21.5 N / 88.5 E	< 1000																					
6 Aug	D	21.0 N / 88.0 E	< 996																					
7 Aug	D	22.5 N / 84.0 E	< 994																					

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
11 October, 1985	184.0	53.5	CS (core pressure < 998 hPa) crossed North Andhra coast near Vishakhapatnam in the early hours of 11 October. Details: 8 Oct LP 13.5 N / 90.5 E < 1006 9 Oct D 12.5 N / 90.0 E < 1006 10 Oct D 16.0 N / 85.5 E < 998 11 Oct CS 18.0 N / 82.0 E < 1000 12 Oct DD 20.5 N / 80.0 E < 1002	Vishakhapatnam recorded the lowest pressure 994.2 hPa at 0330 hrs of 11 October.
16 October, 1985	208.0	34.4	SCS (core pressure < 994 hPa) crossed Orissa coast near Balasore in the early hours of 16 October. Details: 13 Oct LP 14.0 N / 95.0 E < 1006 14 Oct DD 16.0 N / 89.5 E < 1002 15 Oct SCS 19.5 N / 87.5 E < 994 16 Oct CS 21.2 N / 87.0 E < 996 17 Oct CS 24.5 N / 85.5 E < 998	Lowest Pressure at Balasore 987.8 hPa at 0330 hours of 16 October. Tidal waves of 1.5 to 2 mts height were reported from Balasore district.
12 August, 1986	189.0	70.4	DD (core pressure < 992 hPa) crossed North Andhra coast near Kalingapatnam in the night of 12 August. Details: 9 Aug LP 18.5 N / 85.0 E <1000 10 Aug LP 17.5 N / 87.5 E < 998 11 Aug DD 18.0 N / 86.5 E < 994 12 Aug DD 18.0 N / 84.5 E < 992 13 Aug DD 19.5 N / 83.5 E < 992	985.2 hPa at Kalingapatnam at 1730 hrs of 12 August was the lowest pressure recorded.



Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
9 November, 1986	164.0	27.9	CS (core pressure < 1000 hPa) crossed Bangladesh coast in the forenoon of 9 November. Details: 6 Nov LP 12.5 N / 84.0 E < 1009 7 Nov D 14.0 N / 82.0 E < 1004 8 Nov D 18.0 N / 85.5 E < 1002 9 Nov CS 22.0 N / 89.5 E < 1000 10 Nov D Over Bangladesh < 1010	990 hPa was recorded at Paradip at 2000 hrs of 8 November.
16 October, 1987	132.0	35.4	CS (core pressure < 1000 hPa) crossed Andhra coast just north of Ongole on 16 October morning. Details: 13 Oct LP 10.0 N / 92.0 E < 1010 14 Oct D 13.0 N / 87.5 E < 1006 15 Oct CS 14.5 N / 83.5 E < 1000 16 Oct DD 15.8 N / 79.5 E < 1008	Ongole reported The lowest pressure of 995.1 hPa at 0730 hrs on 16 October.
3 November, 1987	172.0	39.0	SCS (core pressure < 996 hPa) crossed south Andhra coast just North of Nellore in the early hours of 3 November.  Details: 31 Oct D 11.5 N / 86.0 E < 1006 1 Nov CS 14.0 N / 84.5 E < 1002 2 Nov SCS 13.5 N / 82.0 E < 996 3 Nov CS 14.9 N / 79.5 E < 1000 4 Nov LP 15.0 N / 76.5 E < 1000	Nellore recorded the lowest pressure of 984.3 hPa at the time of landfall. The remnant of the system entered the Arabian sea to become SCH later.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
13 November, 1987	190.0	70.1	<p>SCS (core pressure &lt;1000 hPa) crossed South Andhra coast just south of Machilipatnam in the early hours of 13 November.</p> <p>Details:</p> <p>9 Nov LP 10.0 N / 94.0 E &lt; 1008  10 Nov LP 12.0 N / 90.0 E &lt; 1006  11 Nov DD 13.0 N / 92.0 E &lt; 1006  12 Nov CS 14.5 N / 84.5 E &lt; 1000  13 Nov DD 16.0 N / 80.6 E &lt; 1002</p>	Machilipatnam recorded the lowest pressure of 994.8 hPa at the time of landfall. The remnant emerged into the Arabian sea and dissipated. The tide gauge did not function for about 2 days after the surge event.
17 July, 1988	174.0	25.4	<p>D (core pressure &lt; 993 hPa) crossed Orissa coast near Gopalpur in the night of 17 July.</p> <p>Details:</p> <p>15 Jul LP 19.0 N / 86.5 E &lt; 1002  16 Jul LP 18.5 N / 87.0 E &lt; 1000  17 Jul D 18.0 N / 86.0 E &lt; 994  18 Jul D 19.5 N / 83.5 E &lt; 993</p>	Gopalpur recorded the lowest pressure of 990.5 hPa at 0500 hrs of 18 July.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
29 November, 1988	186.0	34.9	<p>SCH (core pressure &lt; 988 hPa) crossed West Bengal and Bangladesh coast 50 kms east of Sagar islands on 29 November afternoon.</p> <p>Details:</p> <p>22 Nov LP 06.5 N / 98.5 E &lt; 1008</p> <p>23 Nov D 09.8 N / 95.0 E &lt; 1008</p> <p>24 Nov DD 10.0 N / 94.0 E &lt; 1008</p> <p>25 Nov CS 11.5 N / 92.0 E &lt; 998</p> <p>26 Nov SCS 12.0 N / 86.5 E &lt; 996</p> <p>27 Nov SCH 13.5 N / 87.0 E &lt; 988</p> <p>28 Nov SCH 16.0 N / 87.0 E &lt; 988</p> <p>29 Nov SCH 19.5 N / 88.0 E &lt; 1000</p> <p>30 Nov LP Over Assam and Meghalaya</p>	This was one of the super storms that affected the Indian Coast. The lowest estimated core pressure was 942 hPa at 1730 hrs of 29 November however Sagar island lighthouse recorded 990 hPa as the lowest.

## Annexure- II

Chennai

13° 06' N 80° 18' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
2 November, 1975	202.0	43.0	CS (core pressure < 1006 hPa) crossed Andhra coast on 3 November.  Details: 30 Oct LP 12.0 N / 88.5 E < 1009 31 Oct LP 13.5 N / 87.0 E < 1006 1 Nov D 15.0 N / 84.5 E < 1008 2 Nov CS 15.5 N / 83.0 E < 1006 3 Nov LP 14.8 N / 81.5 E < 1006	The estimated pressure at the center of the storm is about 1000 hPa.
27 November, 1975	166.0	33.4	SCS (core pressure < 1002 hPa) passed off Tamilnadu coast during 24 November to 1 December.  Details: 23 Nov LP South East Bay < 1010 24 Nov DD 09.0 N / 84.5 E < 1006 25 Nov CS 11.2 N / 82.0 E < 1002 26 Nov SCS 12.5 N / 81.0 E < 1004 27 Nov CS 14.0 N / 82.0 E < 1004 28 Nov CS 14.0 N / 84.0 E < 1004 29 Nov CS 15.5 N / 86.8 E < 1004 30 Nov D 18.0 N / 91.2 E < 1006 1 Dec D 14.0 N / 87.0 E < 1006	The SCS weakened and diffused over the central Bay.
2 November, 1976	139.0	23.3	SCS (core pressure < 1004 hPa) crossed coast just North of Machilipatnam around 2030 hrs on 4 November.  Details: 3 Nov D 13.0 N / 87.5 E < 1009 4 Nov DD 15.0 N / 84.0 E < 1004 5 Nov SCS 17.2 N / 79.0 E < 1006	A cyclone of narrow core (less than a degree in diameter). Lowest pressure of 985 hPa was recorded at Machilipatnam at 2100 hrs of 4 November.

Chennai

13° 06' N 80° 18' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
27 November, 1976	172.0	39.4	D/CS (core pressure < 996 hPa) skirted Andhra coast upto 27, then moved North eastwards to Arakan coast and weakened on 30 November morning. Details: 22 Nov LP 07.0 N / 91.5 E < 1006 23 Nov DD 09.0 N / 88.2 E < 1004 24 Nov DD 10.0 N / 84.0 E < 1000 25 Nov DD 13.6 N / 80.5 E < 996 26 Nov DD 14.0 N / 80.2 E < 1006 27 Nov CS 16.3 N / 82.2 E < 1004 28 Nov DD 18.0 N / 87.0 E 29 Nov DD North West Bay	The D seems to have become CS on 27 morning for a short time.
22 August, 1977	150.0	4.3	DD (core pressure < 996 hPa) crossed Orissa coast near Gopalpur on 22 August early morning. Details: 19 Aug D 19.0 N / 91.0 E < 1000 20 Aug DD 18.4 N / 89.6 E < 996 21 Aug DD 19.5 N / 87.0 E < 996 22 Aug DD 18.8 N / 85.0 E < 996 23 Aug DD 19.1 N / 82.2 E < 998	The pressure departure from normal at the core was about -12.0 hPa.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
12 November, 1977	183.0	36.4	SCS (core pressure < 1000 hPa) crossed Tamilnadu coast just South of Nagapattinam in the early morning of 12 November.  Details: 8 Nov LP 08.0 N / 93.0 E < 1010 9 Nov D 08.0 N / 91.5 E < 1008 10 Nov CS 11.0 N / 87.5 E < 1000 11 Nov SCS 11.0 N / 82.3 E < 1000 12 Nov CS 10.9 N / 79.5 E < 1002	Later emerged into Lakshadweep as a DD. The eye had a diameter of 10 km. The estimated lowest sea level pressure is 979.0 hPa at the time of landfall.
15 August, 1978	144.0	-8.7	DD (core pressure < 988 hPa) crossed Orissa coast between Gopalpur and Puri on 15 May afternoon.  Details: 12 Aug LP 21.0 N / 89.4 E < 997 13 Aug D 19.5 N / 89.0 E < 994 14 Aug DD 19.2 N / 87.7 E < 992 15 Aug DD 19.2 N / 87.2 E < 988 16 Aug DD Near Mandla (U.P) < 994	A negative surge.
4 November, 1978	185.0	36.1	DD (core pressure < 1002 hPa) crossed Tamilnadu coast around noon of 4 November near Cuddalore.  Details: 3 Nov D 10.5 N / 82.0 E < 1004 4 Nov DD 12.5 N / 80.4 E < 1002	Weakened into a D; emerged into Arabian sea on 5 November.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
7 August, 1979	164.0	-22.0	SCS (core pressure < 980 hPa) crossed Orissa coast near Balasore in the early night of 7 August.  Details: 5 Aug LP 22.1 N / 90.0 E < 996 6 Aug D 21.0 N / 90.0 E < 990 7 Aug SCS 21.5 N / 87.5 E < 980 8 Aug SCS 22.3 N / 85.0 E < 984	A negative surge. Balasore recorded the lowest MSL pressure of 970 hPa at 2100 hrs of 7 August.
2 November, 1979	173.0	23.3	LP (core pressure < 1008 hPa) crossed north Tamilnadu coast by noon of 2 November.  Details: 29 Oct D 10.0 N / 89.5 E < 1010 30 Oct D 10.0 N / 86.5 E < 1008 31 Oct DD 12.0 N / 84.0 E < 1008 1 Nov DD 12.3 N / 81.5 E < 1006 2 Nov LP 12.5 N / 80.2 E < 1008	
24 November, 1979	180.0	36.8	CS (core pressure < 1000 hPa) crossed Tamilnadu Andhra coast near Sriharikota by about 1430 hrs on 25 November.  Details: 22 Nov LP < 1010 23 Nov D 08.5 N / 87.5 E < 1008 24 Nov CS 10.5 N / 83.5 E < 1000 25 Nov CS 13.4 N / 81.0 E < 1004 26 Nov LP 12.0 N / 74.2 E < 1011	The lowest MSL pressure recorded at Sriharikota was 1001.2 hPa at 1430 hrs on 25 November.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
5 December, 1980	160.0	27.3	CS (core pressure < 1002 hPa) passed off Tamilnadu coast about 5 December. Details: 2 Dec LP 07.0 N / 87.2 E < 1008 3 Dec D 09.4 N / 84.8 E < 1006 4 Dec DD 11.4 N / 83.0 E < 1004 5 Dec CS 13.5 N / 83.0 E < 1002 6 Dec CS 14.0 N / 84.0 E < 1006	Estimated pressure at the core was 998 hPa.
17 December, 1980	160.0	26.1	CS (core pressure < 1002 hPa) crossed SriLanka coast near Trincomalee on 17 December forenoon. Weakened into a depression, emerged into Gulf of Mannar on the same evening, and weakened further to a low over Comorin on 18 December morning. Details: 12 Dec D 10.5 N / 91.5 E < 1008 13 Dec DD 11.0 N / 93.5 E < 1006 14 Dec DD 10.5 N / 93.6 E < 1006 15 Dec DD 09.0 N / 91.0 E < 1006 16 Dec CS 08.5 N / 87.0 E < 1002 17 Dec CS 08.5 N / 81.5 E < 1002 18 Dec LP Over Comorin	The core pressure on 17 December morning is estimated to be about 998 hPa.
21 June, 1981	180.0	24.2	DD (core pressure < 988 hPa) crossed West Bengal coast near Contai on 21 June morning. 20 Jun D 21.0 N / 89.0 E < 992 21 Jun DD 22.5 N / 87.5 E < 988 22 Jun DD 22.5 N / 85.2 E < 990	



Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
26 September, 1981	162.0	12.0	SCS (core pressure < 992 hPa) crossed Orissa coast near Puri on the early morning of 26 September. Details: 24 Sep LP 17.0 N / 91.0 E < 1002 25 Sep CS 18.0 N / 88.5 E < 994 26 Sep SCS 20.5 N / 85.5 E < 992 27 Sep DD 22.8 N / 80.5 E < 998	Puri reported the lowest pressure of 983.1 hPa at 0530 hrs of 26 September.
2 November, 1981	180.0	33.3	D (core pressure < 1006 hPa) persisted off Tamilnadu coast for a few days and merged with the seasonal low over the Bay. Details: 31 Oct D 12.0 N / 87.5 E < 1009 1 Nov D 12.5 N / 86.0 E < 1006 2 Nov D 12.5 N / 84.0 E < 1009 3 Nov LP 12.5 N / 83.5 E < 1008 4 Nov LP 13.0 N / 84.0 E < 1009 5 Nov LP 14.5 N / 84.0 E < 1006	
18 October, 1982	186.0	38.8	SCS (core pressure < 1004 hPa) crossed south Andhra coast near Sriharikota around 2200 hrs of 18 October. Details: 17 Oct D 11.0 N / 84.0 E < 1008 18 Oct SCS 13.1 N / 81.2 E < 1004 19 Oct DD 14.8 N / 79.0 E < 1005	Lowest pressure of 982.8 hPa was recorded at Sriharikota at 2000 hrs on 18 October. A narrow core system.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
15 August, 1984	162.0	05.1	DD (core pressure < 992 hPa) crossed North Orissa coast near Balasore on 16 morning. Details: 13 Aug LP 19.5 N / 90.5 E < 998 14 Aug LP 20.0 N / 90.0 E < 996 15 Aug D 20.0 N / 90.0 E < 992 16 Aug DD 21.5 N / 87.0 E < 992 17 Aug DD 23.0 N / 84.0 E < 994	Balasore reported a MSL pressure of 989.6 hPa at the time of landfall.
14 November, 1984	206.0	57.2	SCS (core pressure < 998 hPa) crossed land near Sriharikota at about 0800 hrs on 14 November. Details: 9 Nov LP 09.0 N / 88.0 E < 1008 10 Nov DD 10.0 N / 86.0 E < 1002 11 Nov CS 10.5 N / 82.0 E < 998 12 Nov SCS 12.0 N / 80.8 E < 1002 13 Nov SCS 13.7 N / 80.5 E < 1004 14 Nov SCS 14.0 N / 80.2 E < 1006 15 Nov LP 14.0 N / 80.0 E < 1010	Sriharikota recorded lowest pressure 984.1 hPa at 0840 hrs on 14 November. Tide gauge did not function after the surge.
12 November, 1985	165.0	41.5	D (core pressure < 1004 hPa) formed and diffused off Tamilnadu coast on 12 November. Details: 11 Nov LP 11.5 N / 82.0 E < 1008 12 Nov D 12.5 N / 81.5 E < 1004 13 Nov LP 12.8 N / 81.5 E < 1008	Tide gauge break down on 15 November.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks																				
3 November, 1987	136.0	27.0	<p>SCS (core pressure &lt; 996 hPa) crossed south Andhra coast just North of Nellore in the early hours of 3 November.</p> <p>Details:</p> <table> <tr> <td>31 Oct</td> <td>D</td> <td>11.5 N / 86.0 E</td> <td>&lt; 1006</td> </tr> <tr> <td>1 Nov</td> <td>CS</td> <td>14.0 N / 84.5 E</td> <td>&lt; 1002</td> </tr> <tr> <td>2 Nov</td> <td>SCS</td> <td>13.5 N / 82.0 E</td> <td>&lt; 996</td> </tr> <tr> <td>3 Nov</td> <td>CS</td> <td>14.9 N / 79.5 E</td> <td>&lt; 1000</td> </tr> <tr> <td>4 Nov</td> <td>LP</td> <td>15.0 N / 76.5 E</td> <td>&lt; 1000</td> </tr> </table>	31 Oct	D	11.5 N / 86.0 E	< 1006	1 Nov	CS	14.0 N / 84.5 E	< 1002	2 Nov	SCS	13.5 N / 82.0 E	< 996	3 Nov	CS	14.9 N / 79.5 E	< 1000	4 Nov	LP	15.0 N / 76.5 E	< 1000	Nellore recorded the lowest pressure of 984.3 hPa at the time of landfall. The remnant of the system entered the Arabian sea to become SCH later.
31 Oct	D	11.5 N / 86.0 E	< 1006																					
1 Nov	CS	14.0 N / 84.5 E	< 1002																					
2 Nov	SCS	13.5 N / 82.0 E	< 996																					
3 Nov	CS	14.9 N / 79.5 E	< 1000																					
4 Nov	LP	15.0 N / 76.5 E	< 1000																					
12 November, 1987	124.0	38.1	<p>SCS (core pressure &lt;1000 hPa) crossed South Andhra coast just south of Machilipatnam in the early hours of 13 November.</p> <p>Details:</p> <table> <tr> <td>9 Nov</td> <td>LP</td> <td>10.0 N / 94.0 E</td> <td>&lt; 1008</td> </tr> <tr> <td>10 Nov</td> <td>LP</td> <td>12.0 N / 90.0 E</td> <td>&lt; 1006</td> </tr> <tr> <td>11 Nov</td> <td>DD</td> <td>13.0 N / 92.0 E</td> <td>&lt; 1006</td> </tr> <tr> <td>12 Nov</td> <td>CS</td> <td>14.5 N / 84.5 E</td> <td>&lt; 1000</td> </tr> <tr> <td>13 Nov</td> <td>DD</td> <td>16.0 N / 80.6 E</td> <td>&lt; 1002</td> </tr> </table>	9 Nov	LP	10.0 N / 94.0 E	< 1008	10 Nov	LP	12.0 N / 90.0 E	< 1006	11 Nov	DD	13.0 N / 92.0 E	< 1006	12 Nov	CS	14.5 N / 84.5 E	< 1000	13 Nov	DD	16.0 N / 80.6 E	< 1002	Machilipatnam recorded the lowest pressure of 994.8 hPa at the time of landfall. The remnant emerged into the Arabian sea and dissipated.
9 Nov	LP	10.0 N / 94.0 E	< 1008																					
10 Nov	LP	12.0 N / 90.0 E	< 1006																					
11 Nov	DD	13.0 N / 92.0 E	< 1006																					
12 Nov	CS	14.5 N / 84.5 E	< 1000																					
13 Nov	DD	16.0 N / 80.6 E	< 1002																					

## Annexure -II

Kochi

09° 58' N 76° 16' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
25 November, 1974	109.0	23.3	LP (core pressure < 1010 hPa) formed and dissipated on 25 November. Details: 25 Nov LP 09.0 N / 73.5 E < 1010	
29 May, 1975	109.0	11.2	DD (core pressure < 1004 hPa) crossed Maharashtra coast near Alibagh on May late evening. Details: 28 May LP 07.0 N / 75.0 E < 1006 29 May LP 07.2 N / 74.8 E < 1007 30 May DD 12.0 N / 71.0 E < 1006 31 May DD 16.3 N / 70.2 E < 1004	
12 October, 1976	78.0	-8.5	SCS weakened into a D on 17 October near Socotra and dissipated later.  Details: 11 Oct LP 08.0 N / 69.5 E < 1011 12 Oct LP 09.8 N / 70.2 E < 1010 13 Oct D 12.0 N / 69.0 E < 1008 14 Oct D 13.0 N / 66.0E < 1008	A negative surge. System became a CS on 14 evening, became SCS on 15 evening and later dissipated near Socotra.

Kochi

09° 58' N 76° 16' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks																																								
20 November, 1977	108.0	30.1	<p>CS (core pressure &lt; 1000 hPa) crossed the coast between Mangalore and Honavar in the early morning of 22 November.</p> <p>Details:</p> <table> <tr> <td>13 Nov</td> <td>DD</td> <td>11.0 N / 75.0 E</td> <td>&lt; 1006</td> </tr> <tr> <td>14 Nov</td> <td>CS</td> <td>12.0 N / 71.5 E</td> <td>&lt; 1002</td> </tr> <tr> <td>15 Nov</td> <td>SCS</td> <td>13.1 N / 69.3 E</td> <td>&lt; 1002</td> </tr> <tr> <td>16 Nov</td> <td>SCS</td> <td>13.8 N / 66.0 E</td> <td>&lt; 1002</td> </tr> <tr> <td>17 Nov</td> <td>SCH</td> <td>10.0 N / 84.0 E</td> <td>&lt; 960</td> </tr> <tr> <td>18 Nov</td> <td>SCH</td> <td>12.6 N / 82.5 E</td> <td>&lt; 960</td> </tr> <tr> <td>19 Nov</td> <td>SCS</td> <td>15.2 N / 81.0 E</td> <td>&lt; 960</td> </tr> <tr> <td>20 Nov</td> <td>SCS</td> <td>10.3 N / 71.5 E</td> <td>&lt; 1000</td> </tr> <tr> <td>21 Nov</td> <td>SCS</td> <td>11.5 N / 75.0 E</td> <td>&lt; 1000</td> </tr> <tr> <td>22 Nov</td> <td>DD</td> <td>14.5 N / 75.0 E</td> <td>&lt; 1004</td> </tr> </table>	13 Nov	DD	11.0 N / 75.0 E	< 1006	14 Nov	CS	12.0 N / 71.5 E	< 1002	15 Nov	SCS	13.1 N / 69.3 E	< 1002	16 Nov	SCS	13.8 N / 66.0 E	< 1002	17 Nov	SCH	10.0 N / 84.0 E	< 960	18 Nov	SCH	12.6 N / 82.5 E	< 960	19 Nov	SCS	15.2 N / 81.0 E	< 960	20 Nov	SCS	10.3 N / 71.5 E	< 1000	21 Nov	SCS	11.5 N / 75.0 E	< 1000	22 Nov	DD	14.5 N / 75.0 E	< 1004	The SCS, which crossed Tamilnadu coast on 12 November, merged into the Arabian sea on 13 as DD. This intensified to a SCS. Interacted with the cyclone in the Bay, made a loop and weakened to a CS in the early hours of 22 November before landfall. The estimated core pressure is 974 hPa.
13 Nov	DD	11.0 N / 75.0 E	< 1006																																									
14 Nov	CS	12.0 N / 71.5 E	< 1002																																									
15 Nov	SCS	13.1 N / 69.3 E	< 1002																																									
16 Nov	SCS	13.8 N / 66.0 E	< 1002																																									
17 Nov	SCH	10.0 N / 84.0 E	< 960																																									
18 Nov	SCH	12.6 N / 82.5 E	< 960																																									
19 Nov	SCS	15.2 N / 81.0 E	< 960																																									
20 Nov	SCS	10.3 N / 71.5 E	< 1000																																									
21 Nov	SCS	11.5 N / 75.0 E	< 1000																																									
22 Nov	DD	14.5 N / 75.0 E	< 1004																																									
6 June, 1980	97.0	-7.0	<p>D (core pressure &lt; 998 hPa) crossed North Maharashtra coast by 6 June afternoon.</p> <p>Details:</p> <table> <tr> <td>3 Jun</td> <td>LP</td> <td>14.5 N / 72.5 E</td> <td>&lt; 1004</td> </tr> <tr> <td>4 Jun</td> <td>D</td> <td>15.0 N / 70.5 E</td> <td>&lt; 1002</td> </tr> <tr> <td>5 Jun</td> <td>D</td> <td>16.5 N / 70.5 E</td> <td>&lt; 1002</td> </tr> <tr> <td>6 Jun</td> <td>D</td> <td>19.0 N / 72.0 E</td> <td>&lt; 998</td> </tr> </table>	3 Jun	LP	14.5 N / 72.5 E	< 1004	4 Jun	D	15.0 N / 70.5 E	< 1002	5 Jun	D	16.5 N / 70.5 E	< 1002	6 Jun	D	19.0 N / 72.0 E	< 998	A negative surge.																								
3 Jun	LP	14.5 N / 72.5 E	< 1004																																									
4 Jun	D	15.0 N / 70.5 E	< 1002																																									
5 Jun	D	16.5 N / 70.5 E	< 1002																																									
6 Jun	D	19.0 N / 72.0 E	< 998																																									

Kochi

09° 58' N 76° 16' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
19 December, 1980	112.0	22.0	CS from the Bay crossed SriLankan coast, emerged into southeast Arabian sea on 18 December. Details: 18 Dec LP 08.0 N / 75.5 E < 1008 19 Dec LP 08.0 N / 71.0 E < 1008 20 Dec LP 09.5 N / 69.0 E < 1010	
28 October, 1981	106.0	15.1	SCH (core pressure < 992 hPa) crossed Saurashtra coast close to Mangrol after midnight of 1 November. Details: 28 Oct LP 12.6 N / 71.5 E < 1008 29 Oct DD 12.0 N / 70.8 E < 1004 30 Oct CS 13.5 N / 68.0 E < 1002 31 Oct SCH 16.5 N / 68.0 E --- 1 Nov SCH 19.5 N / 69.5 E < 996 2 Nov SCS 22.2 N / 69.7 E < 992 3 Nov DD 27.0 N / 75.0 E < 1002	The estimated core pressure was 983 hPa.
9 August, 1983	102.0	-6.46	A land depression over Bangladesh on 4 August, traveled across India and emerged into Arabian sea on 9 August morning, intensified into a DD and crossed Oman coast around noon on 10 August. Details: 8 Aug D 21.7 N / 73.0 E < 994 9 Aug DD 22.5 N / 62.5 E < 994 10 Aug DD 21.5 N / 61.5 E < 988	A negative surge.
12 November, 1985	108.0	-11.7	LP (core pressure < 1006 hPa) formed and dissipated over sea. Details: 9 Nov LP 11.0 N / 73.0 E < 1010 10 Nov LP 08.0 N / 70.0 E < 1006 11 Nov LP 10.0 N / 69.0 E < 1007	A negative surge.

Kochi

09° 58' N 76° 16' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
8 November, 1986	94.0	15.7	DD (core pressure < 1004 hPa) dissipated over west central and adjoining southwest Arabian sea on 11 November. Details: 8 Nov LP 13.0 N / 71.0 E < 1006 9 Nov DD 13.0 N / 70.0 E < 1004 10 Nov DD 12.0 N / 66.0 E < 1008	LP persisting over east central Arabian sea since 1 November rapidly intensified to DD.
7 December, 1987	121.0	17.4	LP (core pressure < 1008 hPa) persisted off west coast of India for a long time and dissipated. Details: 5 Dec LP 09.0 N / 74.5 E < 1010 6 Dec LP 10.0 N / 74.0 E < 1008 7 Dec LP 08.5 N / 75.0 E < 1008 8 Dec LP 10.0 N / 73.0 E < 1010 9 Dec LP 10.5 N / 72.0 E < 1009	

## Annexure- II

Marmagao

15° 25' N 73° 48' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
31 May, 1975	216.0	23.4	DD (core pressure < 1004 hPa) crossed Maharashtra coast near Alibagh on 31 May late evening. Details: 28 May LP 07.0 N / 75.5 E < 1006 29 May LP 07.2 N / 74.8 E < 1007 30 May DD 12.0 N / 71.0 E < 1006 31 May DD 16.3 N / 70.2 E < 1004	
31 May, 1976	235.0	24.1	SCH (core pressure < 994 hPa) crossed Saurashtra near Mahuva on the morning of 3 June and again near port Cambay on 4 June morning. Details: 29 May LP 12.0 N / 70.0 E < 1006 30 May D 13.0 N / 71.0 E < 1002 31 May CS 14.2 N / 72.0 E < 1000 1 Jun SCS 17.0 N / 71.0 E < 996 2 Jun SCH 18.5 N / 71.0 E < 994 3 Jun SCH 20.5 N / 72.0 E < 996	Bhavnagar reported MSL pressure of 983.4 hPa at 2300 hrs on 3 June.
8 June, 1977	228.0	14.1	SCH (core pressure < 984 hPa) passed through Masirah island on 13 June morning and entered Oman. Details: 8 Jun LP 15.5 N / 71.5 E < 1004 9 Jun DD 16.5 N / 70.2 E < 1000 10 Jun CS 18.5 N / 69.3 E < 984 11 Jun SCH 19.7 N / 64.3 E < 984	Masirah at the time of landfall reported lowest pressure of 959.0 hPa.



Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks																																								
14 November, 1977 22 November, 1977	250.0 206.0	19.1 14.2	<p>The SCS (core pressure &lt; 960 hPa) from the Bay moved over the Peninsula and emerged into Lakshadweep on 13 November morning as a DD which became a SCS, interacted with another cyclone in the Bay, made a loop. Weakened into a CS and crossed the coast near Honavar in the early morning of 22 November.</p> <p>Details:</p> <table border="0"> <tr> <td>13 Nov</td> <td>DD</td> <td>11.0 N / 75.0 E</td> <td>&lt; 1006</td> </tr> <tr> <td>14 Nov</td> <td>CS</td> <td>12.0 N / 71.5 E</td> <td>&lt; 1002</td> </tr> <tr> <td>15 Nov</td> <td>SCS</td> <td>13.1 N / 69.3 E</td> <td>&lt; 1002</td> </tr> <tr> <td>16 Nov</td> <td>SCS</td> <td>13.8 N / 66.0 E</td> <td>&lt; 1002</td> </tr> <tr> <td>17 Nov</td> <td>SCH</td> <td>10.0 N / 84.0 E</td> <td>&lt; 960</td> </tr> <tr> <td>18 Nov</td> <td>SCH</td> <td>12.6 N / 82.5 E</td> <td>&lt; 960</td> </tr> <tr> <td>19 Nov</td> <td>SCS</td> <td>15.2 N / 81.0 E</td> <td>&lt; 960</td> </tr> <tr> <td>20 Nov</td> <td>SCS</td> <td>10.3 N / 71.5 E</td> <td>&lt; 1000</td> </tr> <tr> <td>21 Nov</td> <td>SCS</td> <td>11.5 N / 75.0 E</td> <td>&lt; 1000</td> </tr> <tr> <td>22 Nov</td> <td>DD</td> <td>14.5 N / 75.0 E</td> <td>&lt; 1004</td> </tr> </table>	13 Nov	DD	11.0 N / 75.0 E	< 1006	14 Nov	CS	12.0 N / 71.5 E	< 1002	15 Nov	SCS	13.1 N / 69.3 E	< 1002	16 Nov	SCS	13.8 N / 66.0 E	< 1002	17 Nov	SCH	10.0 N / 84.0 E	< 960	18 Nov	SCH	12.6 N / 82.5 E	< 960	19 Nov	SCS	15.2 N / 81.0 E	< 960	20 Nov	SCS	10.3 N / 71.5 E	< 1000	21 Nov	SCS	11.5 N / 75.0 E	< 1000	22 Nov	DD	14.5 N / 75.0 E	< 1004	The estimated core pressure is 974 hPa.
13 Nov	DD	11.0 N / 75.0 E	< 1006																																									
14 Nov	CS	12.0 N / 71.5 E	< 1002																																									
15 Nov	SCS	13.1 N / 69.3 E	< 1002																																									
16 Nov	SCS	13.8 N / 66.0 E	< 1002																																									
17 Nov	SCH	10.0 N / 84.0 E	< 960																																									
18 Nov	SCH	12.6 N / 82.5 E	< 960																																									
19 Nov	SCS	15.2 N / 81.0 E	< 960																																									
20 Nov	SCS	10.3 N / 71.5 E	< 1000																																									
21 Nov	SCS	11.5 N / 75.0 E	< 1000																																									
22 Nov	DD	14.5 N / 75.0 E	< 1004																																									
7 November, 1978	214.0	19.3	<p>SCH (core pressure &lt; 986 hPa) weakened to DD (core pressure &lt; 1004 hPa) crossed Gujarat coast near Okha on the forenoon of 12 November.</p> <p>Details:</p> <table border="0"> <tr> <td>5 Nov</td> <td>D</td> <td>11.5 N / 74.5 E</td> <td>&lt; 1004</td> </tr> <tr> <td>6 Nov</td> <td>CS</td> <td>12.2 N / 72.0 E</td> <td>&lt; 998</td> </tr> <tr> <td>7 Nov</td> <td>SCS</td> <td>13.0 N / 68.5 E</td> <td>&lt; 1002</td> </tr> <tr> <td>8 Nov</td> <td>SCH</td> <td>15.2 N / 64.6 E</td> <td>&lt; 992</td> </tr> <tr> <td>9 Nov</td> <td>SCH</td> <td>17.5 N / 62.3 E</td> <td>&lt; 986</td> </tr> <tr> <td>10 Nov</td> <td>SCH</td> <td>21.3 N / 64.5 E</td> <td>&lt; 996</td> </tr> <tr> <td>11 Nov</td> <td>SCH</td> <td>23.0 N / 67.0 E</td> <td>&lt; 998</td> </tr> <tr> <td>12 Nov</td> <td>DD</td> <td>23.0 N / 68.7 E</td> <td>&lt; 1004</td> </tr> </table>	5 Nov	D	11.5 N / 74.5 E	< 1004	6 Nov	CS	12.2 N / 72.0 E	< 998	7 Nov	SCS	13.0 N / 68.5 E	< 1002	8 Nov	SCH	15.2 N / 64.6 E	< 992	9 Nov	SCH	17.5 N / 62.3 E	< 986	10 Nov	SCH	21.3 N / 64.5 E	< 996	11 Nov	SCH	23.0 N / 67.0 E	< 998	12 Nov	DD	23.0 N / 68.7 E	< 1004	The estimated core pressure on 8 November morning is 959 hPa.								
5 Nov	D	11.5 N / 74.5 E	< 1004																																									
6 Nov	CS	12.2 N / 72.0 E	< 998																																									
7 Nov	SCS	13.0 N / 68.5 E	< 1002																																									
8 Nov	SCH	15.2 N / 64.6 E	< 992																																									
9 Nov	SCH	17.5 N / 62.3 E	< 986																																									
10 Nov	SCH	21.3 N / 64.5 E	< 996																																									
11 Nov	SCH	23.0 N / 67.0 E	< 998																																									
12 Nov	DD	23.0 N / 68.7 E	< 1004																																									

## Annexure- II

Mumbai

18° 55' N 72° 50' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
5 May, 1975	367.0	41.2	SCS (core pressure < 1000 hPa) weakened into a LP and diffused over sea. Details: 30 Apr LP 1 May DD 09.0 N / 71.5 E < 1006 2 May CS 10.5 N / 71.0 E < 1004 3 May CS 10.8 N / 69.8 E < 1002 4 May CS 11.8 N / 71.2 E < 1002 5 May SCS 14.0 N / 70.5 E < 1000 6 May CS 14.5 N / 69.5 E < 1006 7 May CS 13.8 N / 67.5 E < 1004 8 May CS 14.5 N / 65.0 E < 1002 9 May CS 15.5 N / 64.2 E < 1002 10 May D 16.5 N / 64.5 E < 1000 11 May LP 18.0 N / 65.0 E < 1006	The estimated lowest pressure is 979 hPa on 8 May.
31 May, 1975	405.0	39.9	DD (core pressure < 1004 hPa) crossed Maharashtra coast near Alibagh on 31 May late evening. Details: 28 May LP 07.0 N / 75.5 E < 1006 29 May LP 07.2 N / 74.8 E < 1007 30 May DD 12.0 N / 71.0 E < 1006 31 May DD 16.3 N / 70.2 E < 1004	
24 June, 1975	412.0	27.1	D (core pressure < 994 hPa) moved over Saurashtra, weakened into a low and dissipated over North Arabian sea by 25 June evening. Details: 23 Jun LP 20.5 N / 71.8 E < 996 24 Jun D 22.0 N / 69.5 E < 994 25 Jun D 23.0 N / 67.5 E < 994	

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks																								
19 October, 1975	409.0	-16.5	<p>SCH (core pressure &lt; 1000 hPa) crossed Saurashtra coast near Porbandar on 22 October afternoon.</p> <p>Details:</p> <table> <tr> <td>18 Oct</td> <td>LP</td> <td>14.0 N / 71.8 E</td> <td>&lt; 1005</td> </tr> <tr> <td>19 Oct</td> <td>LP</td> <td>17.0 N / 72.3 E</td> <td>&lt; 1002</td> </tr> <tr> <td>20 Oct</td> <td>D</td> <td>18.0 N / 70.0 E</td> <td>&lt; 1002</td> </tr> <tr> <td>21 Oct</td> <td>CS</td> <td>19.5 N / 68.5 E</td> <td>&lt; 1004</td> </tr> <tr> <td>22 Oct</td> <td>SCH</td> <td>20.8 N / 68.5 E</td> <td>&lt; 1002</td> </tr> <tr> <td>23 Oct</td> <td>SCS</td> <td>23.8 N / 71.5 E</td> <td>&lt; 1000</td> </tr> </table>	18 Oct	LP	14.0 N / 71.8 E	< 1005	19 Oct	LP	17.0 N / 72.3 E	< 1002	20 Oct	D	18.0 N / 70.0 E	< 1002	21 Oct	CS	19.5 N / 68.5 E	< 1004	22 Oct	SCH	20.8 N / 68.5 E	< 1002	23 Oct	SCS	23.8 N / 71.5 E	< 1000	The estimated lowest core pressure of the cyclone on 22 October was 967 hPa, while Porbandar reported 972 hPa.
18 Oct	LP	14.0 N / 71.8 E	< 1005																									
19 Oct	LP	17.0 N / 72.3 E	< 1002																									
20 Oct	D	18.0 N / 70.0 E	< 1002																									
21 Oct	CS	19.5 N / 68.5 E	< 1004																									
22 Oct	SCH	20.8 N / 68.5 E	< 1002																									
23 Oct	SCS	23.8 N / 71.5 E	< 1000																									
2 June, 1976	480.0	63.9	<p>SCH (core pressure &lt; 994 hPa) crossed Saurashtra near Mahuva on the morning of 3 June and again near port Cambay on 4 June morning.</p> <p>Details:</p> <table> <tr> <td>29 May</td> <td>LP</td> <td>12.0 N / 70.0 E</td> <td>&lt; 1006</td> </tr> <tr> <td>30 May</td> <td>D</td> <td>13.0 N / 71.0 E</td> <td>&lt; 1002</td> </tr> <tr> <td>31 May</td> <td>CS</td> <td>14.2 N / 72.0 E</td> <td>&lt; 1000</td> </tr> <tr> <td>1 Jun</td> <td>SCS</td> <td>17.0 N / 71.0 E</td> <td>&lt; 996</td> </tr> <tr> <td>2 Jun</td> <td>SCH</td> <td>18.5 N / 71.0 E</td> <td>&lt; 994</td> </tr> <tr> <td>3 Jun</td> <td>SCH</td> <td>20.5 N / 72.0 E</td> <td>&lt; 996</td> </tr> </table>	29 May	LP	12.0 N / 70.0 E	< 1006	30 May	D	13.0 N / 71.0 E	< 1002	31 May	CS	14.2 N / 72.0 E	< 1000	1 Jun	SCS	17.0 N / 71.0 E	< 996	2 Jun	SCH	18.5 N / 71.0 E	< 994	3 Jun	SCH	20.5 N / 72.0 E	< 996	Bhavnagar reported MSL pressure of 983.4 hPa at 2300 hrs on 3 June.
29 May	LP	12.0 N / 70.0 E	< 1006																									
30 May	D	13.0 N / 71.0 E	< 1002																									
31 May	CS	14.2 N / 72.0 E	< 1000																									
1 Jun	SCS	17.0 N / 71.0 E	< 996																									
2 Jun	SCH	18.5 N / 71.0 E	< 994																									
3 Jun	SCH	20.5 N / 72.0 E	< 996																									

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
7 September, 1976	432.0	31.1	CS (core pressure < 996 hPa) weakened to a D, intensified to CS and weakened again. Dissipated over the sea. Details: 31 Aug CS 23.0 N / 69.0 E --- 1 Sep D 23.5 N / 65.5 E < 996 2 Sep D 24.0 N / 64.0 E < 998 3 Sep D 21.0 N / 66.0 E < 1000 4 Sep D 21.5 N / 67.0 E < 1002 5 Sep CS 21.0 N / 69.0 E < 996 6 Sep D 23.5 N / 66.5 E < 998 7 Sep D 23.0 N / 63.0 E < 1000 8 Sep D 22.0 N / 60.0 E ---	The system made a loop along the track.
10 June, 1977	387.0	56.0	SCH (core pressure < 984 hPa) passed through Masirah island on 13 June morning and entered Oman. Details: 8 Jun LP 15.5 N / 71.5 E < 1004 9 Jun DD 16.5 N / 70.2 E < 1000 10 Jun CS 18.5 N / 69.3 E < 984 11 Jun SCH 19.7 N / 64.3 E < 984	Masirah at the time of landfall reported lowest pressure of 959.0 hPa.
17 June, 1979	438.0	52.5	SCS (core pressure < 992 hPa) crossed African coast by the morning of 20 June. Details: 15 Jun LP 13.0 N / 71.5 E < 1002 16 Jun D 14.0 N / 70.5 E < 1000 17 Jun DD 16.5 N / 69.5 E < 996 18 Jun CS 18.0 N / 65.0 E < 994 19 Jun SCS 19.5 N / 62.5 E < 992	A ship 150 kms away from the storm center reported the lowest pressure of 989.1 hPa.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
16 November, 1979	412.0	46.6	DD (core pressure < 1002 hPa) weakened into a LP and diffused near Saurashtra on 17 November evening. Details: 13 Nov D 09.5 N / 72.0 E < 1008 14 Nov D 11.5 N / 70.5 E < 1006 15 Nov DD 14.0 N / 69.0 E < 1002 16 Nov DD 17.0 N / 71.0 E < 1002 17 Nov LP 19.5 N / 70.5 E < 1006	
22 November, 1979	460.0	22.8	LP (core pressure < 1008 hPa) formed and diffused off west coast of India. Details: 21 Nov LP 15.0 N / 70.0 E < 1008 22 Nov LP 18.5 N / 71.0 E < 1008 23 Nov LP 18.5 N / 70.0 E < 1011	
6 June, 1980	424.0	37.6	D (core pressure < 998 hPa) crossed North Maharashtra coast by 6 June afternoon. Details: 3 Jun LP 14.5 N / 72.5 E < 1004 4 Jun D 15.0 N / 70.5 E < 1002 5 Jun D 16.5 N / 70.5 E < 1002 6 Jun D 19.0 N / 72.0 E < 998	
31 October, 1981	455.0	70.4	SCH (core pressure < 992 hPa) crossed Saurashtra coast close to Mangrol after midnight of 1 November. Details: 28 Oct LP 12.6 N / 71.5 E < 1008 29 Oct DD 12.0 N / 70.8 E < 1004 30 Oct CS 13.5 N / 68.0 E < 1002 31 Oct SCH 16.5 N / 68.0 E --- 1 Nov SCH 19.5 N / 69.5 E < 996 2 Nov SCS 22.2 N / 69.7 E < 992 3 Nov DD 27.0 N / 75.0 E < 1002	The estimated core pressure was 983 hPa.

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
7 November, 1982	409.0	80.2	SCS (core pressure < 992 hPa) crossed Gujarat coast west of Kodinar at about 1700 hrs on 8 November. Details: 3 Nov LP 10.0 N / 72.0 E < 1009 4 Nov LP 11.0 N / 65.5 E < 1008 5 Nov CS 12.5 N / 62.5 E < 1000 6 Nov SCS 14.0 N / 64.0 E < 998 7 Nov SCS 15.5 N / 66.5 E < 992 8 Nov SCS 19.0 N / 69.5 E < 998 9 Nov CS 23.0 N / 73.5 E < 1000	Veraval reported lowest pressure of 963.7 hPa just before landfall.
28 May, 1985	402.0	30.8	Cs (core pressure < 996 hPa) dissipated over northeast Arabian sea. Details: 28 May D 15.0 N / 67.0 E < 998 29 May D 17.5 N / 67.0 E < 996 30 may CS 20.0 N / 68.0 E < 996 31 May LP 22.0 N / 65.0 E < 998	
5 October, 1985	364.0	23.4	D (core pressure < 1002 hPa) crossed Saurashtra coast near Mahuva, made a loop, entered the sea and crossed the Gujarat coast south of Bulsar in the forenoon of 8 October. Details: 5 Oct LP 18.5 N / 71.5 E < 1004 6 Oct D 19.5 N / 71.5 E < 1004 7 Oct D 21.5 N / 72.0 E < 1002 8 Oct D 20.5 N / 72.5 E < 1000	

Mumbai

18° 55' N 72° 50' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
5 November, 1987	424.0	-35.2	SCS from the Bay crossed the east coast on 2 November, moved over land and emerged into Arabian sea as LP on 5 November and dissipated over sea. Details: 2 Nov      SCS      13.5 N / 82.0 E      < 996 3 Nov      CS        14.9 N / 79.5 E      < 1000 4 Nov      LP        15.0 N / 76.5 E      < 1000 5 Nov      LP        15.5 N / 71.0 E      < 1008	A negative surge.
10 December, 1987	405.0	43.3	LP (core pressure < 1008 hPa) diffused over the sea. Details: 9 Dec      LP        10.0 N / 72.0 E      < 1009 10 Dec     LP        11.0 N / 71.0 E      < 1010 11 Dec     LP        13.0 N / 71.0 E      < 1008 12 Dec     LP        12.0 N / 69.0 E      < 1010	

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks																																
22 September, 1979	229.0	22.3	<p>SCH (core pressure &lt; 1000 hPa) weakened to a DD and crossed Oman coast on 24 September night.</p> <p>Details:</p> <table> <tr> <td>17 Sep</td> <td>LP</td> <td>13.0 N / 73.5 E</td> <td>&lt; 1008</td> </tr> <tr> <td>18 Sep</td> <td>D</td> <td>12.0 N / 73.0 E</td> <td>&lt; 1006</td> </tr> <tr> <td>19 Sep</td> <td>D</td> <td>13.5 N / 71.5 E</td> <td>&lt; 1004</td> </tr> <tr> <td>20 Sep</td> <td>D</td> <td>15.2 N / 70.5 E</td> <td>&lt; 1004</td> </tr> <tr> <td>21 Sep</td> <td>D</td> <td>17.5 N / 70.0 E</td> <td>&lt; 1004</td> </tr> <tr> <td>22 Sep</td> <td>CS</td> <td>18.5 N / 66.5 E</td> <td>&lt; 1004</td> </tr> <tr> <td>23 Sep</td> <td>SCH</td> <td>20.5 N / 62.4 E</td> <td>&lt; 1000</td> </tr> <tr> <td>24 Sep</td> <td>DD</td> <td>Over Oman</td> <td>&lt; 1006</td> </tr> </table>	17 Sep	LP	13.0 N / 73.5 E	< 1008	18 Sep	D	12.0 N / 73.0 E	< 1006	19 Sep	D	13.5 N / 71.5 E	< 1004	20 Sep	D	15.2 N / 70.5 E	< 1004	21 Sep	D	17.5 N / 70.0 E	< 1004	22 Sep	CS	18.5 N / 66.5 E	< 1004	23 Sep	SCH	20.5 N / 62.4 E	< 1000	24 Sep	DD	Over Oman	< 1006	
17 Sep	LP	13.0 N / 73.5 E	< 1008																																	
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24 Sep	DD	Over Oman	< 1006																																	
18 November, 1979	228.0	42.8	<p>DD (core pressure &lt; 1002 hPa) weakened into a LP and diffused near Saurashtra on 17 November evening.</p> <p>Details:</p> <table> <tr> <td>13 Nov</td> <td>D</td> <td>09.5 N / 72.0 E</td> <td>&lt; 1008</td> </tr> <tr> <td>14 Nov</td> <td>D</td> <td>11.5 N / 70.5 E</td> <td>&lt; 1006</td> </tr> <tr> <td>15 Nov</td> <td>DD</td> <td>14.0 N / 69.0 E</td> <td>&lt; 1002</td> </tr> <tr> <td>16 Nov</td> <td>DD</td> <td>17.0 N / 71.0 E</td> <td>&lt; 1002</td> </tr> <tr> <td>17 Nov</td> <td>LP</td> <td>19.5 N / 70.5 E</td> <td>&lt; 1006</td> </tr> </table>	13 Nov	D	09.5 N / 72.0 E	< 1008	14 Nov	D	11.5 N / 70.5 E	< 1006	15 Nov	DD	14.0 N / 69.0 E	< 1002	16 Nov	DD	17.0 N / 71.0 E	< 1002	17 Nov	LP	19.5 N / 70.5 E	< 1006													
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15 Nov	DD	14.0 N / 69.0 E	< 1002																																	
16 Nov	DD	17.0 N / 71.0 E	< 1002																																	
17 Nov	LP	19.5 N / 70.5 E	< 1006																																	
22 November, 1979	244.0	27.2	<p>LP (core pressure &lt; 1008 hPa) crossed Gujarat coast on 22 November evening.</p> <p>Details:</p> <table> <tr> <td>21 Nov</td> <td>LP</td> <td>16.5 N / 69.5 E</td> <td>&lt; 1008</td> </tr> <tr> <td>22 Nov</td> <td>LP</td> <td>18.5 N / 71.0 E</td> <td>&lt; 1008</td> </tr> <tr> <td>23 Nov</td> <td>LP</td> <td>18.5 N / 70.5 E</td> <td>&lt; 1011</td> </tr> </table>	21 Nov	LP	16.5 N / 69.5 E	< 1008	22 Nov	LP	18.5 N / 71.0 E	< 1008	23 Nov	LP	18.5 N / 70.5 E	< 1011																					
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22 Nov	LP	18.5 N / 71.0 E	< 1008																																	
23 Nov	LP	18.5 N / 70.5 E	< 1011																																	



Veraval

20° 54' N 70° 22' E

Date	Maximum sea level (cm)	Maximum surge level (cm)	Associated meteorological events	Remarks
20 June, 1983	200.0	39.1	DD (core pressure < 994 hPa) moved over Saurashtra on 20 June morning. Details: 19 Jun    LP        20.5 N / 71.0 E        < 998 20 Jun    DD        21.5 N / 70.0 E        < 994 21 Jun    DD        22.0 N / 70.5 E        < 994 22 Jun    DD        22.5 N / 71.5 E        < 996	System lasted for 3 ½ days over Saurashtra.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
22-11-48	SCS crossed near Dahanu, 50 miles north of Bombay at 1000 hrs. on 22 <sup>nd</sup> November.					Gust wind speed at Juhu was 94 mph at 0940 hrs. on 22 <sup>nd</sup> November. No reports on the damages in the coastal region.
21-09-49	DD crossed the east coast just north of Masulipatnam in the morning on 21 <sup>st</sup> October.					Bombay had 28.73 " of rainfall in 24 hrs. and 31.69 " in 48 hrs.
28-10-49	SCS crossed the Andhra coast near Masulipatnam on 28 <sup>th</sup> October at 0130 hrs.	800 human lives perished.		Severe damage to about 3 lakh houses. Heavy breach of road and railway lines. Breakdown of telecommunication links in four districts.	Damage to million acres of crops. The estimated loss to property, livestock and crops is several crores of rupees.	Masulipatnam recorded a pressure departure of 30 mb. from normal (976.9 mb). High wind speed of 85 mph. Surge level of 10-15 ft was reported. Net loss is estimated at several crores of rupees. 20 " rainfall in 12 hrs. at Machilipatnam.
10-6-50	CS crossed the coast near Saugor islands on 10 <sup>th</sup> afternoon.			Estimated property loss was at several lakhs of rupees.		Landslides at Darjeeling due to heavy rains (17.9" in 24 hrs.)

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
13-09-50	CS crossed Orissa coast on 13 <sup>th</sup> September night.					No reports
05-06-51	D crossed the Orissa coast near Balasore on 5 <sup>th</sup> June afternoon					No reports
11-06-51	D in east Arabian sea off Kathiawar coast moved in NW direction on 11 <sup>th</sup> June			Due to squally weather a 1600 ton cargo vessel sunk near Bhatkal on 10 <sup>th</sup> June.		No reports on the coastal region.
26-06-51	D crossed Orissa coast near Balasore on 26 <sup>th</sup> June on the evening.					No reports
21-07-51	D crossed Andhra coast to the south of Kalingapatnam on 22 <sup>nd</sup> July.					No reports
25-07-51	CS crossed Orissa coast between Puri and Gopalpur on 25 <sup>th</sup> July.					No reports
10-08-51	D formed in the evening of 10 <sup>th</sup> Oct. off the Orissa coast,	Heavy rains caused severe	Some loss of cattle.	Some loss of property		The system did not cross the coast.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	merged on the 15 <sup>th</sup> into another trough of LP, which existed off Konkan.	floods and loss of life.				
14-11-51	D on 12 <sup>th</sup> Nov. in the SE Arabian sea intensified into a CS by 14 <sup>th</sup> and became SCS by 15 <sup>th</sup> evening, 500 miles WSW of Bombay. Weakened later.	14 persons were drowned in Dwarka.		Breaches occurred in railway tracks		Wind speed 50mph occasionally in Dwarka. Heavy rainfall of 14 " in 24 hrs in Saurashtra. The system did not cross the coast.
25-11-51	DD, 50 miles south of Vishakapatnam, weakened later.					Heavy rainfall in Andhra and Orissa. The system did not cross the coast.
07-12-51	D in SE bay on 5 <sup>th</sup> Dec, intensified into a CS on 6 <sup>th</sup> , became SCS on 7 <sup>th</sup> , weakened rapidly as a LP off Chittagong-Arakan coast on 13 <sup>th</sup> evening			Low lying coastal areas were inundated and damage to light vessels was reported.		Despite the large distance from the system the entire east coast of India was affected with large swells. The system did not cross the coast.
19-05-52	DD formed in the southwest bay on 19 <sup>th</sup> evening near 13 <sup>0</sup> N 87 <sup>0</sup> E, deepened			Low-lying areas of Madras city were flooded		The system did not cross the coast.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	rapidly, became SCS on 21 <sup>st</sup> and rapidly weakened to a DD with its core close to the coast of Masulipatnam			and traffic was dislocated. Breaches occurred in railway lines.		
24-06-52	D moved from head bay to SW Uttar Pradesh between the 24 <sup>th</sup> and 28 <sup>th</sup> June giving abnormally heavy rains.					No reports in the coastal region.
04-07-52	CS in head bay on 4 <sup>th</sup> July, landfall at Contai					No reports
20-08-52	D in NW bay on 20 <sup>th</sup> August. Landfall near Orissa coast.					No reports
10-09-52	D was formed in NW bay by 10 <sup>th</sup> Sep. The landfall details are not available					No reports
09-10-52	D on 9 <sup>th</sup> Oct 1952 in SE bay crossed Orissa coast					No reports
16-10-52	D in west central bay on the 14 <sup>th</sup> of Oct.					No reports

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	Landfall near south Circars coast between Ongole and Masulipatnam on 16 <sup>th</sup> night.					
24-10-52	DD in north Andaman sea concentrated into a CS on 23 <sup>rd</sup> evening, centered about 100 miles west of Bassein. Landfall near Akyab on 24 <sup>th</sup> morning					No reports
12-11-52	CS on 9 <sup>th</sup> November centered near 18 <sup>o</sup> N and 88 <sup>o</sup> E, weakened to a depression and landfall near Chittagong on 12 <sup>th</sup> November.					No reports.
30-11-52	SCS on 29 <sup>th</sup> Nov. about 400 miles southeast of Madras. Landfall on 30 <sup>th</sup> Nov. afternoon, at south of Nagapattinam.	168 human lives lost	7570 cattle were reported lost.	Strong winds uprooted a large no of trees. 11,954 huts and mud houses	Destroyed 10,000 acres of plantation and gardens.	The core pressure was 970 mb. 40 mb less than surroundings. Nagapattinam observatory measured a wind speed of 50 mph at

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
				damaged. Caused dislocation of road, rail, telegraph and other communication in that area.		1130 hrs IST on the 30 <sup>th</sup> , after which the wind instrument got damaged.
01-05-53	D in SE bay on 29 <sup>th</sup> April, intensified into a SCS, landfall near Burma coast on 1 <sup>st</sup> May.					No report.
19-06-53	D in west central bay on 15 <sup>th</sup> June intensified into a CS on 19 <sup>th</sup> , landfall at Orissa coast on same afternoon.			Rail communication was temporarily dislocated between Bombay and Gujarat.		
30-06-53	D in northwest bay on 29 <sup>th</sup> June with its core near Sandheads, landfall on 30 <sup>th</sup> evening.					No reports

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
02-08-53	D formed in the head bay on 1 <sup>st</sup> August and intensified into CS on same night. Landfall near Balasore at night.					No reports
14-08-53	D formed at head bay on 10 <sup>th</sup> August, became DD then D and landfall near Chandbali on 14 <sup>th</sup> at night.			The river Dudh washed away the bridge over it. 300 villages on the banks of Ganges were inundated.		
23-08-53	D over the head bay, 40 miles south of Calcutta and landfall at night.					No reports
07-09-53	D on 7 <sup>th</sup> September about 220 miles south of Calcutta, landfall at night.					No reports.
26-09-53	D on 21 <sup>st</sup> Sep. in north bay turned to CS on 26 <sup>th</sup> morning, weakened to D and crossed coast near Contai at night.					No reports.



ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
22-10-53	D on 21 <sup>st</sup> October about 200 miles SE of Madras crossed coast near Nellore on 22 <sup>nd</sup> .					No reports
28-10-53	D formed in west central bay on 26 <sup>th</sup> October evening at 13.5 <sup>o</sup> N & 84.5 <sup>o</sup> E and weakened to a LP off circars coast.			About 20 irrigation tanks (12 major and 8 minor) were breached.	Thousands of acres of standing crops were affected.	
10-11-53	D on 3 <sup>rd</sup> Nov in SE bay; intensified into DD by 8 <sup>th</sup> Nov. and became a LP on 10 <sup>th</sup> evening.					No reports.
10-06-54	D in east Arabian Sea on 8 <sup>th</sup> June, about 160 miles west of Bombay. Crossed Saurashtra coast between Veraval and Porbandar on 10 <sup>th</sup> afternoon.			All India Radio station got flooded and temporarily stopped functioning		
06-07-54	D on 5 <sup>th</sup> July about 100 miles east of					No reports.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	Puri crossed the Orissa coast on 6 <sup>th</sup> .					
08-08-54	D in northwest bay on 7 <sup>th</sup> August and landfall near Orissa coast on 8 <sup>th</sup> evening.					No reports.
02-09-54	D from NW bay moved over land.					No reports.
28-09-54	CS in west central bay on 26 <sup>th</sup> Sept crossed coast on 28 <sup>th</sup> near Circars coast.					No reports.
21-10-54	D in SE bay on 20 <sup>th</sup> Oct. Landfall near Cuddalore as DD on 21 <sup>st</sup> evening. Weakened and then intensified again to a D on the 24 <sup>th</sup> , later weakened and crossed Sundarbans coast between Barisal and Chittagong on 27 <sup>th</sup> early hours.			Destruction of about 2000 huts due to floods in Guntur in Andhra.	Standing crops were submerged in Guntur area.	Heavy rainfall in Tamilnadu and Andhra.
08-12-54	D formed over southwest bay on 8 <sup>th</sup>					Heavy rainfall activity in Tamilnadu.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	Dec., about 150 miles east of Madras, weakened into a LP on 12 <sup>th</sup> and diffused later.					
16-12-54	CS on 16 <sup>th</sup> November at 7.5 <sup>o</sup> N and 86 <sup>o</sup> E moved northwestwards and diffused later near the Orissa coast on 19 <sup>th</sup> .					Did not cross the coast. Good rains in Orissa and Gangetic West Bengal.
07-05-55	D in SW and adjoining WC bay on 5 <sup>th</sup> May intensified into a CS on 6 <sup>th</sup> . Weakened to DD and the landfall near Kakinada on 7 <sup>th</sup> .			Breaches occurred in southern railway.		
18-05-55	D in SW bay on 17 <sup>th</sup> May about 200 miles east of Nagapattinam. Landfall near Cuddalore on 18 <sup>th</sup> .					Thunder showers in Tamilnadu.
03-09-55	D formed in the north bay on 1 <sup>st</sup> September	Lakhs of people were				Floods in Orissa; worst in 100 years.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	Intensified to CS and crossed Orissa coast on 3 <sup>rd</sup> .	reported marooned.				
21-09-55	D formed in NW bay on 21 <sup>st</sup> Sept. and crossed the Orissa coast.					No reports.
30-09-55	CS formed in the north bay on 30 <sup>th</sup> Sept. and crossed the Orissa coast near Chandbali.					No reports.
09-10-55	D in east central bay on 5 <sup>th</sup> Oct 1955, weakened and later intensified into a CS on 9 <sup>th</sup> Oct. Landfall near Kalingapatnam on 11 <sup>th</sup> early hours.					Estimated max. wind speed at Kalingapatnam was about 60 knots. Whatever damages caused to the state were due to the associated rainfall and not due to the associated surge.
16-10-55	LP on 14 <sup>th</sup> Oct. over SW bay became D and diffused later off Andhra coast.					No reports.
21-10-55	D off Kalingapatnam diffused later off					No reports.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	Gangetic West Bengal.					
06-11-55	SCS with its center at 0830 hrs IST of 6 <sup>th</sup> about 150 miles to the east southeast of Kakinada, became a DD on 7 <sup>th</sup> and diffused gradually.					Did not cross the coast. No reports.
28-11-55	D in SW bay on 28 <sup>th</sup> Nov., became DD and intensified into a SCH, crossed the coast near Rajamadam in Tanjore district on 1 <sup>st</sup> December 1955 in the early hours.	About 200 saltpan workers were washed away. Total 500 human lives were lost.	1 lakh cattle heads were killed.	Heavy damage to property, seriously dislocating rail, road and telegraphic communication in the southern districts of Tamilnadu.		Estimated core wind speed was 80-120 mph. The tidal wave coincided with the epoch of the high tide.
29-04-56	D in bay at 10 <sup>o</sup> N and 89 <sup>o</sup> E on 27 <sup>th</sup> , intensified into CS on 28 <sup>th</sup> and crossed Nellore on 29 <sup>th</sup> night.					After landfall traveled over land and emerged into Arabian sea near Karwar on 30 <sup>th</sup> April and diffused off Bombay on 3 <sup>rd</sup> May.
31-05-56	D over NW bay near Saugor island on 29 <sup>th</sup> May, intensified into	More than a million people were		More than 10000 persons rendered	More than 30000 acres of paddy fields in the	

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	SCH on 31 <sup>st</sup> May centered about 60 miles to the south of Calcutta and hit the coast near Contai.	affected by the cyclone in West Bengal.		homeless in Midnapore district. Many buildings and houses collapsed in Calcutta.	coastal West Bengal were inundated by the saline waters, due to breaches in embankments.	
24-06-56	D in west central bay on 24 <sup>th</sup> June, crossed coast near Kalingapatnam on 25 <sup>th</sup> at night.					No reports.
01-07-56	D formed off Orissa coast and crossed coast between Puri and Chandbali at night on 2 <sup>nd</sup> .					No reports.
01-08-56	D formed in bay, about 100 miles southeast of Cuttack on 1 <sup>st</sup> August and crossed the coast on 3 <sup>rd</sup> .					No reports.
07-08-56	D near Saugor island on 7 <sup>th</sup> August moved westwards.					No reports.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
16-08-56	D about 200 miles ESE of Gopalpur on 13 <sup>th</sup> August, crossed coast on 16 <sup>th</sup> Aug.					No reports.
09-09-56	D on 9 <sup>th</sup> September about 100 miles SE of Calcutta. Landfall between Contai and Balasore on 10 <sup>th</sup> .		Heavy loss of cattle.	Extensive floods caused collapse of 15,000 houses. Rail traffic was interrupted in east Uttar Pradesh and adjoining Bihar	Standing crops on 2 lakh acres of land were severely damaged in Uttar Pradesh and Bihar.	The damages caused were due to the heavy downpour.
30-10-56	D at 10 <sup>0</sup> N and 87 <sup>0</sup> E on 27 <sup>th</sup> October concentrated into a CS on 28 <sup>th</sup> . Landfall between Masulipatnam and Ongole on 30 <sup>th</sup> October as a DD.					No reports.
20-11-56	D on 18 <sup>th</sup> November at 8.5 <sup>0</sup> N and 84.5 <sup>0</sup> E. crossed coast between Nagapattinam and Cuddalore.	154 persons were reported killed.		Madras – Tuticorin express train met with tragic accident At Ariyalur as		

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
				one embankment was washed away by the flood.		
22-08-57	D on 18 <sup>th</sup> August at 20.5 <sup>o</sup> N and 90.5 <sup>o</sup> E, intensified into DD on 21 <sup>st</sup> morning, became a CS and crossed coast between Puri and Gopalpur on 22 <sup>nd</sup> morning.					No reports.
11-09-57	LP on 8 <sup>th</sup> September in north bay, intensified to a D which crossed the coast between Gopalpur and Kalingapatnam on 11 <sup>th</sup> September.					No damages in the coastal region.
10-11-57	D over southwest Bay on 8 <sup>th</sup> at 11.5 <sup>o</sup> N and 69.0 <sup>o</sup> E, turned to a DD on 9 <sup>th</sup> , a CS in the evening, to a					Heavy rains and no reports on the damages in the coastal region.



ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	SCS on 10 <sup>th</sup> and weakened gradually.					
25-12-57	DD at south bay on 25 <sup>th</sup> became a CS of small extent in the evening, weakened to a D on 27 <sup>th</sup> moved over to Arabian Sea and diffused later.					Did not cross the coast. No reports.
18-05-58	D at the central bay on 16 <sup>th</sup> evening, 640 km south of Calcutta became a CS on 17 <sup>th</sup> May and crossed east Sunderbans coast on the night of 18 <sup>th</sup> May.					No reports on damages in the coastal region. Heavy rainfall in Assam.
30-08-58	D on 29 <sup>th</sup> August in NW Bay, crossed coast near Puri on 30 <sup>th</sup> Aug.					No reports.
08-09-58	D in NW Bay on 8 <sup>th</sup> Sept., crossed coast near Chandbali on 9 <sup>th</sup>					No reports.
13-09-58	D in NW bay on 13 <sup>th</sup> September, crossed west Bengal coast			Several houses were destroyed in		

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	near Contai on same evening.			the Kakdwip area and country boats sunk at Diamond Harbour due to heavy rains and squally weather. Dislocation of southeastern railway is reported.		
21-09-58	LP over north and adjoining central bay on 21 <sup>st</sup> Sept. which moved over Orissa.					No report on the damages near the landfall. Caused copious rains in UP, Rajasthan and Punjab and flood.
07-10-58	DD by 7 <sup>th</sup> October about 200 km. to eastsoutheast of Madras, weakened same evening and moved over land.			Breaches in railway track of southern railway.		Widespread rainfall. No reports on damages on the landfall. This emerged in Arabian sea and became a CS.
10-10-58	D in Arabian sea intensified rapidly into a SCS on 10 <sup>th</sup>					Did not cross the coast. No report on loss.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	October about 400 km. to the WSW of Bombay. Moved to area off Gujarat on 15 <sup>th</sup> morning and diffused later.					
17-10-58	LP concentrated into a D in the west central bay on 17 <sup>th</sup> Oct. about 300 km. to the southeast of Masulipatnam. Weakened and moved over Andhra.	20,000 people rendered homeless		Breaches in railway tracks by heavy rains.		Heavy rains in Andhra. No report on the coastal area.
23-10-58	D about 400 km. SSE of Calcutta intensified rapidly into a CS by 23 <sup>rd</sup> ; landfall at Sunderbans coast between Barisal and Noakhali on same night.			Railway communication between Dacca and Chittagong was dislocated.		No report on the Indian coast.
08-11-58	D on 6 <sup>th</sup> Nov. with its core about 250 km. southeast of Vishakapatnam					Did not cross the coast. No report.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	intensified into a CS on 8 <sup>th</sup> about 450 km. to the west of Sandoway in Burma. Later it weakened.					
18-11-58	D with center at 7.5 <sup>0</sup> N and 91.0 <sup>0</sup> E on 18 <sup>th</sup> became DD on 19 <sup>th</sup> and rapidly turned into a CS storm on 20 <sup>th</sup> at 400 km. to southeast of Madras. Weakened later and landfall over Madras coast as a D on 22 <sup>nd</sup> morning.			Heavy rains in Madras resulted flood in low-lying areas rendering 5000 families homeless.		This emerged in Arabian sea and intensified later.
26-11-58	D on 23 <sup>rd</sup> 150 km. NW of Mangalore became DD on 26 <sup>th</sup> with its center at 15.0 <sup>0</sup> N and 66.5 <sup>0</sup> E, intensified into a CS on 27 <sup>th</sup> and weakened thereafter a DD and further as LP off Gujarat coast.					Caused rains in Maharashtra state. No report on the damages in coastal area.
20-05-59	D on 19 <sup>th</sup> at 10.0 <sup>0</sup> N			Swells from the		Did not cross the coast.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	and 70.0° E, turned a DD on 20 <sup>th</sup> intensified into a CS on 21 <sup>st</sup> and became SCS on same evening and weakened gradually from next day.			storm caused the destruction of many saltpans around Bombay.		
28-06-59	D on 25 <sup>th</sup> June in east central Arabian sea turned a DD on 28 <sup>th</sup> and intensified into SCS in the evening.					No reports.
29-06-59	D in north bay on 27 <sup>th</sup> evening, became a CS at 280 km. to the SE of Puri and crossed coast between Puri and Chandbali on 29 <sup>th</sup> June.					No reports.
10-07-59	D on 10 <sup>th</sup> July over the Sunderbans coast moved over land and emerged in NE Arabian Sea on 15 <sup>th</sup> .			Collapse of several buildings and houses in Bhuj.		No reports on the damages in coastal region.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
01-10-59	D on 28 <sup>th</sup> September at 18.0 N and 89.0 E, intensified into SCS on 30 <sup>th</sup> morning about 250 km. south of Calcutta. Landfall near Balasore on 1 <sup>st</sup> October.	75 persons lost their lives.	1000 heads of cattle perished.	The storm blew off rooftops and uprooted electric and telegraphic poles, disrupted power supply in many districts of West Bengal, Bihar and Orissa.	About 8 lakh acres of standing paddy crops were destroyed in Balasore. Large number of trees uprooted.	At Calcutta, Hugli river has reached a all time tide record on 5 <sup>th</sup> October.
10-10-59	D in east central Arabian sea, south of Kathiawar coast on 10 <sup>th</sup> October crossed Saurashtra coast near Mahuva on 11 <sup>th</sup> and emerged in the Arabian sea as a DD on 15 <sup>th</sup> rapidly became CS at about 100 km. SSW of Veraval in the evening. Moving westward, became	Many human lives were lost.	Several cattle heads perished.	Several houses collapsed. One cargo vessel Premasavai and a few ferryboats and country craft were tossed by the winds and perished.		

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	SCH and landfall on 18 <sup>th</sup> night in Arabia.					
30-10-59	D in SW bay on 27 <sup>th</sup> October about 100 km. NE of Trincomalee, crossed Sunderbans coast between Noakhali and Chittagong on 30 <sup>th</sup> .					Caused noteworthy amounts of rainfall all along the east coast of India.
28-11-59	D in SW bay about 300 km. ESE of Nagapattinam on 28 <sup>th</sup> November. Crossed coast between Nagapattinam and Pamban on 28 <sup>th</sup> night.			Railway tracks were flooded.		Causing heavy rains all along the system emerged into the Arabian sea.
08-12-59	D on 5 <sup>th</sup> December in SE bay about 300 km. WNW of car Nicobar had landfall over Andhra coast.					No report on damages.
10-10-60	LP entered the bay on 7 <sup>th</sup> , became a D, turned to SCS and crossed East					Considerable loss of life and property (not quantified).

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	Pakistan coast on 10 <sup>th</sup> near Noakhali.					
31-10-60	D developed in the SE and SW bay on 29 <sup>th</sup> , intensified to SCS and crossed the East Pakistan coast near Chittagong.					The conditions in the landfall point due to the earlier storm were aggravated.
20-11-60	D developed in south bay at 10.5 ° N and 85.0 ° E and crossed coast near Madras on 20 <sup>th</sup> afternoon.	Some loss of life was reported. 20,000 people were rendered homeless.		Heavy damage to buildings and huts.	Numerous trees were uprooted in Madras and its suburbs.	
17-11-60	D at 11.5 <sup>0</sup> N and Long 66.5 <sup>0</sup> E intensified into a CS by the 19 <sup>th</sup> at 13 ° N and 62 ° E and weakened near Arabian coast.					No report on loss.
13-01-61	D developed in SW bay about 100 km. NNE of Trincomalee on 9 <sup>th</sup> evening. It crossed extreme			Squally weather near Tuticorin sank ten cargo boats off		Heavy rains in Madras state.



ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	south peninsula weakened and moved to SE Arabian sea.			Tuticorin port.		
09-05-61	D on 5 <sup>th</sup> May with centre about 350 km. ESE of Port Blair, intensified into a CS by 6 <sup>th</sup> , became a SCS on 7 <sup>th</sup> , crossed Sunderbans coast near Barisal on 9 <sup>th</sup> .	Over 1000 deaths were reported from ten districts of Bangladesh.		Several thousand houses were destroyed and scores of vessels laden with valuable cargo were sunk. At Agartala airport extensive damage was caused by winds of 90 knots.		Wind velocity was 100 mph. A tidal bore of 16 ft. high was seen. One ship reported 982 mb. atm. press. , 96 kmph of wind speed and mountainous swell and poor visibility on 8 <sup>th</sup> . On 9 <sup>th</sup> another ship reported a pressure of 994.5 mb. and a wind speed of 30 knots. The bay islands and Assam received heavy rainfall.
24-05-61	SCS crossed coast near Devgad on night of 24-25 <sup>th</sup> May			About 1700 houses were completely destroyed and 25,000 houses partly damaged.	The gales razed 5 lakh fruit trees to ground.	Caused good rainfall on the west coast of India and the advancement of the monsoon.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
30-05-61	D developed over north Andaman sea on 27 <sup>th</sup> , turned to CS in bay on 28 <sup>th</sup> , and a SCS on 29 <sup>th</sup> and crossed the East Pakistan coast on 30 <sup>th</sup> . May struck E. Pakistan near Chittagong.					No detailed report on loss. Heavy rains with gales and squalls occurred in the coastal districts of East Pakistan. Winds reached a speed of 100 mph and tidal waves were reported.
23-06-61	D about 200 km. WNW of Bombay on 21 <sup>st</sup> , turned to a CS on 23 <sup>rd</sup> , 150 km. West of Porbander, crossed Kutch coast near Naliya on same night.					No report on loss.
28-06-61	D formed in east central bay on 27 <sup>th</sup> became DD and crossed Sunderbans coast on 28 <sup>th</sup> afternoon.					No report on loss.
01-07-61	D over NW bay on 1 <sup>st</sup> July, crossed coast near Balasore.					No reports.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
01-09-61	LP crossed the Sunderbans and North Orissa coast.					No reports.
06-09-61	DD crossed Orissa coast near Contai on 6 <sup>th</sup> September.					No reports.
13-09-61	LP intensified into a CS on 12 <sup>th</sup> Sept. Landfall near Contai on 13 <sup>th</sup> morning.					No reports.
28-09-61	DD from NW bay crossed Sunderbans on 28 <sup>th</sup> .	Nearly 900 people lost their lives		100 feet of railway line was washed away. 2500 sq. miles with a population of 10 lakhs was affected by floods in Orissa. 3500 houses were completely destroyed and 5000 houses damaged.	Over 1 lakh acres of agricultural land was washed away.	
22-10-61	LP from east central bay on 22 <sup>nd</sup> ,					No reports.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	concentrated into a D on 24 <sup>th</sup> morning and crossed coast near Noakhali on 25 <sup>th</sup> October night.					
16-05-62	LP from SW bay on 13 <sup>th</sup> May, intensified into a CS by 15 <sup>th</sup> evening, 100 km. NE of Cuddalore; later crossed coast near Cuddalore on 16 <sup>th</sup> in the early hours.					No reports. This emerged into Arabian sea as a DD.
31-05-61	D formed in the central Arabian Sea at 17 ° N and 64 ° E, moved westwards and crossed Arabia coast.					No reports.
08-06-62	D formed in the north bay on 6 <sup>th</sup> , 200 km. ESE of Puri, crossed coast at Sunderbans.					Caused very heavy rains in Assam and Sub-Himalayan West Bengal.
12-06-62	LP over north and central bay turned to D by 11 <sup>th</sup> morning and crossed coast					The system merged with a D hovering over Saurashtra and this combination enhanced

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	near Gopalpur on 12 <sup>th</sup> .					the monsoon activity and caused heavy spells of rain, which caused heavy damages.
3 <sup>rd</sup> to 7 <sup>th</sup> & 7 <sup>th</sup> to 18 <sup>th</sup> August '62	A series of LPs from the North and NW bay moved inland causing heavy rains and serious flood in Uttar Pradesh, Bihar and Assam.	75 human lives lost.		10000 villages were affected and 38823 houses were damaged.		
08-09-62	D formed in the bay on 8 <sup>th</sup> and crossed the coast near Kakinada at night.					
17-09-62	D formed in the West Central bay and became DD and crossed the coast near Gopalpur.					
21-09-62	D from north bay on 20 <sup>th</sup> intensified to CS and crossed the coast at Sunderbans on 21 <sup>st</sup> .					Heavy flood in West Bengal and Uttar Pradesh.
26-10-62	LP from SW and SE bay on 19 <sup>th</sup> became					Heavy rains in Tamilnadu and Andhra. Low-lying

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	D on 23 <sup>rd</sup> , intensified to DD. Crossed the coast near Nellore on 26 <sup>th</sup> at night.					areas of Vishakapatnam were inundated. Emerged into Arabian sea.
30-10-62	D formed in the bay by 26 <sup>th</sup> evening, 150 km. south of Port Blair, intensified to CS on 29 <sup>th</sup> at 200 km. east of Masulipatnam and crossed East Pakistan coast near Chittagong by 30 <sup>th</sup> evening.					Caused heavy rains and gales in Andhra, Orissa, West Bengal and Assam, which aggravated the conditions in Andhra due to the earlier D.
30-11-62	D from east moved into Andaman sea on 26 <sup>th</sup> , moving westwards intensified to CS on 27 <sup>th</sup> evening, became a SCH and crossed coast near Nellore on 29 <sup>th</sup> night.					No details on damages.
08-12-62	D from SE bay on 8 <sup>th</sup> evening intensified to SCS on 10 <sup>th</sup> and					Very heavy rainfall in the bay islands.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	stayed so up to 12 <sup>th</sup> and weakened.					
26-05-63	LP from SE Arabian sea, became D on 18 <sup>th</sup> morning. Became CS at 10 ° N & 68.5 ° E on 20 <sup>th</sup> morning and SCH in the evening. Crossed Arabia coast.					No damages recorded. Heavy rainfall activity in Kerala.
28-05-63	D formed in the SE bay on 24 <sup>th</sup> , became a SCH on 27 <sup>th</sup> evening. Crossed the coast on 28 <sup>th</sup> night near Chittagong.					Flood in Brahmaputra; an all weather bridge in Dikronj river washed away.
09-08-63	D formed over the head bay on 9 <sup>th</sup> and crossed the coast near Contai at night.					Heavy rainfall in the coastal Orissa. No damages reported in the vicinity of landfall.
11-09-63	D in the bay became DD on 9 <sup>th</sup> at 80 km. ESE of Sandheads. Crossed the coast near Balasore at night of 11 <sup>th</sup> .					Heavy rainfall in the coastal Orissa, UP and Punjab. Major rivers flooded and caused damage to public property and loss of life.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
27-09-63	D moved into bay from the east turned to DD and crossed coast near Balasore in the early hours of 27 <sup>th</sup> .	15 persons lost their lives.		Serious damage to property in Orissa due to rains.		Heavy rainfall in Orissa and Bihar.
06-10-63	LP from east moved into bay, turned to D, intensified to DD and crossed the East Pakistan coast on 6 <sup>th</sup> night.					Heavy rains in Bay islands and Assam.
13-10-63	D on 13 <sup>th</sup> in the East Central Arabian sea became a CS on 14 <sup>th</sup> weakened later.					Did not cross the coast. No damages reported.
21-10-63	D formed over the SE bay at 9.5 ° N & 91.5 ° E intensified to SCS by 20 <sup>th</sup> and crossed the coast near Cuddalore during afternoon of 21 <sup>st</sup> . The weakened system recurved and emerged into the bay near Gopalpur on			Disruption of telecommunication, rail and air services in the Madras state.	Flood caused serious damage to standing crops in Andhra and Orissa.	



ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	26 <sup>th</sup> . Became a SCS, moved towards Burma and weakened.					
26-10-63	D formed in the bay on 24 <sup>th</sup> at 150 km. SSW of Port Blair and crossed the South Arakan coast on 26 <sup>th</sup> morning.					No report on damages.
07-12-63	D over SE Arabian sea intensified to CS on 2 <sup>nd</sup> and crossed Kuria-Muria coast on 7 <sup>th</sup> .					No reports on damages.
03-12-63	D over SE bay turned to a CS on 3 <sup>rd</sup> and weakened on 6 <sup>th</sup> .			Severe damage to public property.	37000 acres of paddy field submerged in flood.	The reported damages are due to the heavy rainfall associated with the CS in the bay.
08-05-64	LP from the South Andaman Sea turned to a D on 6 <sup>th</sup> and intensified to a CS by 7 <sup>th</sup> and crossed the Arakan coast at night on 8 <sup>th</sup> .					No damages reported.
12-06-64	LP from East Central	27 persons		Damages to		Cyclonic winds and tidal

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	Arabian sea on 9 <sup>th</sup> became a SCS by 11 <sup>th</sup> at about 100 km. SW of Veraval and crossed the coast near Naliya on 12 <sup>th</sup> .	were killed.		public property along the Kathiawar coast. Many country craft and barges loaded with bauxite sunk.		wave of 15 ft. caused the havoc.
07-08-64	CS developed off Bombay on 7 <sup>th</sup> .	2 persons were killed.		2 small ships broke loose from their moorings.	Very extensive damage to Chiku and Plantain orchards in Thana.	No report on landfall. Heavy rains in konkan belt of west coast.
28-09-64	DD formed on 27 <sup>th</sup> in the west central bay crossed coast near Kakinada on 28 <sup>th</sup> afternoon.	Few fishermen were lost among the 500 caught in the high seas.		Disruption of rail and road communication and one bridge over the Krishna river was washed away.		Associated heavy rains caused the damages.
05-10-64	LP from east moved into bay turned to D on 4 <sup>th</sup> , intensified to DD on 5 <sup>th</sup> and crossed the East					No damages reported.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	Pakistan coast near Barisal on 5 <sup>th</sup> .					
18-10-64	LP from Andaman sea on 16 <sup>th</sup> turned to DD by 18 <sup>th</sup> and crossed the coast near Gopalpur on 18 <sup>th</sup> night.					No damages reported.
02-11-64	LP from SE Arabian sea intensified to D, then CS on 4 <sup>th</sup> . This could not be traced after 8 <sup>th</sup> due to lack of observations at sea.					No damages reported.
07-11-64	D formed over the south Andaman sea, intensified to SCH on 6 <sup>th</sup> at 13 ° N & 84 ° E, weakened to CS on 7 <sup>th</sup> ; Crossed coast near Madras at night.					The weakened system emerged into Arabian sea and vanished. No reports on damages.
16-11-64	LP from east became a D at on 16 <sup>th</sup> at 13.5 ° N & 82.5 ° E, turned a SCS on 18 <sup>th</sup> , went close to Madras by	A few persons lost their lives.		Over 5000 huts were submerged and 30000 people were		The damages were due to the heavy rains. The system did not cross the coast.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	19 <sup>th</sup> , weakened to CS by 20 <sup>th</sup> , moved away from coast and diffused on 29 <sup>th</sup> .			rendered homeless.		
23-11-64	D from extreme SE bay on 17 <sup>th</sup> at 5 ° N & 93 ° E intensified to SCS on 20 <sup>th</sup> and crossed coast near Tondi in Tamilnadu on 23 <sup>rd</sup> afternoon.	Over 900 persons were dead including all passengers of a train which got washed off.		The railway bridge between Mandapam and Pamban was washed off by the tidal waters. Communication between the island and the main land was cut off.		Cyclonic winds and tidal wave ravaged, the landfall area, Dhanushkodi. Weakened to CS and emerged into Arabian sea and diffused later.
11-05-65	LP from SE bay became a D on 9 <sup>th</sup> then CS on 10 <sup>th</sup> and then SCH on 11 <sup>th</sup> evening and crossed the East Pakistan coast on 11 <sup>th</sup> night.					No damages were reported.
31-05-65	D formed on 26 <sup>th</sup> at 15 ° N & 89 ° E intensified to CS on 30 <sup>th</sup> and then SCS on					No reports on damages.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	31 <sup>st</sup> near 20.5 ° N & 90.5 ° E.					
02-01-66	SCS with center about 150 km. east of Nellore on 2 <sup>nd</sup> . Landfall near Vishakhapatnam on 3 <sup>rd</sup> .					No reports on damages.
01-05-66	LP over the south Andaman sea on 25 <sup>th</sup> concentrated into a D by 28 <sup>th</sup> morning. It further intensified into a CS by 29 <sup>th</sup> morning and into a SCS by 30 <sup>th</sup> at 11.0° N and 84.0° E. Land fall just north of Cuddalore on 1 <sup>st</sup> May.			Rail and air traffic services were disrupted.		No loss reported.
25-09-66	LP moved from east into the SE bay on 25 <sup>th</sup> , became D on 27 <sup>th</sup> and crossed East Pakistan coast on 1 <sup>st</sup> October.					No reports on damages.
29-09-66	D over east central Arabian sea on 29 <sup>th</sup> ,					No reports on damages. Did not cross the coast.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	intensified to CS on 1 <sup>st</sup> October and later diffused.					
11-10-66	LP intensified to a D on 11 <sup>th</sup> at 12 <sup>o</sup> N and Long. 86 <sup>o</sup> E. and approached Andhra coast.					No reports on damages. Did not cross the coast.
03-11-66	LP of Andaman sea on 31 <sup>st</sup> October intensified into a D on 1 <sup>st</sup> November, intensified into a CS on 2 <sup>nd</sup> , turned to a SCH on 3 <sup>rd</sup> and crossed coast near Madras.	26 members of crew and a few on main land lost their lives.		Madras harbour suffered heavy loss. 3 ships got grounded. S.S Progress split into two. Communications were seriously interrupted.		The weakened system emerged into Arabian sea on 5 <sup>th</sup> , intensified to CS on 7 <sup>th</sup> , to SCH on 10 <sup>th</sup> and then weakened off Arabia coast on 12 <sup>th</sup> .
09-11-66	LP from SE bay on 7 <sup>th</sup> , intensified into a D on 8 <sup>th</sup> crossed Madras coast near Tondi at night on 9 <sup>th</sup> . Emerged into Arabian Sea on 11 <sup>th</sup> , intensified to SCS on			Coastal shipping and fishing crafts were affected. Heavy rains caused breaching of tanks and	Seriously affected the standing crops and harvesting operations.	

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	12 <sup>th</sup> and crossed coast near Ratnagiri by 13 <sup>th</sup> evening.			inundation. Ratnagiri was cut off totally from rest of the places.		
21-11-66	D on 18 <sup>th</sup> at 9.5 <sup>0</sup> N & 87 <sup>0</sup> E intensified into a CS by 19 <sup>th</sup> then to SCS on 20 <sup>th</sup> and crossed coast near Kalingapatnam on 22 <sup>nd</sup> November.					Caused heavy rainfall in Andhra and Orissa.
28-11-66	LP from South Andaman sea on 22 <sup>nd</sup> , intensified into a D on 25 <sup>th</sup> , later to a CS on 27 <sup>th</sup> and intensified into a SCS at night and crossed coast near madras on 28 <sup>th</sup> morning.	2 adults and a child killed.		No property loss reported.		The weakened system emerged into Arabian sea on 30 <sup>th</sup> and weakened further.
12-12-66	D on 7 <sup>th</sup> at 8 <sup>0</sup> N and 88 <sup>0</sup> E turned to CS on 9 <sup>th</sup> and crossed East Pakistan coast near Chittagong on 12 <sup>th</sup> night.					Caused good rainfall.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
20-12-66	LP from South Andaman sea on 13 <sup>th</sup> became a D on 16 <sup>th</sup> , then a DD on 18 <sup>th</sup> and weakened to a LP off Madras coast. Moved close to cape and crossed the Maldives on 22 <sup>nd</sup> .					Good rainfall in bay islands and Madras state.
18-05-67	D on 5 <sup>th</sup> at 11.5 <sup>o</sup> N & 91.5 <sup>o</sup> E, intensified into a CS on 6 <sup>th</sup> , then to a SCS and crossed coast the Arakan coast on 18 <sup>th</sup> morning.					No reports on damages.
30-06-67	D from NW bay on 29 <sup>th</sup> crossed Orissa coast on 30 <sup>th</sup> .					No reports.
04-08-67	DD over NW bay crossed Orissa coast.					No reports.
18-08-67	D formed in head bay on 18 <sup>th</sup> August and crossed West Bengal coast.					No reports in the vicinity of the landfall.



ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
01-09-67	DD over head bay on 1 <sup>st</sup> , crossed West Bengal coast on 2 <sup>nd</sup> .					No reports in the vicinity of the landfall.
09-10-67	LP from east got into the north and adjoining central bay and intensified to a D at 18.5 <sup>o</sup> N & 89.0 <sup>o</sup> E on 8 <sup>th</sup> . On 9 <sup>th</sup> moved close to Orissa coast and intensified to SCS and landfall at Orissa coast between Puri and Paradip on 9 <sup>th</sup> . Moved along the coast and emerged back into the head bay at midnight of 9 <sup>th</sup> and crossed East Pakistan coast on 11 <sup>th</sup> night.	About 1000 persons lost their lives.	50,000 heads of cattle perished.	A stretch of 120 km land parallel to the coast was seriously damaged. Large number of villages destroyed. Damage to property ran into crores of rupees.		
21-10-67	CS of small extent over Comorin on 20 <sup>th</sup> with center about 100 km. west of Colombo. Crossed			CS caused serious floods and havoc in Ceylon.		No damages reported for Indian coast.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	west coast of Ceylon on 21 <sup>st</sup> .					
23-10-67	LP from east turned to a D on 20 <sup>th</sup> at 9 <sup>o</sup> N & 90 <sup>o</sup> E, became a SCS by 23 <sup>rd</sup> and crossed East Pakistan coast near Cox's Bazaar on 23 <sup>rd</sup>					No damages reported.
02-11-67	D over SW bay on 31 <sup>st</sup> October turned to a DD and crossed coast near Cuddalore on 2 <sup>nd</sup> .					Weakened after landfall to D and emerged into Arabian sea and diffused.
08-12-67	D at 5 <sup>o</sup> N & 88 <sup>o</sup> E intensified to a CS, crossed east coast of Ceylon near Batticola on 6 <sup>th</sup> . Intensified into a SCS by 7 <sup>th</sup> and crossed coast near Nagapattinam on 8 <sup>th</sup> .	7 lives lost. 15,000 people rendered homeless.		Rail and road communications were disrupted in Madras state.		Rameswaram island was totally cut off from the main land. Cyclone had caused havoc in Tanjore and Ramanathapuram districts in Madras state through gale winds and tidal waves.
10-05-68	LP from Andaman sea on 6 <sup>th</sup> turned to a D by 7 <sup>th</sup> at 14 <sup>o</sup> N & 95.5 <sup>o</sup> E, intensified into SCS by 8 <sup>th</sup> and	1000 people lost their lives in Akyab. One lakh		90 percent of Akyab was completely destroyed. Greek freighter		

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	crossed Arakan coast near Akyab on 10 <sup>th</sup> .	people in Assam were affected by flood.		was reported to have sunk.		
12-06-68	D at head bay on 12 <sup>th</sup> crossed West Bengal coast on 12 <sup>th</sup> .					No damages were reported.
12-09-68	CS on 11 <sup>th</sup> over NW bay, crossed coast near Gopalpur on 12 <sup>th</sup> .					No report on loss.
02-10-68	D over central bay, intensified to CS on 1 <sup>st</sup> at 17 <sup>o</sup> N & 87 <sup>o</sup> E, then a SCS and crossed coast near Kalingapatnam on 2 <sup>nd</sup> October.	1000 persons lost their lives.		Heavy rains led to severe floods and landslides. Many villages were wiped off.		No reports on loss in the vicinity of the landfall. The damages given are at West Bengal due to the rains associated with the cyclone.
28-10-68	LP from Andaman sea turned to a D on 21 <sup>st</sup> , a CS on 23 <sup>rd</sup> , then a SCS. Landfall near Puri in Orissa on 28 <sup>th</sup> .	Many lost their lives.	Thousands of cattle heads lost.	Cyclonic storm left a trail of devastation in coastal districts of Ganjim, Puri and Cuttack. Floods affected a number of villages. Rail	Vast areas of paddy fields were damaged.	

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
				and road communication were completely disrupted due to breaches.		
05-11-68	LP from south bay concentrated into a D by 2 <sup>nd</sup> , intensified into a CS by 4 <sup>th</sup> and crossed coast near Nellore on 5 <sup>th</sup> .					No reports on damages.
14-11-68	LP from Andaman sea concentrated into a D on 9 <sup>th</sup> , rapidly intensified into SCS on 10 <sup>th</sup> , skirted Andhra and Orissa coasts. Became a CS and the landfall was near Saugor island on 14 <sup>th</sup> night.			The condition of Ganjim and Puri worsened. All modes of communications were paralysed.		
18-12-68	LP over south Bay on 8 <sup>th</sup> , concentrated to a D on 12 <sup>th</sup> , a CS on 14 <sup>th</sup> , weakened to a D on 17 <sup>th</sup> 100 km.					Caused heavy rains and no damages reported.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	east of Nagapattinam and moved across the cape and entered Arabian sea.					
17-05-69	LP in east central bay on 13 <sup>th</sup> , turned to a D on 14 <sup>th</sup> , became a CS on 16 <sup>th</sup> and crossed south Andhra coast near Bapatla on 17 <sup>th</sup> forenoon.	600 human lives lost.	A few lakh heads of cattle were killed.	A few villages were wiped out. There was extensive damage to major irrigation canal systems, irrigation tanks, roads and railway tracks. Disruption of all communication systems. Total loss was estimated at more than a 100 crore rupees.	Trees were uprooted. Several lakh acres of rich standing crops were destroyed.	
16-06-69	D from central Bay on 16 <sup>th</sup> moved over land towards south Assam by 20 <sup>th</sup> .				The floods in Assam caused serious damage to standing crops and property.	Damages due to the associated rains.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
14-08-69	D from north bay on 13 <sup>th</sup> turned to CS in the evening and crossed the Orissa coast on 14 <sup>th</sup> .					No damages reported.
06-09-69	D on 6 <sup>th</sup> September about 400 km. east of Vishakapatnam crossed coast.					No damages reported at the landfall point.
18-09-69	D formed in bay on 18 <sup>th</sup> about 450 km. east of Vishakapatnam, crossed south Orissa coast on same night.			Heavy rains in Telangana, caused flood in Godavari inundating low lying areas.		
23-10-69	LP from south bay on 19 <sup>th</sup> concentrated into a D on 21 <sup>st</sup> , intensified to a CS on 21 <sup>st</sup> night and crossed north Tamilnadu coast on 23 <sup>rd</sup> .			Torrential rains paralysed city life, left more than 20,000 slum dwellers homeless and caused breaches in railway lines in the Madras-Arkonam section		

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
11-10-69	D in west central bay on 9 <sup>th</sup> about 500 km. SSW of Calcutta, intensified to CS on 10 <sup>th</sup> and crossed Bangladesh coast near Barisal on 11 <sup>th</sup> .					No reports on damages.
07-11-69	CS on 5 <sup>th</sup> about 300 km. NW of Port Blair, intensified to SCS on 6 <sup>th</sup> crossed Andhra coast between Kakinada and Masulipatnam on 7 <sup>th</sup> .	200 human lives are lost. 42 fishermen from Kolletikota island were washed away.		Damage to property in Krishna, east and west Godavari districts of coastal Andhra Pradesh.	Heavy damage to standing crops (particularly paddy and sugarcane).	Damages due to the cyclone are estimated to be Rs. 110 crores. Max. wind speed was estimated as 100-150 kmph.
21-12-69	D on 21 <sup>st</sup> at SE bay, intensified to a CS at 6 ° N & 85.5 ° E on 23 <sup>rd</sup> and after persisting for a while weakened to D on 25 <sup>th</sup> December.					Did not cross the coast. Caused good rains in Tamilnadu.
07-05-70	LP over Andaman sea on 30 <sup>th</sup> April moved into SW bay on 1 <sup>st</sup> May and					No report on damages.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	concentrated to a D on 2 <sup>nd</sup> , became CS on 3 <sup>rd</sup> and then a SCS on 4 <sup>th</sup> . Crossed Bangladesh coast near Cox's bazaar on 7 <sup>th</sup> .					
23-05-70	D formed in the NE bay on 23 <sup>rd</sup> and crossed coast south of Cox's bazaar on same night.					No report on damages.
27-05-70	D on 28 <sup>th</sup> at 14.5 ° N & 71.5 ° E intensified to CS on 29 <sup>th</sup> May and then weakened to DD on 31 <sup>st</sup> and moved away.					No report on damages.
09-06-70	D formed in north bay, intensified to CS on 9 <sup>th</sup> and crossed the north Orissa coast the same night.					No report on damages.
30-06-70	DD moved from bay to north Orissa on 30 <sup>th</sup> June.					No report on damages.



ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
08-07-70	DD moved from bay to Bihar. Landfall at West Bengal.					No report on damages.
17-08-70	D formed in West Central bay on 17 <sup>th</sup> and crossed coast on the same day.					No report on damages.
09-09-70	DD from north bay on 8 <sup>th</sup> crossed West Bengal coast on 9 <sup>th</sup> .	150 in UP and 80 lives in Bengal were lost.		Disastrous flood in West Bengal and UP.		
21-09-70	D moved from Central bay over land. Landfall on 21 <sup>st</sup> over Orissa coast.					No report on damages.
08-05-71	D formed in South Andaman sea on 3 <sup>rd</sup> , intensified to CS on 5 <sup>th</sup> and crossed the Chittagong coast on 8 <sup>th</sup> .					No report on damages.
Jun.– Sep. 1971						No detailed account of the events. June: One SCS in the first week and one D in the last week in the bay.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	29-09-71-CS Landfall on the West Bengal coast on 29 <sup>th</sup> September.	60 human lives were lost.		Thousands of houses collapsed in Calcutta.	Crops damaged	One D in the NE Arabian sea in the first week. July: Two Ds crossed West Bengal coast. August: One D moved from NW bay over land. September: Two land based D.  Wind speed in Calcutta was 100-120 mph.
Oct.-Dec. 1971	CS from West Central bay crossed Andhra coast on 15 <sup>th</sup> October afternoon.					Good rainfall in Orissa, West Bengal and Andhra.
	D developed over Lakshadweep area became SCS and moved towards Somalia coast in the last week of October.					Good rains in Kerala.
30-10-71	SCS had a landfall on the Orissa coast	10000 people had	50000 heads of cattle died.	8 lakh houses were		Total damage of crops and other properties was

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	on 30 <sup>th</sup> early morning	lost their lives. One million rendered homeless.		damaged.		estimated to be a few crores. Maximum wind: 150 kmph and a tidal wave of 5m played havoc. Core pressure was 966 mb.
06-11-71	D from Andaman sea on 3 <sup>rd</sup> became SCS on 5 <sup>th</sup> and crossed coast near Chittagong on 6 <sup>th</sup> .					Caused heavy rains and flood in Manipur and Mizoram.
15-12-71	DD formed over SE Arabian sea turned to SCS and moved to Arabian coast.					Heavy rains in Kerala and Laccadives.
06-04-72	LP on 6 <sup>th</sup> from Andaman sea turned to a D on 7 <sup>th</sup> and became a SCS on 9 <sup>th</sup> and weakened on 11 <sup>th</sup> April.					No damages reported. Caused good rains in bay islands. Did not cross the coast.
25-06-72	D formed in NE Arabian sea and moved westwards.					No reports on damages.
29-06-72	LP over NE Arabian sea on 29 <sup>th</sup> June					No reports on damages.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	moved westwards and turned to a D.					
05-07-72	D moved from Head bay crossed West Bengal coast on 5 <sup>th</sup> .					No reports on damages.
14-07-72	SCS on 14 <sup>th</sup> crossed North Orissa coast.			Heavy damage to railway tracks, irrigation works and houses.	Heavy damage to crops.	Train services were disrupted. Heavy rains caused flooding in Orissa.
12-08-72	DD moved from north bay over Bangladesh coast on 12 <sup>th</sup> .					No reports on damages.
10-09-72	SCS crossed North Andhra coast on 10 <sup>th</sup> .	90 people have lost their lives.	8000 cattle heads were lost.	Considerable damage to houses, tele-communication and other property in coastal Orissa.	Considerable damage to crops.	
22-09-72	SCS crossed South Orissa and North Andhra coast on 22 <sup>nd</sup> .			Considerable damage to houses.	Considerable damage to crops.	The SCS was not so intense but the damages were due to heavy rains.
05-10-72	DD crossed south Andhra coast on 5 <sup>th</sup> forenoon.			10000 persons were rendered homeless.	Flooded East Godavari dist. damaged	

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
				Train services were disrupted.	standing crops.	
23-10-72	LP over Arabian sea became a D on 19 <sup>th</sup> and turned to a SCS on 23 <sup>rd</sup> and moved westwards.					No damages were reported.
13-11-72	D from SE Arabian sea on 13 <sup>th</sup> , became DD on 15 <sup>th</sup> and moved towards Somalia coast.					No damages were reported.
22-11-72	DD from SE bay on 15 <sup>th</sup> turned to a SCS on 18 <sup>th</sup> and struck Sriharikota Island on 22 <sup>nd</sup> early night.			The coastal road to Sriharikota island was damaged. A large number of telegraph and electric posts were bent.	A large number of giant trees were uprooted. Casuarina and eucalyptus plantations near Sriharikota were damaged.	Heavy to very heavy rainfall in Andhra.
26-11-72	LP from Andaman sea turned to D on 26 <sup>th</sup> , became DD on 27 <sup>th</sup> and weakened.					No damages were reported.
06-12-72	D from SE bay on 1 <sup>st</sup> ,	80 persons		Several		Considerable damage to

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	became SCS on 4 <sup>th</sup> and crossed coast near Cuddalore on 6 <sup>th</sup> early morning.	have lost their lives.		thousands of houses were damaged. Several thousand were rendered homeless in 7 districts and in Madras alone 30000 were homeless. Rail and road communication cut off.		crops and other properties. Cuddalore reported the wind speed of 70-80 kts. Lowest recorded surface pressure was 984 mb.
06-12-72	Remnants of typhoon "Sally" moved into Andaman sea on 6 <sup>th</sup> as D and diffused.					No damages were reported.
20-12-72	D developed on 20 <sup>th</sup> in SW bay and weakened off Srilanka on 21 <sup>st</sup> .					Light to moderate showers in Tamilnadu.
26-05-73	D on 26 <sup>th</sup> over SW and WC Arabian sea became DD on 27 <sup>th</sup> and moved to Gulf of Aden.					No damages were reported.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
06-06-73	D on 6 <sup>th</sup> near 16 ° N & 68.5 ° E became DD on 7 <sup>th</sup> evening and CS on 10 <sup>th</sup> , weakened to D on 12 <sup>th</sup> and dissipated later.					No damages were reported. Did not cross the coast.
06-07-73	D formed in Arabian sea on 6 <sup>th</sup> and diffused off kutch.					No damages were reported. Did not cross the coast.
07-07-73	DD crossed Orissa coast between Puri and Paradip on 7 <sup>th</sup> morning.					No damages were reported.
13-07-73	DD crossed coast near Chandbali on 13 <sup>th</sup> afternoon.					No damages were reported.
19-07-73	CS crossed coast near Contai on 19 <sup>th</sup> night.				In Orissa floods caused damage to standing crops and property.	No indication of tidal waves or any serious effect due to winds.
27-08-73	D on the morning of 26 <sup>th</sup> near Sandheads crossed coast close to south of Balasore on same afternoon.					No damages reported in the vicinity of the landfall. After landfall the D became DD over land.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
11-10-73	CS crossed Orissa coast near Chandbali around midnight of 11 <sup>th</sup> Oct.	Less than a 100 people died in Orissa. 1.5 million people were affected by flood in Orissa.	Many heads of cattle died	More than 60,000 houses were damaged in north Orissa. Road, rail and telecommunica tions were disrupted and number of bridges damaged. In Midnapore 5000 houses were damaged and damage to property and crops was estimated to 10 lakhs.	Mild tidal waves affected large areas of agricultural land.	Core pressure of 994 mb. and a wind speed of 45 kts. was estimated.
24-10-73	D formed on 24 <sup>th</sup> and diffused on 27 <sup>th</sup> in Arabian sea off Maharashtra.					No damages were reported. Did not cross the coast.
09-11-73	D over SE bay on 3 <sup>rd</sup> intensified into SCS on 5 <sup>th</sup> . Landfall over Orissa coast close to			Saline water inundation affected 2070 acres of land.	Cyclone caused some damage to standing crops in the coastal	Core pressure of 989 mb was estimated.



ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	Paradip on 9 <sup>th</sup> .				districts of Orissa.	
18-11-73	D on 14 <sup>th</sup> over SE bay intensified to SCS on 16 <sup>th</sup> , then weakened to CS on 17 <sup>th</sup> and crossed Bangladesh coast near Hatia as D on 18 <sup>th</sup> November.					Core pressure was estimated to be 994 mb and a max. wind of 55 kt. on 17 <sup>th</sup> . No report on the damages.
09-12-73	D on 5 <sup>th</sup> near 7.5 ° N & 88 ° E became CS on 6 <sup>th</sup> , became SCS on 7 <sup>th</sup> and crossed Bangladesh coast near Barisal on 9 <sup>th</sup> .	10 crew of a ship lost their lives.	Considerable damage to cattle life.	“Sonavati” was caught in the cyclone and sank.	Heavy rains in gangetic west Bengal caused some damage to crops in coastal districts.	Tidal wave of about 4.5 m was reported to have caused the damages in Bangladesh.
15-12-73	D on 13 <sup>th</sup> near 7 ° N & 88.5 ° E became DD on 14 <sup>th</sup> and crossed Tamilnadu coast near Pamban on 15 <sup>th</sup> .					No report on damages.
27-12-73	D on 25 <sup>th</sup> near 4 <sup>0</sup> N & 89.5 <sup>0</sup> E crossed coast near Batticoala in Sri Lanka.					No report on damages.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
17-04-1974	D at SE Arabian sea on 12 <sup>th</sup> became a CS on 13 <sup>th</sup> and weakened on 16 <sup>th</sup> and dissipated.					No damage recorded. Did not cross the coast.
18-05-1974	D at SE Arabian sea on 17 <sup>th</sup> became CS on 18 <sup>th</sup> and weakened to D on 22 <sup>nd</sup> .					No damage recorded. Did not cross the coast.
30-05-1974	D on 29 <sup>th</sup> in the head bay intensified to CS on 30 <sup>th</sup> and crossed the Bangladesh coast near Patuakhali on 30 <sup>th</sup> night.			Vast area of Manipur valley was inundated by flood resulting in some damage to houses.	Damages to crops.	
16-06-1974	DD crossed Orissa coast near Puri on 16 <sup>th</sup> night.					No report on losses.
09-08-1974	D crossed Orissa coast near Balasore on 9 <sup>th</sup> night.					No report on losses.
15-08-1974	D on 13 <sup>th</sup> in the head bay turned to CS on 14 <sup>th</sup> , to SCS on 15 <sup>th</sup> and crossed West			Uprooted trees & telegraph posts, damaged houses & flooded some parts in	Damage to crops in Orissa.	SCS are rare in August and retention of their intensity

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	Bengal coast near Contai on 15 <sup>th</sup> noon.			the districts of midnapore, MP, Gujrat.		over land for considerable distance is also rare. This SCS had these two exceptionally interesting features.
19-09-1974	D at East Central Arabian sea on 19 <sup>th</sup> intensified to CS on 21 <sup>st</sup> , turned to SCS on 22 <sup>nd</sup> , weakened to D on 24 <sup>th</sup> and dissipated over Northwest Arabian sea.					No damage recorded. Did not cross the coast.
28-09-1974	D on 26 <sup>th</sup> in Andaman sea became CS on 27 <sup>th</sup> and crossed Orissa coast close to Paradip on 28 <sup>th</sup> evening.					No damage recorded.
08-10-1974	D crossed Andhra coast close to					No damage recorded.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	Vishakapatnam on 8 <sup>th</sup> evening.					
15-10-1974	DD crossed Andhra coast between Kakinada & Vishakapatnam on 15 <sup>th</sup> morning.					No damage recorded.
24-10-1974	D formed on 24 <sup>th</sup> off Karnataka coast and diffused on 25 <sup>th</sup> off Maharashtra coast.					No damage recorded. Did not cross the coast.
28-11-1974	CS on 24 <sup>th</sup> over East Central bay turned SCS on 25 <sup>th</sup> and crossed coast near Chittagong on 28 <sup>th</sup> noon.					This cyclone did not cause any damage in India. Tidal wave of 3 to 4 meter reported.
04-05-1975	DD on 1 <sup>st</sup> May at SE Arabian sea turned to CS on 2 <sup>nd</sup> , SCS on 4 <sup>th</sup> , weakened to CS on 6 <sup>th</sup> , D on 10 <sup>th</sup> and diffused later.					No damages reported.
07-05-1975	D over Andaman sea on 4 <sup>th</sup> turned to CS on 5 <sup>th</sup> then SCS	Caused some loss of life in Arakan coast.		Damage to sailing vessels in south Arakan coast.		No damages in India.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	on 6 <sup>th</sup> and crossed Burma coast on 7 <sup>th</sup> .					
31-05-1975	D on 29 <sup>th</sup> at SE Arabian sea became DD and crossed the Maharashtra coast near Alibag on 31 <sup>st</sup> .					Road and rail communication were disrupted due to heavy rain and land slide and the steamer link was also dislocated.
07-06-1975	DD on 4 <sup>th</sup> in the head bay became CS on 6 <sup>th</sup> and crossed coast near chittagong on 7 <sup>th</sup> forenoon.	50 fishermen were missing off Bangladesh coast.		Caused damage to houses in Bangladesh.	Damage to crops in Bangladesh. Inundation of low lying area and standing crops in Tripura.	
18-06-1975	D crossed Orissa coast near Paradip on 18 <sup>th</sup> night.					No damage recorded.
27-06-1975	D crossed Orissa coast near Puri on 27 <sup>th</sup> morning.					No damage recorded.
17-08-1975	DD crossed West Bengal on 17 <sup>th</sup> .	About 10 lakh people were affected in 5000			The flood affected 9 lakh hectares.	Floods in Subarnarekha affected some

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
		villages.				parts of Midnapore district.
09-09-1975	D crossed Orissa between Paradip & Puri on 9 <sup>th</sup> evening.					No damages reported.
18-10-1975	D crossed Andhra near Ongole on 18 <sup>th</sup> .					No damages reported. This emerged into Arabian sea which triggered the SCH below
22-10-1975	D on 19 <sup>th</sup> at East Central Arabian sea turned to CS on 20 <sup>th</sup> and SCH on 21 <sup>st</sup> crossed Saurashtra coast on 22 <sup>nd</sup> afternoon near Porbandar.	About 85 people lost their lives.		Considerable damage to buildings & other properties. Estimated loss was about Rs.75 crores. Hurricane winds uprooted many trees and electric & telephone poles and blew off the roofs of houses. Thousands of houses were damaged due to hurricane winds. A train was blown off its rails.	Considerable damage to crops.	Jamnagar recorded a wind speed of 160-180 kmph. Swells of 4-6 meters were recorded. A pressure departure of 36 mb was recorded. The core pressure was estimated to be 967 mb.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
01-11-1975	D on 1 <sup>st</sup> intensified to CS on 2 <sup>nd</sup> and weakened to D on 3 <sup>rd</sup> and diffused off Andhra.					No damages reported. Did not cross the coast.
11-11-1975	D at SE bay on 7 <sup>th</sup> intensified to CS, weakened to DD on 10 <sup>th</sup> and crossed Bangladesh coast near Chittagong on 11 <sup>th</sup> night.					No damages reported. Widespread rains in Andhra.
24-11-1975	D at SW bay on 24 <sup>th</sup> became a CS on 25 <sup>th</sup> , turned to SCS on 26 <sup>th</sup> , weakened to CS on 27 <sup>th</sup> and weakened to D on 29 <sup>th</sup> and diffused.	Few deaths were reported.		Many thousands of slum dwellers were rendered homeless and about a thousand huts were damaged.		
02-05-1976	D on 29 <sup>th</sup> April in SE bay became CS on 30 <sup>th</sup> , SCS on 1 <sup>st</sup> May and crossed Arakan coast on 2 <sup>nd</sup> .					Bay islands received good rains. No damages.
03-06-1976	D of Lakshadweep sea on 29 <sup>th</sup> became CS on 31 <sup>st</sup> , SCS	70 persons lost their lives in Gujrat.	Nearly 4500 heads of cattle perished.	Loss of houses & crops around 3 crores in Gujrat. About 2500		The lowest pressure recorded was

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	around noon and was found to be SCH on 2 <sup>nd</sup> ; crossed Saurashtra coast near Gopinath point on 3 <sup>rd</sup> and again Gujarat coast near port Cambay on 4 <sup>th</sup> morning.	17 fishermen from Bombay lost their lives.		villages in 9 districts in Gujarat were affected. Trees, electric & telephone poles were uprooted in these places.		983.4 mb at Bhavnagar and a max. wind was 90 kt. and 110 kt. in gust. Swells of 10-15 m. were reported by some ships.
01-08-1976	D from NW bay on 1 <sup>st</sup> , became DD and crossed coast near Paradip on the same night.					No damages reported.
13-08-1976	D over north bay on 12 <sup>th</sup> became DD and Orissa coast on 13 <sup>th</sup> between Balasore & Contai.					No damages in the vicinity of the landfall area.
31-08-1976	CS close to Nalia on 31 <sup>st</sup> emerged into NE Arabian sea, weakened to D on 1 <sup>st</sup> , intensified to CS on 5 <sup>th</sup> , weakened again and moved off the coast.					No report on damages.



ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
11-09-1976	D on 8 <sup>th</sup> at East Central bay became DD on 9 <sup>th</sup> , SCH on 10 <sup>th</sup> and crossed West Bengal coast near Contai on 11 <sup>th</sup> .	40 persons lost their lives.	4000 heads of cattle perished.	Considerable damage was caused by the cyclone in the coastal areas of Midnapore & 24-paraganas districts of WB & Orissa. Many trees & telephone poles were uprooted. Thousands of houses were damaged.	Crops in about 1.25 lakh acres were damaged.	Tidal wave of 2-3 m., Max. surface wind of 70-80 kt., gust of 85 kt. and surface pressure of 971.5 mb were recorded at Sagar island.
15-10-1976	D over SE Arabian sea on 12 <sup>th</sup> turned to CS on 14 <sup>th</sup> , SCS on 15 <sup>th</sup> weakened into a depression on 17 <sup>th</sup> and dissipated.					Caused widespread rain in Kerala and no damages reported.
21-10-1976	D in the bay became CS on 16 <sup>th</sup> at 12.5 ° N & 82.5 ° E, weakened to DD, turned to CS on 20 <sup>th</sup> and crossed the Bangladesh coast near Chittagong on 21 <sup>st</sup> .			Rail & road communication in the coastal areas of north Tamilnadu & south coastal Andhra Pradesh were disrupted due to breaches.	About 50 villages in Nellore districts were affected by flood resulting in damage to crops.	
04-11-1976	D on 3 <sup>rd</sup> over central bay became SCH on	18 people lost their lives.		Damage to large no. of houses in Andhra	Considerable damage to	No tidal wave was reported.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	4 <sup>th</sup> and crossed coast 50km. north of Masulipatnam on 4 <sup>th</sup> .			Pradesh. Many trees & electric poles were uprooted in Masulipatnam. Masulipatnam port suffered a damage of about 1 lakh rupees.	tobacco, cotton, banana, sugarcane & paddy crops from Krishna districts.	
16-11-1976	D near Andaman sea on 15 <sup>th</sup> , became DD on same day, rapidly a SCS on 16 <sup>th</sup> and crossed south Andhra coast between Nellore & Kavali on 16 <sup>th</sup> night.	30 people lost their lives.		Trees were uprooted. Electric & telephone poles were bent. About 10,000 houses were damaged. The total damage was estimated to be of the order of 3 crores of rupees.	Considerable damage to tobacco, betel vine, banana & mango gardens in Kavali & Kovur talukas of Nellore district.	Max. wind of 60 kt. and the estimated core pressure was 992 mb.
27-11-1976	D over southeast bay on 22 <sup>nd</sup> turned to DD on 23 <sup>rd</sup> , a CS on 27 <sup>th</sup> , moved off the east coast towards Arakan coast and weakened on 30 <sup>th</sup> . The CS during its curved path, skirted along the south Andhra	50 persons lost their lives in Madras city. About 3 lakh people were affected due to torrential and flood.  The death toll was 45 in		Many houses collapsed in Madras city. Extensive damage to roads & telecommunication systems. Disruption of train services.	Crops in Nellore, Guntur, Krishna, Chittur, Cuddapah & East Godavari districts were damaged.	Due to 3 storms in Nov. the total loss in Andhra: Rs. 200 crores. About 160 persons killed and 2 lakh houses damaged. Paddy in 16

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	coast from 25 <sup>th</sup> to 27 <sup>th</sup> .	Andhra.				lakh acres and other crops in 4.5 lakh acres were severely affected.
31-12-1976	D over SE bay on 28 <sup>th</sup> became CS on 29 <sup>th</sup> , SCS on 30 <sup>th</sup> and a SCH on 31 <sup>st</sup> . Passed within 50 km. of Port Blair. Weakened to CS on 1 <sup>st</sup> Jan. and D on the same night.	Few lives were lost.		Heavy damages due to strong winds & very heavy rain. The roofs of several houses were blown off.	Several trees were uprooted; considerable damage to fruit orchards, vegetable gardens & crops in the fields.	On 31 <sup>st</sup> Port Blair recorded max. wind of 52 kt. in gust and 993 mb. pressure.
13-05-1977	D on SW bay on 9 <sup>th</sup> became CS on 11 <sup>th</sup> , SCS on 12 <sup>th</sup> and crossed Bangladesh coast on 13 <sup>th</sup> .	Few killed & several were lost in coastal districts of Bangladesh.				No damage in India.
13-06-1977	DD on 9 <sup>th</sup> off Maharashtra coast turned to CS on 10 <sup>th</sup> , SCS in the evening, SCH on 11 <sup>th</sup> and crossed the northern tip of	50 persons were killed in Masirah Island & in the mainland of Oman.		Caused severe damage in Masirah Island & in the mainland of Oman. 20,000 people were left homeless.	Severe damage to main agricultural crops and Thousands of palm & lime	No damage in India.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural trees.	
	Masirah Island on 13 <sup>th</sup> morning.					
05-07-1977	D over north bay on 4 <sup>th</sup> became DD and crossed near Contai on 5 <sup>th</sup> .					No damages reported.
24-07-1977	D from north bay on 24 <sup>th</sup> crossed West Bengal coast on the same day.					No damages reported.
04-08-1977	D over NW bay on 4 <sup>th</sup> crossed West Bengal coast on the same day.					No damages reported.
20-08-1977	D over East Central bay became DD on 20 <sup>th</sup> and crossed coast near Gopalpur on 22 <sup>nd</sup> morning.					No damages reported.
30-08-1977	D on 30 <sup>th</sup> crossed North Orissa coast on the same day.					No damages reported.
11-09-1977	D on 8 <sup>th</sup> over NE bay became DD on 11 <sup>th</sup> and crossed near Puri at night.					No damages reported.
01-10-1977	D on 30 <sup>th</sup> became					No damages

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	DD on 1 <sup>st</sup> October and crossed the coast near Masulipatnam at night.					reported.
31-10-1977	D on 27 <sup>th</sup> over East Central bay became CS on 28 <sup>th</sup> and SCS on 31 <sup>st</sup> . Crossed south Andhra coast near Kavali on 31 <sup>st</sup> .			One passenger bus overturned by gale. Telephone posts over 80km stretch for about 40 km on either side of the storm track stood slanting.	Tobacco crops in about 35000 acres were damaged.	No tidal wave was reported. Emerged into Arabian sea on 1 <sup>st</sup> November evening.
12-11-1977	D over the SE bay on 8 <sup>th</sup> became CS on 10 <sup>th</sup> , a SCS on 11 <sup>th</sup> and crossed Tamilnadu coast within 10 km south of Nagapattinam on 12 <sup>th</sup> .	560 persons lost their lives.	23000 heads of cattle (sheep included) & 5000 poultry perished.	Roofs of the buildings were blown off. Trees uprooted. Electric & telegraph poles were bent. Houses collapsed. About 10 lakh people were rendered homeless. Railway bridges washed away.	Crops over an area of 4 lakh acres were affected. Total estimated loss was Rs.42 crores.	No tidal wave was reported. Considerable loss to life and property in 7 districts of Tamilnadu in the vicinity of the landfall. Total estimated loss of life and property was Rs. 155 crores. After landfall weakened to

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
						CS and emerged into Arabian sea on 13 <sup>th</sup> as DD.
19-11-1977	DD over SE bay on 14 <sup>th</sup> became CS on 15 <sup>th</sup> , SCS in the evening, SCH on 16 <sup>th</sup> , reacting with a SCS in Arabian sea (both turned around each other cyclonically) changed course and crossed Andhra coast near Nizampatnam on 19 <sup>th</sup> evening.	Heavy loss of life was reported.		Trees were uprooted and telegraph & telephone posts were bent. Road & rail traffic were disrupted. Telecommunications & power supply in these coastal districts were affected. Steel column of the Vijayawada thermal power station under construction were sheared off.		Core pressure was recorded as 941 mb. (uncorrected). Gale reached 200 kmph. Tidal wave of height 5 m. was reported and 12 km. from the coast was affected due to that.
22-11-1977	DD in Lakshadweep sea on 13 <sup>th</sup> turned to CS on 14 <sup>th</sup> , SCS on 15 <sup>th</sup> , interacting with the Andhra cyclone changed course and became SCH on 17 <sup>th</sup> . Weakened to CS and crossed			Widespread damage from Quilon to Kasargode. About 8400 houses were totally damaged & 19000 houses partially damaged. 620 fishing vessels were damaged. Most	Crops over 40,000 acres were damaged. Loss to standing crops of paddy, coconut, sugarcane, arecanut, houses & other	This is the remnant of the SCS, which crossed Tamilnadu coast on 12 <sup>th</sup> .

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	coast between Mangalore & Honavar on 22 <sup>nd</sup> .			houses in Kalpeni Island in Lakshadweep were damaged.	property was estimated to be about Rs. 10 crores. Kalpeni Island in Lakshadweep was the worst affected. About a lakh of coconut trees, the main cash crop of the Island, were uprooted.	
24-11-1977	D with center near 8.5° N & 87.0°E moved over Sri Lankan coast.					No damages reported.
17-05-1978	DD over SE bay on 14 <sup>th</sup> became CS on 15 <sup>th</sup> , SCS on 17 <sup>th</sup> and probably SCH before landfall crossed Burma Coast just North of Kyaukpyu on 17 <sup>th</sup> .			Heavy damage to property was caused in Kyaukpyu town & neighbouring places.		No report on damages.
17-06-1978	D over north Andhra					No report on

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	coast on 16 <sup>th</sup> turned DD on 17 <sup>th</sup> and had landfall just south of Vishakapatnam on 17 <sup>th</sup> afternoon.					losses.
12-07-1978	D over NW bay on 11 <sup>th</sup> turned DD on 12 <sup>th</sup> had landfall over Orissa coast on 12 <sup>th</sup> .					No report on losses.
15-08-1978	D over north bay on 13 <sup>th</sup> turned DD and crossed Orissa coast near Gopalpur & Puri on 15 <sup>th</sup> .					No report on losses.
27-08-1978	DD over north bay on 26 <sup>th</sup> turned a CS on 27 <sup>th</sup> and crossed Orissa coast near Chandbali & Balasore on 27 <sup>th</sup> .	A fishing boat capsized killing one fisherman.		Many huts collapsed in Contai.	Some trees were uprooted and paddy fields in Contai were submerged.	
16-09-1978	D off Orissa coast on 15 <sup>th</sup> crossed coast near Gopalpur & Puri on 16 <sup>th</sup> .					No report on damages.
21-09-1978	D over NW bay on 21 <sup>st</sup> crossed Orissa coast on 21 <sup>st</sup> .					No report on damages.



ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
04-10-1978	D over West Central bay on 2 <sup>nd</sup> turned DD on 3 <sup>rd</sup> and crossed over West Bengal near Contai on 4 <sup>th</sup> .					No report on damages.
25-10-1978	D over SE bay on 25 <sup>th</sup> turned to a CS on the same day and dissipated over north bay on 28 <sup>th</sup> .					No report on damages.
04-11-1978	D off Tamilnadu coast on 3 <sup>rd</sup> turned DD on 4 <sup>th</sup> and crossed Tamilnadu coast around noon near Cuddalore.	Flood & landslides due to heavy rain took a toll of about 120 human lives in Tamilnadu. About 90 persons died in Nilgiris district alone. About 50 persons died in Kerala due to floods & a house collapse.			Considerable damage to crops & houses was reported from Tamilnadu & Kerala.	It emerged into the Arabian Sea off north Kerala coast on 5 <sup>th</sup> evening.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
07-11-1978	D off Kerala coast on 5 <sup>th</sup> turned to CS on 6 <sup>th</sup> , SCS on 7 <sup>th</sup> morning, SCH in the evening and weakened to CS 11 <sup>th</sup> and DD on 12 <sup>th</sup> . DD crossed Gujrat coast near Okha on 12 <sup>th</sup> .	In Gujrat state, three crew lost their lives.		A sailing vessel sank. Asbestos sheets of the roof of the transmitter station at Bhuj airport were blown off. Almost all electric poles in the vicinity of the aerodrome near Naliya were bent. More than 60 kutchha houses were damaged in Jakhau. Huge stocks of salt belonging to the salt house at Jakhau port were washed away. Few glass panes of lighthouse tower & residential quarters at Dwarka were broken.	Damage to coconut trees & houses was reported from the northern islands in Lakshadeep.	This is the remnant of the D which crossed Tamilnadu coast on 4 <sup>th</sup> . Lakshadweep reported 3-4 m. of waves.
24-11-1978	D on 17 <sup>th</sup> over south Andaman sea turned to CS on 20 <sup>th</sup> , SCH on 21 <sup>st</sup> and crossed Sri Lankan coast on 23 <sup>rd</sup> near Batticoola and then moved	1 thousand people lost their lives in Sri Lanka.		About 5000 huts were damaged in Ramanathpuram district. Large no. of trees uprooted. About 1000 country boats & mechanized fishing	Crops of betal vines, chillies, sugarcane & plaintain were also damaged in the interior talukas of	The system emerged into the Arabian Sea off Kerala coast as a DD on 25 <sup>th</sup> . Min. pressure

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	south of Pamban and crossed Tamilnadu coast between Killakarai & Roche Mary nagar in Ramanathpuram district on 24 <sup>th</sup> evening.			vessels were damaged. Boat building yards were also damaged. Materials & machinery stored for the construction of road bridge near Pamban were washed away. Extensive damage to roads. Thanjavur & Tirunelveli districts also suffered some damage to roads. Roads and rail communications were disrupted in south Tamilnadu. Serious loss of property was reported from Sri Lanka.	Ramnathpurnam district.	of SCH was 993.4 mb. Tidal wave of 3-5 m. affected the Rameswaram island. Total damage to property was estimated to be about 5 crores of rupees.
25-11-1978	DD off Kerala coast on 25 <sup>th</sup> turned to CS in the evening and weakened to D on 28 <sup>th</sup> and dissipated later.					This is a remnant of the SCH, which crossed Tamilnadu & Sri Lanka coast

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
						on 24 <sup>th</sup> . No damages reported.
12-05-1979	D on SE bay on 5 <sup>th</sup> turned CS on 7 <sup>th</sup> , SCH on 8 <sup>th</sup> crossed Andhra coast near Ongole on 12 <sup>th</sup> . Nellore recorded the lowest pressure of about 980 mb between 0600 and 1800 GMT on 12 <sup>th</sup> .	700 human lives were lost.	3 lakh heads of cattle lost.	Many trees were uprooted & electric poles were bent, which led to disruption of road transport & telecommunications & extensive damage to power lines. Enormous damage was caused to railway property in these districts by the swollen rivers & heavy rain. Two bridges near Tanguturu (Prakasam district) were washed away. 40 lakh of people were affected. 7 Lakh houses were damaged. Total damage to crops, houses & public utilities was about 170 crores of rupees.	Crops in 0.7 Lakh hectares were damaged.	First time in 100 years that in May a SCH formed at a low latitude. Another noteworthy feature of this storm was a very heavy rain along and to the left of its track over south coastal Andhra Pradesh and Telangana. Gale of 100 to 160 kmph was reported. Sea level of 3-4 m. was reported.
20-06-1979	D off Karnataka					No damages in

## ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	coast on 16 <sup>th</sup> turned DD in the evening, CS on 18 <sup>th</sup> , SCS on 19 <sup>th</sup> and crossed Arabia coast on 20 <sup>th</sup> .					India reported.
24-06-1979	DD crossed Orissa coast on 24 <sup>th</sup> .					No damages were reported.
28-06-1979	DD crossed coast of Bangladesh on 28 <sup>th</sup> .					No damages were reported.
08-07-1979	D crossed Orissa coast on 8 <sup>th</sup> .					No damages were reported.
07-08-1979	DD over north bay on 6 <sup>th</sup> turned to CS on 7 <sup>th</sup> , SCS afternoon and had landfall over Orissa coast on 7 <sup>th</sup> .		.	Road & Rail and Telephone & power services were disrupted.	Some damages caused to crops in Orissa and West Bengal. West Bengal suffered saline inundation.	Lowest pressure of 970 mb reported. No details on the loss in the vicinity of the landfall are available.
22-09-1979	D on Lakshadweep area on 18 <sup>th</sup> turned CS on 21 <sup>st</sup> , SCH on 22 <sup>nd</sup> , moved westwards and weakened.					No damages in India reported.
24-11-1979	D over SE bay on 22 <sup>nd</sup> turned to CS on				Some damage to harvested	No big damage was reported

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	24 <sup>th</sup> and crossed over Tamilnadu and south Andhra coast near Sriharikota on 25 <sup>th</sup> .				paddy crops in Krishna & Guntur districts due to rain.	associated with this storm.
06-06-1980	D crossed over Maharashtra coast on 6 <sup>th</sup> .					No damage was reported.
17-09-1980	DD crossed Orissa coast on 17 <sup>th</sup> .	About 200 persons in Orissa & about 60 persons in Andhra Pradesh lost their lives.	About 6000 cattle perished in Orissa & about 3000 in Andhra Pradesh	About 30,000 houses/huts were damaged in Andhra. Serious damage was caused to railway tracks in Srikakulam district.		The damages were due to the flash flood due to rain.
04-10-1980	D formed over north bay crossed coast of Bangladesh on 4 <sup>th</sup> .	3 lakh people marooned in Imphal due to flash flood.		80 villages in Manipur & Ekou bridge on the Imphal river were completely washed away.	Heavy loss to standing crops & property was reported in Manipur & Imphal areas.	
18-10-1980	D on SE bay on 16 <sup>th</sup> turned CS on 17 <sup>th</sup> , weakened to DD and crossed Andhra coast on 18 <sup>th</sup> near Masulipatnam.			Damage to roads, buildings and major irrigation works in Andhra.	Caused damage to standing paddy, banana and sugarcane crops in Andhra.	Damages are due to rain alone and not due to wind.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
04-12-1980	D on SW bay on 3 <sup>rd</sup> turned DD on 4 <sup>th</sup> , CS in the evening, weakened and diffused in the West central bay on 8 <sup>th</sup> .	.				No damage to life or property was caused by this system. Did not cross the coast.
16-12-1980	D on Andaman sea on 12 <sup>th</sup> turned a DD on 14 <sup>th</sup> , a CS on 16 <sup>th</sup> over SE bay and over Sri Lanka coast near Tricomalee on 17 <sup>th</sup> . Emerged as D in Gulf of Mannar.					No damage to life or property was caused by this system.
20-06-1981	DD crossed West Bengal coast on 20 <sup>th</sup> .			3500 houses were affected in Midnapore.	Affected 0.28 lakh hectares of paddy land. 51000 hectares of cultivated land was affected which resulted in crop loss of about 6.0 lakh.	The damages were due to rainfall.
07-08-1981	D over NW bay on 7 <sup>th</sup> turned to CS in	15 people lost their lives in		In Orissa, an area of 36,536 hectares was	Affected crop area was 3690	

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	the evening and crossed the Orissa coast near Puri on 8 <sup>th</sup> .	Orissa.		affected. About 47 blocks in the state were affected covering 1017 villages. Over 500 houses collapsed and 1200 houses were partially collapsed.  A total area of 2173 hectares of cultivated lands were reported to have been sand cast in the districts of Puri, Ganjam, & Phulbani.	hectares.	
14-08-1981	D crossed West Bengal coast near Contai on 14 <sup>th</sup> .			The whole of Ramnagar, Egra, Potaspur, P.S.contai sub-division was submerged due to rains.		
18-09-1981	D had landfall over Andhra coast on 18 <sup>th</sup> .			In Srikakulam district about 100 houses collapsed.	In Srikakulam district 800 acre of paddy field were affected.	
26-09-1981	D from Andaman sea on 24 <sup>th</sup> turned to CS on 25 <sup>th</sup> , a SCS			5 launches were lost. Many houses were damaged West Bengal		



ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	and crossed Orissa coast near Puri on 26 <sup>th</sup> .			and Orissa. Many villages in low lying areas were flooded. About 7000 acres of paddy lands were submerged.		
01-11-1981	D on Lakshadweep sea on 28 <sup>th</sup> became DD on 29 <sup>th</sup> , became CS on 30 <sup>th</sup> , SCS in the evening crossed Saurashtra coast close to Mangrol on 1 <sup>st</sup> .	One dozen persons died due to wall collapses.		In Junagadh & Jamnagar districts many trees, electric & telegraph posts were damaged or uprooted and about 5700 houses & an equal number of huts were partially or fully damaged. A few cargo ships & fishing boats sank near the coastal waters. There was damage to fishing boats and nets. Estimated loss to Veraval & Navlakhi ports was about Rs. 12.5 lakh.	Groundnut crop loss in Junagadh & Jamnagar districts was estimated to be about Rs. 52 crores.	No tidal wave was reported.
09-11-1981	D from Andaman sea on 8 <sup>th</sup> became a					No damages were reported.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	CS on 9 <sup>th</sup> over east central bay and weakened gradually.					
16-11-1981	D over Andaman sea on 16 <sup>th</sup> became CS on 17 <sup>th</sup> , a SCS on 19 <sup>th</sup> and weakened gradually off the Arakan coast.					No damages were reported.
08-12-1981	D on SE bay on 4 <sup>th</sup> became CS on 6 <sup>th</sup> , a SCS on 8 <sup>th</sup> , SCH on 9 <sup>th</sup> and crossed West Bengal coast near Sagar Island on 10 <sup>th</sup> .	About 200 people reported to have been died. At least one million people were affected in the three sub-divisions of 24 Parganas. Three died in Orissa.	About 400 livestocks were lost.	In Sunderbans 205 km of embankments were completely washed away. 315 km of embankment were either severely or partially damaged by tidal waves apart from 1,292 breaches. In Midnapore district about 1000 huts were reported to have been destroyed. All telegraph & telephone links snapped at Contain town. About 2800 villages & a population of about 13	About 1,97,000 acres of agricultural land were inundated by saline water. Crops worth Rs. 50 crores had been reported damaged in the cyclone hit districts of West Bengal. In Orissa, 57571 hectares of cropped area was affected due to cyclone & saline	

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
				lakh were affected.  About 200 houses & 29.675 thatched houses were damaged. Damage to 1364 public institutions, roads, river embankments, etc. was estimated at about Rs. 317 lakh. Some fishing vessels berthed in Paradip port were sunk.	inundation leading to a loss of about Rs. 90 lakh. Loss to betel vines was about 162 lakh.	
04-05-1982	D on SW bay on 1 <sup>st</sup> turned to CS on 2 <sup>nd</sup> , SCS in evening off Andhra, SCH on 3 <sup>rd</sup> and crossed Arakan coast on 4 <sup>th</sup> .					Did not cause any significant weather.
03-06-1982	CS on central bay on 1 <sup>st</sup> turned to SCS on 3 <sup>rd</sup> , SCH in the evening and crossed the coast north of Paradip on 3 <sup>rd</sup> at night.	In Orissa human casualties were 245 and injured were 493.	In Orissa, 11463 cattle heads lost.	This storm caused considerable damage in Orissa. Damage to Paradip port was severe. In the port two ships experienced minor damage & about		The recorded lowest pressure was 952 mb and wind gust was 120 kt.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
				<p>100 mechanised trawlers were lifted from the lagoon water &amp; dumped on the sandy shores of Paradip port &amp; a no. of vessels were sunk. It blew away the wireless station at Paradip.</p> <p>Cyclone affected a total population of 73.23 lakh covering 25,000 sq. km in Orissa.</p> <p>No. of houses fully or partially damaged were 8.19 Lakh &amp; saline inundated area was 0.89 lakh hectare. About 3390 km P.W.D. roads were damaged. A large no. of electric line towers &amp; electric &amp; telephone poles were damaged or grounded.</p>		

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
19-07-1982	DD on 19 <sup>th</sup> over NW bay weakened to D and crossed coast near Gopalpur & Puri on 19 <sup>th</sup> night.					No damages reported. Caused only widespread rain.
13-08-1982	D crossed coast near Chandbali on 13 <sup>th</sup> morning.					No damages reported.
18-08-1982	D crossed coast near Balasore & Contai on 18 <sup>th</sup> night.					No damages reported.
27-08-1982	D crossed coast near Balasore on 28 <sup>th</sup> night.	Loss of few human lives reported in Orissa.		Widespread damage to property.		Flood in Mahanadi and Kathjuri rivers caused the damage.
10-09-1982	D crossed coast near Puri on 10 <sup>th</sup> .					Last week's flood in Orissa was worsened due to this event.
29-09-1982	D crossed Chittagong coast on 29 <sup>th</sup> morning.					No damages in India reported.
16-10-1982	DD over West Central bay on 15 <sup>th</sup> became SCS by 16 <sup>th</sup>	Exceptionally heavy rain claimed 4 lives.		3000 huts were fully or partially damaged in Vishakapatnam. Loss		

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	weakened to D and crossed north Andhra coast to the south of Kakinada by mid-night of 16 <sup>th</sup> .			due to damages to roads, minor irrigation canals etc., estimated at a few crores in coastal Andhra.		
18-10-1982	DD on 17 <sup>th</sup> off Tamilnadu became a CS in the evening, a SCS on 18 <sup>th</sup> and crossed south Andhra coast near Sriharikota on 18 <sup>th</sup> night.	59 human lives lost.		In Tamil Nadu about 300 to 400 huts were partially damaged. In Cuddapah district 2500 houses were damaged.	Lemon orchards & plantain gardens were destroyed in Nellore & Cuddapah districts of Andhra.	Min. press. recorded was 982.8 mb.
08-11-1982	D on SE Arabian sea on 4 <sup>th</sup> became CS on 5 <sup>th</sup> , a SCS on 6 <sup>th</sup> and crossed south Gujrat coast near Kodinar on 8 <sup>th</sup> .	507 people died in Gujrat. 4 died in Konkan region.	Livestock loss in Gujrat state was reported to be 1,50,332.	In Gujrat, about 12624 pucca & 54549 kutcha buildings were completely destroyed.	The crop damage was estimated at Rs. 127.23 crores.	Veraval reported lowest pressure of 963.7 mb, wind of 65 kt. and tidal wave of 2 m.
02-12-1982	D had landfall over Tamilnadu coast near Tondi on 4 <sup>th</sup> .					No damages were reported.
20-06-1983	LP off Maharashtra moved and crossed Saurashtra coast on 20 <sup>th</sup> as DD. This	Human lives lost were 594 with 1 missing, of these Junagadh	Cattle heads lost were 83,768.	About 17293 houses & 28977 huts collapsed.	68,894 hectares of agricultural land was washed away	The damage is due to the rains. The dams and

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	system lasted for 3½ days over Saurashtra causing incessant and torrential rains.	district accounts for the loss of 558 lives.			resulting in a loss of approx. Rs. 24 crores.	rivers started overflowing and inundated vast areas.
25-06-1983	DD crossed Orissa coast near Gopalpur on 25 <sup>th</sup> .					No damages were reported.
04-10-1983	D over NW bay on 2 <sup>nd</sup> turned to CS on 3 <sup>rd</sup> and crossed Andhra coast near Bheemunpatnam on 4 <sup>th</sup> .	120 persons lost their lives.	94,000 cattle heads perished.	Total loss to crops & property was estimated at about Rs. 520 crores. In Andhra, About 7,000 minor irrigation tanks breached. Flood damaged roads of about 26,000 km in length.		Lowest pressure recorded at Waltair was 989.5 hPa.
15-10-1983	D near Andaman sea on 14 <sup>th</sup> turned to DD in the evening, a SCS on 15 <sup>th</sup> crossed Bangladesh coast on 15 <sup>th</sup> evening.					No damages reported in India.
07-11-1983	D over SE bay on 6 <sup>th</sup> turned CS on 7 <sup>th</sup>					No damages reported in

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	over central bay and SCH before crossing the Bangladesh coast on 9 <sup>th</sup> evening.					India.
01-08-1984	DD over NW bay had landfall over Orissa coast between Puri & Paradip on 1 <sup>st</sup> .					No damages in the vicinity of the landfall.
15-08-1984	DD had landfall near Balasore on 17 <sup>th</sup> .	14 human lives were lost.			Extensive cropped areas were submerged.	3260 villages in six coastal districts of Orissa were severely affected.
14-10-1984	D over North and central bay on 12 <sup>th</sup> became SCH on 13 <sup>th</sup> and crossed coast north of Chandbali on 14 <sup>th</sup> .	10 people were injured in Midnapore district.		Heavy rain pulled down mud houses, uprooted trees & snapped telephone lines in Orissa. Several trees were uprooted & roofs of about 500 huts were blown off.	Standing paddy & biri crops were submerged & partially damaged in Rajnagar, Rajkanika, Aul & chandbali blocks in Orissa.	Remarkable characteristic of this system was very rapid intensification into a SCH from D stage within 12 hrs.
14-11-1984	DD in SE bay on 9 <sup>th</sup> evening became SCS on 11 <sup>th</sup> evening	A toll of 604 lives in Andhra & 54 lives in	Livestock perished were 90650 in	Swarnamukhi river bank was breached several places. About	Damages to crops in Andhra.	Sriharikota recorded lowest



ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	off Tamilnadu, crossed coast near Sriharikotta on 14 <sup>th</sup> .	Tamilnadu of which 17 in Madras.	Andhra.	one foot high water entered Sulerpet town due to breach in the river bank. Low lying areas of Gudur town were submerged. Two railway bridges Sulerpet & Tada railway station were washed away disrupting rail services between Nellore & Madras. Large no. of irrigation tanks in Nellore district to some extent in southern parts of Prakasam district of Andhra Pradesh breached causing local floods. Sriharikota island was cut-off from the mainland. 3,20,000 buildings were destroyed completely in Andhra.		pressure 984 mb.

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Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
				Damages to crops & property in AP estimated at about Rs. 223.32 crores & that at Madras about Rs. 3 crores.		
01-12-1984	D on SW bay on 27 <sup>th</sup> Nov. turned to CS on 29 <sup>th</sup> Nov. and a SCS on 30 <sup>th</sup> Nov. and crossed the coast near Karaikal on 1 <sup>st</sup> Dec.	About 15,000 persons in east Thanjavur district & 20,000 persons in south Arcot district were affected by the storm.			Standing crops in 50,000 acres in Tamilnadu were submerged due to heavy rains.	Two villages were reported to have been marooned.
25-05-1985	D over central bay on 22 <sup>nd</sup> turned to CS in evening, SCS on 24 <sup>th</sup> and crossed Bangladesh coast near Hatia on 25 <sup>th</sup> .	In Bangladesh 2.5 million people were affected. Thousands of human lives were lost.	Thousands of cattle heads lost in Bangladesh.	Storm left a trail of devastation in coastal Bangladesh. Several coastal villages were almost completely swept away.		Tidal wave of 4.5 m reported. West Bengal and NE states received good rains. No reports on damages in India.
31-05-1985	D over West Central Arabian sea on 28 <sup>th</sup> turned to CS on 29 <sup>th</sup> ,					No damages were reported.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	dissipated over NE Arabian Sea on 31 <sup>st</sup> .					
02-08-1985	D had landfall near Chandbali on 2 <sup>nd</sup> .					No reports on damages.
06-08-1985	D had landfall near Sagar Island on 6 <sup>th</sup> .					No reports on damages.
15-08-1982	D had landfall near Chandbali on 15 <sup>th</sup> .					No reports on damages.
20-09-1985	D on East Central bay on 19 <sup>th</sup> turned to CS on 20 <sup>th</sup> and crossed Orissa coast near Puri on 20 <sup>th</sup> .	Six fishermen were drowned in Chilka lake.			Due to tidal bore in river Devi several villages in Orissa were under 1 m. of water. It caused widespread damages to paddy crops, roads & prawn culture tanks in Puri.	
02-10-1985	D had landfall near Ongole on 2 <sup>nd</sup> .					No reports on damages.
07-10-1985	D crossed near Mahua in Saurashtra coast on 7 <sup>th</sup> . It crossed South	Heavy rains claimed 13 lives.				

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	Gujrat coast near Bulsar in evening.					
11-10-1985	D on SW bay on 9 <sup>th</sup> turned a CS on 10 <sup>th</sup> and crossed Andhra coast on 11 <sup>th</sup> near Vishakapatnam.			The storm affected five coastal districts of Andhra though the damaged caused by it was not significant. Damage to crops & properties, was estimated at about Rs. 31 Lakh.		Heavy rain at Narsapur on 11 <sup>th</sup> inundated low-lying areas due to which 1835 people had to be evacuated.
16-10-1985	D on East Central bay on 13 <sup>th</sup> turned SCS on 15 <sup>th</sup> and crossed Orissa coast near Balasore on 16 <sup>th</sup> .	13 persons lost their lives in West Bengal & 47 in Orissa. Also 38 persons were reported missing in Orissa. About 7.6 lakh were affected in West Bengal.	1570 cattle heads perished in West Bengal & 1073 in Orissa.	30,966 houses collapsed in West Bengal & 8703 in Orissa. Population of about 7.6 lakh was affected by the storm in West Bengal. High winds snapped electric wires in several places. Major irrigation installations in West Bengal were breached. The damage to crops & public utilities in	Crops in 72,000 hectares in 1204 villages of West Bengal & 3,24,795 hectares in 8509 villages of Orissa were affected. In Balasore district saline inundation of some low lying coastal areas damaged standing crops.	Tidal wave of 1-2 m. was reported in Orissa. Winds of 70 to 100 kmph in gusts blew over Sagar islands. Tidal wave of 3-3.5 m. was reported in Sagar islands.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
				West Bengal was estimated to about Rs. 15.1357 crores.		
12-11-1985	D stayed about 40 km south of Tambaram on 12 <sup>th</sup> .			About 50,000 huts were damaged in low-lying areas of madras city due to rain & floods.		Did not cross the coast. Heavy rains due to D alone caused the damage.
15-11-1985	D over south bay on 15 <sup>th</sup> turned to CS on 16 <sup>th</sup> and dissipated over the west central Bay on 18 <sup>th</sup> .					No damages were reported. Did not cross the coast.
13-12-1985	D on SE bay on 11 <sup>th</sup> turned to CS on 12 <sup>th</sup> and crossed South Andhra coast near Sriharikota on 13 <sup>th</sup> .	12 persons reported to have been killed in Nellore district.		Four villages in Nellore district were cut off due to floods. Uprooted a few electric & telegraph poles.		Tamilnadu and Andhra received good rains.
12-08-1986	D crossed north Andhra coast near Kalingapatnam on 12 <sup>th</sup> night.	12 persons lost their lives in Vidarbha. Heavy rain & floods in Andhra claimed 115 lives.		The estimated cost of damages to crops & properties in Vidarbha districts was about 10 crores.		Heavy rains caused flood, which had caused the havoc.

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Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
20-08-1986	D had landfall between Chandbali & Balasore on 20 <sup>th</sup> .					No damages were reported.
25-09-1986	D had landfall near Balasore on 25 <sup>th</sup> .	18 lives lost.		6.15 lakh people left homeless.		
09-11-1986	D on West Central bay on 7 <sup>th</sup> turned to CS on 9 <sup>th</sup> and crossed Bangladesh coast.		Several livestock lost.	Many fishermen living near Chilka coast lost their houses due to inundation by the lake water.	Considerable damage occurred to paddy & rabi crops in Orissa.	
01-02-1987	D over southeast bay on 30 <sup>th</sup> Jan. turned DD on 31 <sup>st</sup> , CS later, SCS on 1 <sup>st</sup> Feb. and dissipated over northeast Bay.					No damages were reported. A rare event of formation of SCS during January.
04-06-1987	CS had landfall over Bangladesh coast near Dakhin Shahbazpur on 4 <sup>th</sup> .					No damages in India.
16-10-1987	CS crossed south Andhra coast close to Ongole on 16 <sup>th</sup> .	17 human lives were lost. 6.2 lakhs in 157 villages in the coastal districts of Andhra were affected.		Damaged about 9000 houses in Andhra.	Damaged crops worth about Rs. 34 crores in Andhra.	Ongole recorded a lowest pressure of 995.1 mb.

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Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
		The remnant of the storm caused several local storms in Bihar plains on 19 <sup>th</sup> & 20 <sup>th</sup> , which took 31 human lives.				
02-11-1987	D on SW bay on 31 <sup>st</sup> Oct. turned to CS by evening, SCS on 2 <sup>nd</sup> and crossed south Andhra coast near Nellore on 2 <sup>nd</sup> .	6.8 lakh people in 288 villages of Andhra were affected. Claimed a toll of 50 human lives.	In Andhra 25800 livestock lost.	Disrupted road & train services & damaged about 68,000 houses. The cost of damage due to storm was estimated to about rupees 60 crores. The sea breached the Buckingham canal embankment.	Inundated vast stretches of paddy field. Saline water from the swollen Buckingham canal in Nellore flooded the adjoining fields.	Min. pressure of 984.3 hPa was recorded.
13-11-1987	CS of West Central bay on 12 <sup>th</sup> turned to SCS crossed coast as CS near Machilipatnam on 13 <sup>th</sup> .	28 people lost their lives in coastal Andhra.		Damaged about 8,400 houses in coastal Andhra.		Min. pressure of 994.hPa was reported. Emerged into Arabian sea on 16 <sup>th</sup> .
09-06-1988	DD had landfall over West Bengal & north					No damages were reported.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	Orissa coast near Contai on 9 <sup>th</sup> .					
17-07-1988	D had landfall over north Andhra & Orissa coast near Gopalpur on 17 <sup>th</sup> .					No damages were reported.
02-08-1988	DD had landfall over Orissa coast near Balasore on 2 <sup>nd</sup> .					No damages were reported. Heavy rains in Orissa.
01-10-1988	DD had landfall over Andhra coast north of Vishakapatnam on 1 <sup>st</sup> .					No damages reported in the vicinity of landfall area.
19-10-1988	D over NE bay on 18 <sup>th</sup> turned to CS over north bay and weakened.	In Bangladesh, 300 people were missing or feared drowned & 430 persons were injured.		Torrential rain submerged low-lying areas of Dhaka. 20 fishing boats were drowned in Chittagong & 15 boats & trawlers were sunk in Patuakhali.		No damage reported in India.
18-11-1988	CS over SE bay on 16 <sup>th</sup> turned SCS on 17 <sup>th</sup> and dissipated over NE & adjoining					No damages reported.



ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	east central Bay on 18 <sup>th</sup> .					
29-11-1988	D over Andaman sea on 23 <sup>rd</sup> turned CS on 25 <sup>th</sup> , SCS around noon, SCH on 27 <sup>th</sup> and crossed West Bengal and Bangladesh coast on 29 <sup>th</sup> .	532 people lost their lives in West Bengal. About 794 fishermen were missing in West Bengal. The storm affected a population of 28.29 Lakh in 3893 villages in West Bengal. 19 crew of a ship were drowned. Two launches of the forest dept. were drowned. A light vessel of Calcutta Port Trust, with 18 people of board was missing.  Over 2000	Perished 57,600 cattle heads in West Bengal.  In Bangladesh, the hurricane killed about 15,000 deer, 9 Royal Bengal Tigers & perished about 65,000 cattle heads.	Damaged either completely or partially about 3,45,530 houses. The estimated cost of damage to crops & properties in West Bengal was Rs. 137.77 crores. One ship was drowned.	Crops in 1,93,780 hectares damaged in West Bengal.  Estimated cost of crops damage in Bangladesh was worth about Taka 9,400 millions.	The system was one of the super storms of Indian coast. Lowest core pressure was estimated as 942 hPa. Sagar Island lighthouse recorded a min. pressure of 990 hPa. The wind was 150-180 kmph over Sagar island.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
		people were killed and 6000 people were reported missing.				
26-05-1989	D over East Central bay on 23 <sup>rd</sup> turned to CS on 24 <sup>th</sup> , SCS on 25 <sup>th</sup> , SCH on 26 <sup>th</sup> and crossed Orissa and West Bengal coast near Balasore at night.	24 people lost their lives in Orissa & 37 in West Bengal. About 6.9 million people were affected.	Perished 1000 cattle heads in West Bengal & 1625 in Orissa.	Damaged completely or partially about 53160 houses in West Bengal & 92000 in Orissa.  Affected about 3.2 million people in West Bengal & 3.7 million people in Orissa.	Damage to crops was considerable in West Bengal and Orissa. Sea water has intruded several villages in both the states.	Tidal wave of 3-6 m. was reported. Min. pressure of 970.4 mb was reported.
09-06-1989	D had landfall over Saurashtra coast near Veraval on 9 <sup>th</sup> .					No damages were reported.
13-06-1989	DD had landfall over Orissa and West Bengal coast on 13 <sup>th</sup> .					No damages were reported.
20-06-1989	D had landfall over north Orissa and West Bengal coast near Contai on 20 <sup>th</sup> .					No damages were reported.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
22-07-1989	D over West Central bay on 21 <sup>st</sup> turned CS and crossed Andhra and Orissa coast near Kalingapatnam on 22 <sup>nd</sup> .	140 persons lost their lives in Andhra.		Unprecedented rain over coastal Andhra & Telangana. Heavy rain caused breach in irrigation tanks in coastal Andhra causing severe floods. Thousands of houses in low-lying areas of Vijayawada town were submerged. 23 villages in Andhra were submerged.	Extensive damage to crops & properties in Andhra.	The damages in the vicinity of the landfall alone are given.
17-08-1989	DD on 17 <sup>th</sup> had landfall over Andhra and Orissa coast near Kalingapatnam.					No damages were reported.
17-10-1989	D had landfall over West Bengal and Bangladesh coast on 17 <sup>th</sup> night.					No damages were reported.
08-11-1989	SCH from Gulf of Siam crossed over Andaman Islands and crossed Andhra coast near Kavali on 8 <sup>th</sup> .	69 lives lost in Andhra. One life was lost in Andaman.	7100 cattle heads were perished in Andhra. About 34,000 poultry birds were lost.	Over 4 lakh people in 836 villages in coastal districts of Andhra were affected. Damaged about 1.49 lakh pucca houses &	Standing crops in thousands of acres of land were damaged in Andhra.	A unique SCH that over 100 years this is only the second SCH entering Indian

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
				huts. Due to sea water inundation Jaladanki & Harijanwada villages, situated about 11 km west of Kavali were razed to the ground. Rail services between Madras & Vijayawada came to a standstill after the landfall. Railway track of a stretch of 40 km. was blocked by uprooted trees and electric traction masts. In Andaman about 709 houses were damaged and electric supply was disrupted due to falling of about 80 electric poles. About 1000 trees were uprooted.		seas from Gulf of Siam and only storm which has traveled 2600 km over Indian seas. The estimated core pressure and the maximum wind speed were 942 mb. and 100-120 kt. respectively. 3-4 m. tidal waves lashed the coast.
09-05-1990	DD over SW bay on 5 <sup>th</sup> turned to CS by evening, SCS on 6 <sup>th</sup> , SCH on 7 <sup>th</sup> and	967 human lives lost. The storm affected about 7.78 million	About 3.61 million livestock perished in Andhra.	Diviseema island formed by the two arms of the river Krishna was	Around 54000 hectares of agricultural land was inundated	A ship trapped in the core of SCH recorded the sea level

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	crossed the south Andhra coast near Machilipatnam on 9 <sup>th</sup> .	people in 5160 villages in Andhra.		completely marooned. Machilipatnam town was under 3 to 6 ft of water for 3 to 4 days. Vishakapatnam airport was under water for about a week. Ankapalla town was engulfed under 4 to 5 ft of water. Road traffic to Machilipatnam from Vijayawada remained closed for 2 days. The heavy rainfall breached road and railway tracks at many places. The rail link between Tuni and Vishakapatnam was suspended for more than three weeks. It had fully or partially damaged about 16 lakh houses in 10 districts of the state. Bapatla Meteorological observatory was	by seawater and 62000 hectares of land were sand cast Banana plantation, coconut trees and mango crops over a vast stretch of land were severely damaged.  In Andhra about 3.08 lakh hectares crops were affected. Horticulture crops in 55,000 hectares of land were damaged.	pressure of 912 mb. The estimated max. wind speed and wave height were 150 kt and 10m respectively. Max. surge of 3-4 m. above normal tide was estimated. The loss of human lives in this cyclone was minimized by timely warnings issued & appropriate precautions taken. About 6.5 lakh people were evacuated to safer places from 546

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
				<p>damaged. The multimet. radar antenna and the cups of the high- speed anemometer were blown off by gale winds.</p> <p>At Ennore, Tamilnadu the sea waves damaged the Kashi Viswanath temple and washed away a few fisherman colonies in Pulicat.</p> <p>As per the Andhra Govt. report, the estimated cost of the damages in the state were about Rs. 2289.63 crores under the following heads:</p> <p>(i) Damages to private dwelling units: Rs. 550.00 crores</p> <p>(ii) Damages to agricultural crops: Rs. 289.34 crores</p>		coastal villages.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
				(iii) Damages to horticulture crops: Rs. 530.35 crores (iv) Damages to irrigation dept.: Rs. 173.85 crores (v) Damages to Panchayat Raj Dept.: Rs. 246.00 crores (vi) Damages to transport, roads & buildings dept.: Rs. 138.50 crores (vii) Damages to Forest energy & environment dept.: Rs. 118.31 crores (viii) Damages to industry, social welfare & other Dept.: Rs. 243.28 crores.		
14-06-1990	DD had landfall near Contai in Orissa on 14 <sup>th</sup> .					No damage reported in the vicinity of the landfall area.
15-08-1990	D had landfall near Gopalpur in Orissa					No damage reported in the

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	on 15 <sup>th</sup> .					vicinity of the landfall area.
21-08-1990	DD had landfall near Paradip in Orissa on 21 <sup>st</sup> .					No damage reported in the vicinity of the landfall area.
08-10-1990	D had landfall near Contai in West Bengal on 8 <sup>th</sup> .	Thousands of people were marooned by flood in Midnapore district.		The system caused heavy rain in Orissa, West Bengal & Assam. About 384 villages in Midnapore district and 938 villages in Nadia district were badly hit by floods. Several districts of Gangetic West Bengal experienced damage due to floods.		
04-11-1990	DD had landfall over north Andhra-south Orissa coast on 4 <sup>th</sup> .	100 human lives lost due to flood.		A population of 6 lakh in 341 villages was seriously hit by the flash flood. Aska town was virtually under flood. Thousands of houses were washed away by flood waters	Immense damage to crops and properties due to flood.	



ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
				of the rivers Rushikulya & Badanadi rendering lakhs of people homeless.		
14-11-1990	D had landfall near Nellore around midnight on 14 <sup>th</sup> .					No damages were reported. This system entered Arabian sea.
18-12-1990	SCS over West Central bay on 17 <sup>th</sup> had landfall over Bangladesh coast near Cox's Bazaar on 18 <sup>th</sup> .					No effect on Indian weather adversely. Caused considerable damage to Bangladesh coast.
29-04-1991	D over SE bay on 24 <sup>th</sup> became a SCS on 27 <sup>th</sup> and crossed Bangladesh coast around midnight on 29 <sup>th</sup> .	132000 lost in Bangladesh. People in cyclone-hit area were affected by diarrhoea & gastroenteritis. 2 human lives lost in Mizoram		About 40 Bangladesh air force planes on the runway were badly damaged and airfield was inundated by flood. Telecommunication links to the outside world were totally cut	Paddy crops over an area of approx. 1000 sq. km. were destroyed in Bangladesh. Considerable damage to the standing crops	Storm surge of 5.5m in height. Tidal waves carried a ship 2 km. inland from Chittagong port. Landslides in Mizoram were

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
		and 5 in Tripura.		off. 250 houses in West Bengal and 7000 houses in Tripura were damaged.	in India.	reported.
02-06-1991	CS had landfall over Bangladesh coast between Bhola & Hatia on 2 <sup>nd</sup> .	300 fishermen were missing in Bangladesh				Tidal waves of 1-2 m. were reported during landfall. No damages reported in India.
28-07-1991	D had landfall over Orissa coast near Paradip on 28 <sup>th</sup> .	17 people lost their lives in Orissa.			Vast areas of paddy field were inundated.	
22-08-1991	D crossed Orissa-West Bengal coast near Balasore on 22 <sup>nd</sup> .	11 human lives lost in Orissa and 9 in Rajasthan.			Submerged vast areas of paddy fields in Orissa.	
21-09-1991	D crossed Andhra coast near Kakinada on 21 <sup>st</sup> .					No damages were reported.
14-10-1991	D crossed the coast of Bangladesh on 14 <sup>th</sup> .	18 lost in Assam. Flood and heavy rain affected 5,94,249 people	109 cattle heads were lost in Assam.		Affected 47,680 hectares of Agricultural land.	Landslides occurred at several places in Assam. No report on the

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
		in 591 villages in Assam.				damages in Bangladesh.
29-10-1991	D crossed Tamilnadu coast near Pondicherry on 29 <sup>th</sup> .	21 human lives lost in Andhra Pradesh and 21 in Tamilnadu.				
13-11-1991	D on 11 <sup>th</sup> turned to CS on 13 <sup>th</sup> and crossed Tamilnadu coast on 14 <sup>th</sup> night.	185 persons lost in Tamilnadu & 16 in Nellore.	540 cattle heads perished in Tamilnadu.	Damage was estimated around Rs. 1508 million as a result of damages to buildings & public works.	Considerable damage to crops & properties; estimated damage due to crop loss – Rs. 1724 million.	
19-05-1992	D on 16 <sup>th</sup> turned to CS on 18 <sup>th</sup> and crossed Arakan coast around noon on 19 <sup>th</sup> .					No damages reported.
11-06-1992	CS formed over Arabian Sea and dissipated.					No damages were reported.
18-06-1992	DD crossed Orissa coast on 18 <sup>th</sup> near Puri.	Heavy rainfall in Orissa caused the death of 7 people.				

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
26-07-1992	DD crossed Orissa coast on 26 <sup>th</sup> near Chandbali					No reports on damages.
03-10-1992	DD formed over Arabian sea became CS and crossed Oman coast on 3 <sup>rd</sup> morning.					Did not cause any rainfall or damages in India.
09-10-1992	DD crossed south Andhra coast near Machilipatnam on 9 <sup>th</sup> .					No reports on damages.
21-10-1992	D on 20 <sup>th</sup> over north bay turned to DD on 21 <sup>st</sup> , CS in the evening and crossed Bangladesh coast near Cox's Bazaar at night.					No reports on damages.
06-11-1992	CS over east central bay on 4 <sup>th</sup> , dissipated over the ocean on 6 <sup>th</sup> .					No reports on damages.
12-11-1992	DD on 11 <sup>th</sup> over SW bay crossed Sri Lanka coast on 12 <sup>th</sup> noon, emerged into	Due to heavy rainfall, landslide and flood about 175 human lives				

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	Gulf of Mannar and crossed south Tamilnadu coast near Tuticorin on 13 <sup>th</sup> around noon. This emerged into Arabian sea as D on 14 <sup>th</sup> , intensified to DD and crossed Karnataka coast near Honavar on 17 <sup>th</sup> evening.	were lost; About 160 reported missing in Tamilnadu & Kerala.				
21-11-1992	D on 15 <sup>th</sup> became CS on 17 <sup>th</sup> , SCH on 18 <sup>th</sup> and crossed over Bangladesh-Myanmar coast near Teknoff on 21 <sup>st</sup> afternoon.					Estimated core pressure was 942 mb. Did not cause any rainfall or damages in India.
17-06-1993	DD crossed the Bangladesh Coast on 17 <sup>th</sup> noon.	6 people lost their lives & more than 50,000 people in 100 villages were reeling under the flood in many districts				

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
		of Assam. 12 lost in Bangladesh due to flood.				
09-11-1993	D crossed south Tamilnadu coast near Tuticorin on 9 <sup>th</sup> .	30 people lost their lives in Tamilnadu.				
14-11-1993	D on 12 <sup>th</sup> over SE Arabian sea became CS on 13 <sup>th</sup> , SCS on 14 <sup>th</sup> , SCH in the evening, weakened to CS on 15 <sup>th</sup> .	About 50 fishermen were reported missing along the north Gujrat coast.				Heavy rains in Gujarat and Kutch.
04-12-1993	CS on 2 <sup>nd</sup> over south bay became SCS on 3 <sup>rd</sup> , SCH in the evening and crossed north Tamilnadu coast near Karaikal on 4 <sup>th</sup> .	Nearly 111 people were killed due to heavy rains & floods in south Tamilnadu.		Disrupted rail & road traffic & damaged the telecomm system.	Damage to standing crops.	
02-05-1994	CS over Andaman sea on 29 <sup>th</sup> April intensified to SCS on 30 <sup>th</sup> , SCH on 1 <sup>st</sup> May and crossed south Bangladesh–north Myanmar	200 people lost their lives and many fishermen were missing along the coast of Bangladesh.				No loss reported over India.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	coast on 2 <sup>nd</sup> May at midnight.					
09-06-1994	CS off Bombay in Arabian sea on 6 <sup>th</sup> , became SCS on 7 <sup>th</sup> and moved off to Saudi Arabian coast.					Did not cause any damage in India.
18-08-1994	DD crossed north Orissa coast near Chandbali on 18 <sup>th</sup> .					Caused flood and damages to the houses & property in the areas along the route of system.
05-10-1994	DD crossed Andhra Pradesh coast near Machilipatnam on 5 <sup>th</sup> morning.	38 human lives lost in Andhra Pradesh due to flood.				
31-10-1994	DD over SW bay on 29 <sup>th</sup> turned CS on 30 <sup>th</sup> , SCS in the evening and crossed the Tamilnadu coast near Madras on 31 <sup>st</sup> .	69 died in Tamilnadu. 235 died in Andhra Pradesh.		Road and tele-links were disrupted. Many telephone poles were damaged. 60,000 huts in Andhra Pradesh & 30,000 in Tamilnadu were damaged.	More than 60,000 hectares of crop area were damaged.	Total damage was Rs. 61 crores in Tamilnadu and about Rs. 3000 crores in Andhra. Tidal wave of 1-2 m. reported.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
04-11-1994	D had landfall over Tamilnadu coast near Karaikal on 4 <sup>th</sup> at midnight.				Caused damage to crops and property in Tamilnadu.	
19-11-1994	DD from SE Arabian sea on 16 <sup>th</sup> became CS on 18 <sup>th</sup> , SCS a few hours later, SCH on 19 <sup>th</sup> and crossed Somalia coast.					No damages reported.
06-05-1995	DD had landfall over north Tamilnadu coast on 6 <sup>th</sup> evening.	12 lost in Tamilnadu and 5 in Kerala.		Damage to about 400 houses in Tamilnadu.	Damage to standing crops.	The damages were due to heavy rains & flood.
09-05-1995	DD had landfall over Andhra coast near Tuni around on 9 <sup>th</sup> .	22 lost in Andhra.		About 40,000 houses were damaged.	Thousands of hectares of crops were destroyed.	Total estimated damage in Andhra was Rs. 470 crores.
16-05-1995	DD had landfall over West Bengal coast near Sagar Island on 16 <sup>th</sup> morning.	35 died in Orissa and 12 in West Bengal. 60 lost in Bangladesh.		Flood caused breaches in several embankments and damaged 20,000.		In Bangladesh, tidal waves made about 60,000 people homeless.
17-09-1995	D had landfall over north Orissa coast near Balasore on 17 <sup>th</sup> .					No report on damages.



ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
26-09-1995	D over NW bay on 26 <sup>th</sup> crossed north Orissa coast near Balasore 26 <sup>th</sup> noon.			Many highways were blocked. Millions of people were affected due to flood in West Bengal.		
13-10-1995	CS formed over SE Arabian sea and diffused over sea.					No report on damages.
09-11-1995	CS over SE bay on 8 <sup>th</sup> turned SCS in the evening, SCH in 3 hrs. and had landfall over north Andhra and Orissa Coast near Ichchapuram in Kalingapatnam district on 9 <sup>th</sup> .	49 died in Andhra, 20 in Orissa and 4 in West Bengal. 240 persons were reported missing from these areas.		About 52000 houses were damaged or partially damaged due to the gale winds & heavy rains. Severe damage to roads, electric poles & telecommunications.	Crops of about 2 million hectares area were badly damaged.	
25-11-1995	DD over SE bay on 22 <sup>nd</sup> turned to CS afternoon, SCS on 23 <sup>rd</sup> , SCH at night had landfall over Bangladesh coast near Cox's Bazaar on 25 <sup>th</sup> noon.					No damages reported in India.
08-05-1996	DD had landfall over Bangladesh-					No reports on damages.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	Myanmar coast near Cox's Bazaar on 8 <sup>th</sup> .					
16-06-1996	DD on 13 <sup>th</sup> over SW bay turned to CS on 14 <sup>th</sup> and crossed the coast near Vishakapatnam on 16 <sup>th</sup> .	Coastal districts of AP reported 68 human deaths. 41 killed in Tamilnadu.		In Andhra, 6000 houses were damaged and estimated loss was Rs. 82 crores. In Tamilnadu, 4 fishing vessels were drowned. Road & railway traffic was badly affected.		
19-06-1996	D at East Central Arabian sea on 17 <sup>th</sup> turned to DD on 18 <sup>th</sup> , CS in the evening, SCS at night and had landfall near south Gujarat coast close to Diu on 19 <sup>th</sup> .	In Gujarat and in Maharashtra respectively 33 and 14 human lives were lost.	In Gujarat 2082 cattle and in Maharashtra 31 cattle heads were perished.	In Gujarat, 161 talukas and 5573 villages were affected.		Estimated max. wind speed was 100 to 120 kmph. and storm surge was 3 to 4 m. above normal.
01-10-1996	D had landfall over South Andhra coast near Ongole on midnight of 1 <sup>st</sup> .	23 people were reported dead in Andhra due to rains.				
25-10-1996	D on West Central Arabian sea on 21 <sup>st</sup> turned to DD on 22 <sup>nd</sup> , Cs on 23 <sup>rd</sup> ,			11 fishing boats were missing off Veraval port and about 50 boats were stranded in		

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	SCS in the evening weakened to CS on 25 <sup>th</sup> and diffused on 28 <sup>th</sup> off Gujarat coast.			the high sea due to strong winds.		
28-10-1996	DD on East Central bay on 25 <sup>th</sup> turned to DD at night and crossed coast near Indo-Bangladesh border on 28 <sup>th</sup> .	14 lives were lost in West Bengal. 100 fishermen were reported missing off West Bengal coast.		In West Bengal heavy rains caused breaches in embankments and affected 1,60,000 people. Nine fishing trawlers / boats were missing. In Bangladesh 20,000 people became homeless due to inundation.	Paddy crops and many houses were damaged.	Storm surge of 3 m. was reported.
06-11-1996	D over East Central bay on 4 <sup>th</sup> became DD on 5 <sup>th</sup> , CS later, SCS on 6 <sup>th</sup> , SCH later and had landfall over Andhra, south of Kakinada on 6 <sup>th</sup> .	1058 lost in Andhra. More than 1677 fishermen were missing.		A microwave tower at Kakinada collapsed due to strong winds. Extensive damage to property. 6800 fishing boats were damaged.		Strong winds of speed 150-200 kmph in gusts and tidal waves of 2.6 m. were reported.
06-12-1996	D over SE bay on 28 <sup>th</sup> Nov. became DD on 29 <sup>th</sup> , CS on 2 <sup>nd</sup> Dec., SCH on 3 <sup>rd</sup>	Did not cause any damage to life.				No reports on the damages. Unique event in the sense that

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	evening, weakened to SCS on 4 <sup>th</sup> and had landfall over Tamilnadu coast on 6 <sup>th</sup> .					the system has made two loops in its path before landfall.
19-05-1997	DD over south bay on 15 <sup>th</sup> turned to CS on 16 <sup>th</sup> , SCS on 17 <sup>th</sup> , SCH on 18 <sup>th</sup> and had landfall over Bangladesh coast near Sitakundu on 19 <sup>th</sup> .	In Bangladesh, 155 people were killed.		In Bangladesh 1,12,160 houses were fully damaged. Roads & other communications got badly affected.		Did not cause any damage in India. Lowest pressure recorded was 965 mb and max. wind was 126 kt.
27-06-1997	D over north bay on 26 <sup>th</sup> turned DD and had landfall near north Orissa – South West Bengal coast on 27 <sup>th</sup> .			500 houses were washed away. More than 40,000 people were rendered homeless due to breaches in the embankment. Due to heavy rains and flood normal life was disrupted. Many highways in West Bengal were blocked.		
30-07-1997	D over north bay on 29 <sup>th</sup> turned to DD on					The system did not cause any

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	30 <sup>th</sup> and had landfall over north Orissa coast near Chandbali in the evening.					damage.
05-08-1997	D over north bay on 4 <sup>th</sup> turned to DD on 5 <sup>th</sup> and had landfall over West Bengal coast near Sagar Islands in the afternoon.					Did not cause any damage.
20-08-1997	DD over NW bay on 20 <sup>th</sup> crossed north Orissa coast between Paradip and Chandbali in the afternoon of 20 <sup>th</sup> .	12 people died due to heavy rains & floods in Orissa.				
28-08-1997	D had landfall over Orissa coast between Paradip and Puri on 28 <sup>th</sup> .					No reports on damages.
27-09-1997	D on West Central bay on 23 <sup>rd</sup> turned to DD in the evening, CS on 24 <sup>th</sup> evening,	32 human lives lost in Andhra.	326 cattle were lost.	39 breaches to tanks and 1470 houses damaged.		

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	SCS a few hours later, weakened to CS still later and crossed Bangladesh coast near Hatia on 27 <sup>th</sup> .					
04-11-1997	CS over north Andaman sea on 4 <sup>th</sup> weakened to DD on 9 <sup>th</sup> and diffused.					Did not cause any damage.
20-05-1998	D over central bay on 17 <sup>th</sup> turned to DD on 18 <sup>th</sup> , CS on the same day, SCS on 19 <sup>th</sup> crossed the coast of Bangladesh on 20 <sup>th</sup> .					Did not cause any damage over India. Widespread rains over NE states of India.
09-06-1998	D on Lakshadweep sea on 4 <sup>th</sup> turned to DD later, CS on 5 <sup>th</sup> , SCS on 6 <sup>th</sup> , VSCS on on 7 <sup>th</sup> and had landfall over Gujrat coast near Porbandar on 9 <sup>th</sup> morning.	In Gujrat, 1173 lives were lost with another 1174 missing.		More than 2.5 lakh houses have been destroyed or damaged. The total extent of damage to the state of Gujrat was of the order of Rs. 190 crores.		Estimated core pressure and max. wind were 962 mb and 98 kt. respectively.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
14-06-1998	D over Central bay on 13 <sup>th</sup> turned to DD in the evening and had landfall over north Andhra coast near Vishakapatnam on 14 <sup>th</sup> .					No report on damages.
14-10-1998	D on West Central bay on 13 <sup>th</sup> turned to DD and had landfall near Narasapur on 14 <sup>th</sup> .	101 human lives were lost in Andhra.			50 villages got submerged and crops in thousands acres of agricultural land got damaged.	Andhra Govt. declared a total loss of Rs. 600 crores.
17-10-1998	D over SE Arabian sea on 11 <sup>th</sup> turned to DD on 12 <sup>th</sup> , CS on 16 <sup>th</sup> and had landfall near Veraval on 17 <sup>th</sup> morning.					No reports on damages.
29-10-1998	D over SE bay on 26 <sup>th</sup> turned to DD on 27 <sup>th</sup> and dissipated near 300 km. southeast of Machilipatnam.				Paddy, Sugar, Cotton crops submerged in water in all the coastal districts of Andhra.	

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
15-11-1998	DD over south bay on 14 <sup>th</sup> turned to CS later, SCS on 15 <sup>th</sup> , VSCS after a few hours and crossed north Andhra coast just south of Vishakapatnam on 15 <sup>th</sup> evening.	16 people lost their lives in Vishakapatnam.		Thousands of houses got damaged and about 28000 families were affected in Vishakapatnam district.		Gale winds of 76 kt. were reported. Damage to the property worth of Rs. 306 crores was reported.
22-11-1998	D over Andaman sea on 19 <sup>th</sup> turned to DD in the evening, CS on 20 <sup>th</sup> , SCS on 21 <sup>st</sup> , VSCS later in the evening and had landfall over West Bengal coast between Sagar Island & Sundarban area of West Bengal on 22 <sup>nd</sup> noon.			Uprooted trees & electric poles. Parts of Sagar Island submerged & affected 25,000 people in eight villages and 3,000 mud houses were collapsed. Lakh of people were affected in 24-Paraganas & Midnapore districts.	Caused damage to crops.	Estimated core pressure and max. wind were 984 mb and 80-100 kmph respectively.
16-12-1998	D over SE Arabian sea on 13 <sup>th</sup> turned to CS in the evening, SCS on 14 <sup>th</sup> , weakened to CS on					Did not cause any damage over India.



ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	15 <sup>th</sup> and DD on 16 <sup>th</sup> and dissipated.					
03-02-1999	D over SE bay on 1 <sup>st</sup> turned to DD on 2 <sup>nd</sup> , CS at night, weakened to DD on 3 <sup>rd</sup> and dissipated.					No damages reported. Did not cross the coast.
20-05-1999	D on Lakshadweep sea on 16 <sup>th</sup> turned to CS on 17 <sup>th</sup> , SCS after 6 hrs, VSCS on 18 <sup>th</sup> and crossed Pakistan coast about 80 km. west of Naliya on 20 <sup>th</sup> .	453 persons (most of them were fishermen) lost their lives in Jamnagar, Mehsana & Kutch districts.	50448 cattle were lost.	More than 4,500 houses were damaged.		Estimated core pressure and max. wind were 946 mb and 102 kt. A storm surge of 2.5 m above the normal tide was reported.
17-06-1999	D over NW bay on 17 <sup>th</sup> turned to DD had landfall near Gopalpur on 17 <sup>th</sup> at night.	5 fishermen were missing in coastal districts of Andhra Pradesh.				
28-07-1999	D over NW bay on 27 <sup>th</sup> turned to DD in the evening and had landfall over West Bengal–Orissa coast on 28 <sup>th</sup> morning.					No report on losses.

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
07-08-1999	D had landfall over West Bengal coast near Digha on 7 <sup>th</sup> .					No report on losses.
17-10-1999	D over north Andaman sea on 15 <sup>th</sup> turned to CS on 16 <sup>th</sup> , SCS at night became a VSCS on 17 <sup>th</sup> and had landfall over Orissa coast near Gopalpur.	197 died in West Bengal.	More than 8,300 cattle were lost.	400 houses got damaged.	Crops over thousand hectares of land were damaged.	Storm surge of height 2 to 2.5 m. was reported.
29-10-1999	D over north Andaman sea on 25 <sup>th</sup> turned to CS on 26 <sup>th</sup> , SCS on 27 <sup>th</sup> , VSCS at night, became a Super CS on 28 <sup>th</sup> and had landfall over Orissa coast near Paradip on 29 <sup>th</sup> .	<u>In Orissa :</u> 9887 human lives lost and 40 missing. 2507 persons were injured.  <u>In West Bengal :</u> 2 children died.	<u>In Orissa :</u> 4.44 lakh of livestock perished.	<u>In Orissa :</u> 16.49 lakh houses were damaged. 9085 fishing boats were lost. 22143 fishing nets were lost. Caused severe damage in 12 districts of Orissa state where all essential services were cut off. 129.22 lakh population were affected. 14643 villages were affected. <u>In West Bengal :</u> 10,000 people were	<u>In Orissa :</u> 18.42 lakh hectares of crop area affected.	Estimated core pressure and max. wind were 912 mb and 140 kt. respectively. After recording 80 kt. Paradip anemometer went out of order. A storm surge of 9 m. above normal tide and tidal inundation of 35 km. from the

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
		50 persons were missing.		affected. 100 houses were damaged.		coastal line were reported. Very heavy rainfall was observed at many places, ex: 43 cm. at Bhubaneshwar.
29-05-2000	D over SE bay on 27 <sup>th</sup> turned to DD on 29 <sup>th</sup> , CS in the evening and dissipated over sea.					No damage to life & property was reported.
23-08-2000	D over west central bay on 23 <sup>rd</sup> crossed north Andhra coast near Kakinada by midnight.	131 lost in central parts of Andhra. 98079 people were evacuated and kept in 189 relief camps.	About 5368 cattle were lost.	About 8651 houses were fully damaged, 27026 were partially damaged in 2886 villages/towns. 7435 km length of road was damaged. 1578 irrigation tanks were breached. 902 power transformers, 787 distribution transformers and 28 sub-stations were damaged. 225 and	An estimated 1,77,987 hectares of paddy and other crops were damaged.	

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
				6000 numbers of 33KV lines and 11 KV lines respectively, were damaged.  Total estimated loss reported by Govt. of Andhra Pradesh was Rs. 776.75 crores.		
17-10-2000	D over west central bay on 15 <sup>th</sup> turned to DD at night, CS on 17 <sup>th</sup> and diffused.					No damage of life & property was reported.
28-10-2000	D over east central bay on 25 <sup>th</sup> turned to DD on 27 <sup>th</sup> , CS at night and crossed Bangladesh coast, east of Sagar Island on 28 <sup>th</sup> .	One child was injured in north 24 paraganas districts.	Caused loss of a large no. of livestock.	Six of the seven districts of Meghalaya state were affected. Extensive damage to infrastructure and damage to hundreds of houses were reported. Thousands of people were rendered homeless. The preliminary estimate of total damage was of the order of Rs. 60 crores.	Caused damaged to standing crops & plantation.	

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
				In Gangetic West Bengal, two irrigation dams and an embankment were damaged. Many mud huts collapsed in south & north 24 Paraganas district.		
29-11-2000	D over SE bay on 26 <sup>th</sup> turned to DD at night, CS on 27 <sup>th</sup> , SCS on 28 <sup>th</sup> , VSCS after 6 hours and crossed north Tamilnadu coast near Cuddalore on 29 <sup>th</sup> .	10 persons in Tamilnadu and 2 in Pondicherry lost their lives.		Partial damage to more than 1000 kucha houses & 14 brick houses. Estimated loss in Cuddalore district was Rs. 20 crores. Total loss estimated in Pondicherry was Rs. 50 crores.	100 acres of Sugarcane, 30000 plantain trees, 50000 plantain saplings got destroyed in Tamilnadu.	Estimated core pressure and max. wind were 978 mb and 110-120 kmph respectively.
28-12-2000	D over south bay on 23 <sup>rd</sup> turned to DD on 24 <sup>th</sup> , CS on 25 <sup>th</sup> , SCS at night, VSCS on 26 <sup>th</sup> and crossed the Sri Lanka coast and emerged in Gulf of Mannar.		3 cattle in Tuticorin and 2 in Tirunelveli were lost.	350 houses in Ramanathapuram district, 162 houses (16 fully and 146 partially) in Tirunelveli district and 318 houses in Tuticorin district (65 fully & 253	281 hectares of Paddy crops, 650 hectares of plantain and 80 hectares of Petal crops were lost in Tuticorin.	

ANNEXURE -III

Date	Description of the meteorological event	Loss of		Property loss		Remarks
		Human lives	Livestock	Infrastructural	Agricultural	
	Weakened to SCS on 27 <sup>th</sup> evening and CS at night and crossed Tamilnadu coast south of Tuticorin on 28 <sup>th</sup> in the early hours.			partially) were damaged. 95 fishing boats were lost in Tuticorin district.		