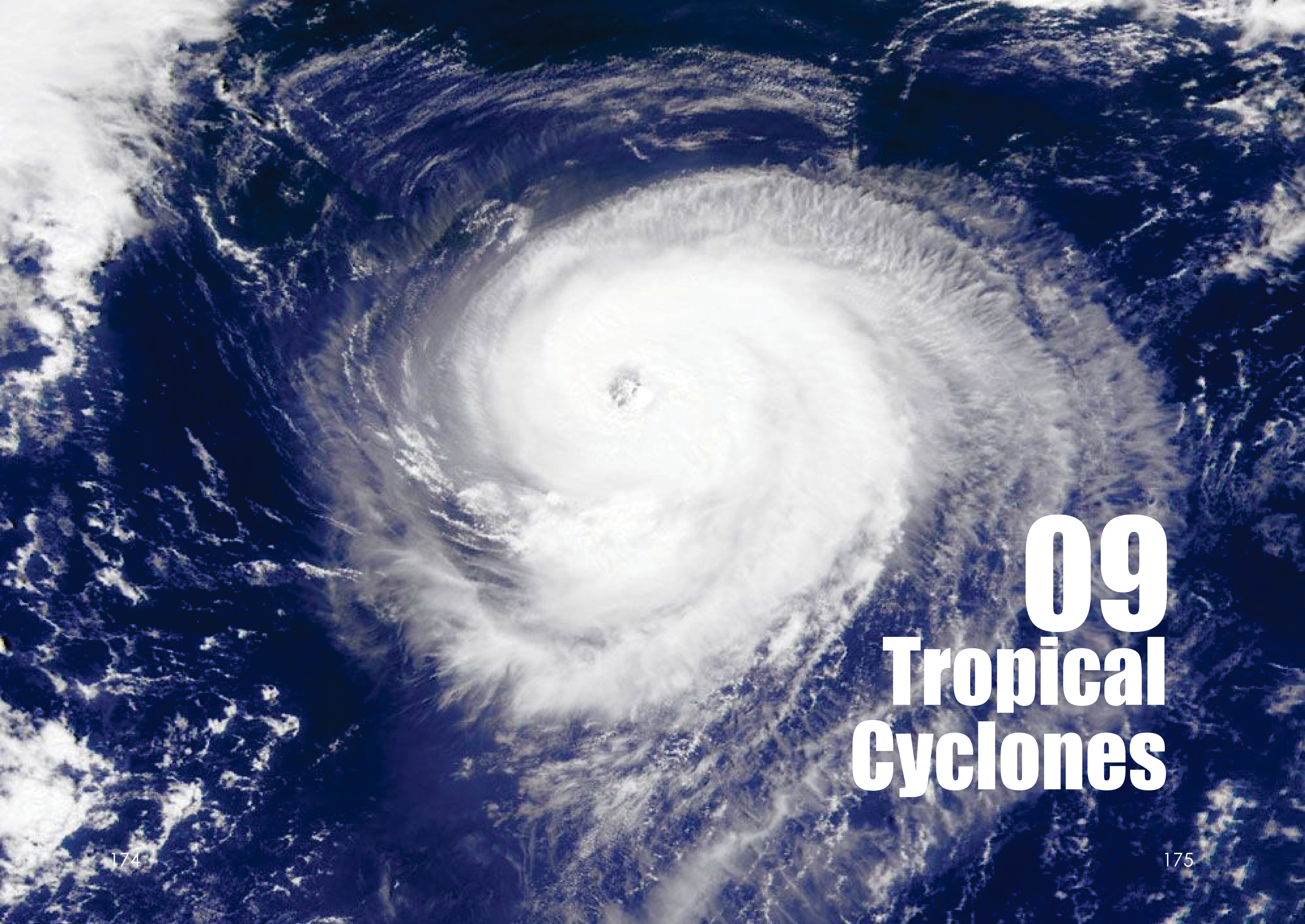


09 Tropical Cyclones

9.1 Background

Tropical region is considered as the region between the Tropic of Cancer (230 North) and the Tropic of the Capricorn (230 South) of the earth. The weather characterized in this region is called tropical weather and Tropical cyclones (TC) are one of the most important tropical weather systems and among the most devastating of all natural hazards. Tropical cyclones are capable of producing very strong winds, particularly near its centre, torrential rainfall and associated storm surge. TC can also be very destructive, often causing severe and widespread damage to coastal communities, infrastructure and ecosystems.

Hurricane, Typhoon and Cyclone are different terms used for tropical cyclones. The term Hurricane is used in the western North Atlantic, Central and Eastern North Pacific, Caribbean Sea and Gulf of Mexico and the term Typhoon is used in the Western North Pacific. In the Indian Ocean and Western South Pacific, tropical cyclones are called Cyclones. In the case of tropical cyclones, when the maximum sustained wind near the centre exceeds 119 km/h, they are called **"severe cyclonic storm"** in the North Indian Ocean. The possibility for the formation of tropical cyclones in the South Atlantic Ocean and the South Eastern Pacific is very low due to the cooler sea surface temperature and higher vertical wind shear. TC's develop at latitudes usually greater than 05^0 from the equator and they reach their highest intensity while they are located over warm tropical waters.

The oceanic basins where tropical cyclones form on regular basis are as follows:

1. Atlantic basin (including the North Atlantic Ocean, the Gulf of Mexico, and the Caribbean Sea)
2. Northeast Pacific basin (from Mexico to about the dateline)
3. Northwest Pacific basin (from the dateline to Asia including the South China Sea)
4. North Indian basin (including the Bay of Bengal and the Arabian Sea)
5. Southwest Indian basin (from Africa to about 100 E)
6. Southeast Indian/Australian basin (100 E to 142 E)
7. Australian/Southwest Pacific basin (142 E to about 120 W)

Besides heavy rains and fairly strong winds during the monsoonal periods, hazardous weather events experienced in Sri Lanka are tropical cyclones and thunderstorms/ thunder squalls. Though Sri Lanka is situated in the periphery of the tropical cyclone belt, the impact of cyclone effect on Sri Lanka is not much severe when compared with the same on other neighboring countries. Although the cyclone impact for Sri Lanka is less severe, whenever a tropical cyclone develop in the Bay of Bengal it indirectly affects the weather in Sri Lanka always.

9.1.1 Causative Factors

A major contributing factor for the formation of tropical cyclones is the sea-surface temperature. Higher loads of solar radiation over the region during the period feeds sensible heat required to maintain the ocean temperature at over 26-27°C which is a critical requirement for cyclogenesis.

Sensible heat maintains the vertical coupling between the lower and upper tropospheric flow pattern in the cyclone. The Cumulus convection acts as prime mechanism for vertical coupling. The absence of sensible heat leads to the degeneration of cyclone.

Numerous studies have shown that Sea Surface Temperatures (SST) below 26°C do not contribute sufficient thermal buoyancy to sustain cumulonimbus convection. Cyclones are influenced, greatly, by the underlying ocean surface over which they form and travel. As long as cyclone remains over warm water, the energy is limitless. Warm and highly humid equatorial and maritime tropical air spirals inward towards the centre of the low pressure to replace the heated and rapidly ascending air. Ascending air releases heat into the atmosphere, cools and are condensed into cloud. Since tropical cyclones are warm-core systems, air from the core rises and cold air sinks which converts heat energy to potential energy and, thereafter, potential energy to kinetic energy. However, the prime energy source in the storm field is the latent heat of condensation (Wijemannage, 2007).

9.1.2 Structure of a Cyclone

At the initial stage, a cyclone is usually a major cloud cluster with rainy weather. Once they develop into a depression, they become almost circular in shape. A well-developed cyclone has the features illustrated in Fig 9.1 and consists of eye, eye wall and Spiral Bands (Feeder Bands). The centre or eye of a tropical cyclone is at the area of lowest pressure and is characterized by little or no wind and often a cloudless sky. In severe cyclones the eye usually shows up as a circular hole in the central cloud mass. The eye is usually about 40 km in diameter, but can vary between less than 10 km and more than 100 km.

Surrounding the eye is a wall of dense convective cloud rising about 15-17 km into the atmosphere. This is the eye wall and is where the most violent winds and heaviest rainfall occur.

Spiral Bands (Feeder Bands) often extend up to 1,000 km from the cyclone centre, and contain heavy rain and strong winds. Distinctive pattern of convective cloud bands are spiraling into the eye wall.

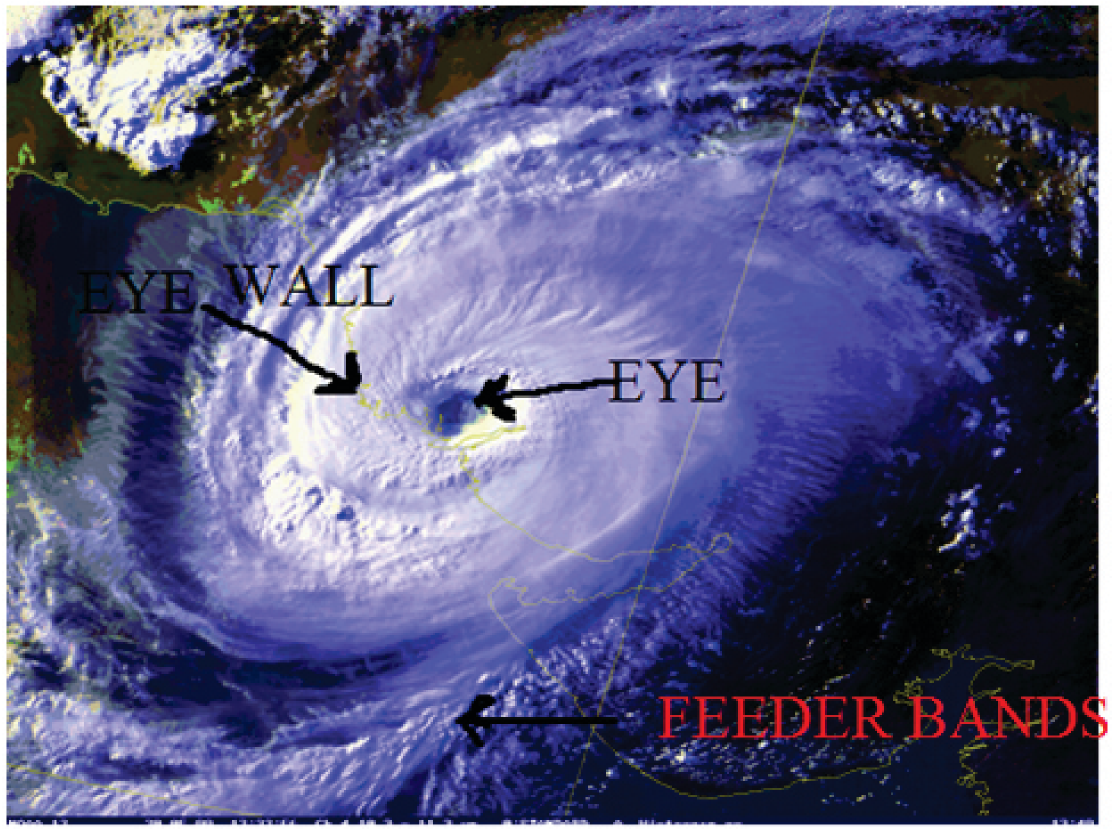


Fig 9.1 Structure of a cyclone

9.1.3 Locations of Development

About 80 tropical cyclones develop over the globe per year (McBride, 1995). Out of the total number, approximately 7% develop in the North Indian Ocean. North Indian Ocean consists of two areas, namely, the Bay of Bengal and Arabian Sea (Fig 9.2 & 8.1.1). The Bay of Bengal is a potentially active region for development of tropical cyclone.

During April to May and from October to mid December, westward propagating minor tropical disturbances near and over the South Bay of Bengal develop into cyclones. The Inter Tropical Convergence Zone (ITCZ) illustrated in Fig 9.3, is the meeting zone of winds from the two hemispheres (Southern and Northern), which play an important role in the formation of tropical cyclones in the Bay of Bengal. ITCZ appears to be more active during the months of April and October, when solar radiation peaks over tropical regions of the earth. Low pressure systems usually develop during these periods near the Inter Tropical Convergence Zone, especially during October and November, and develop into cyclones or even into severe cyclones depending on the conditions of the atmosphere and ocean.

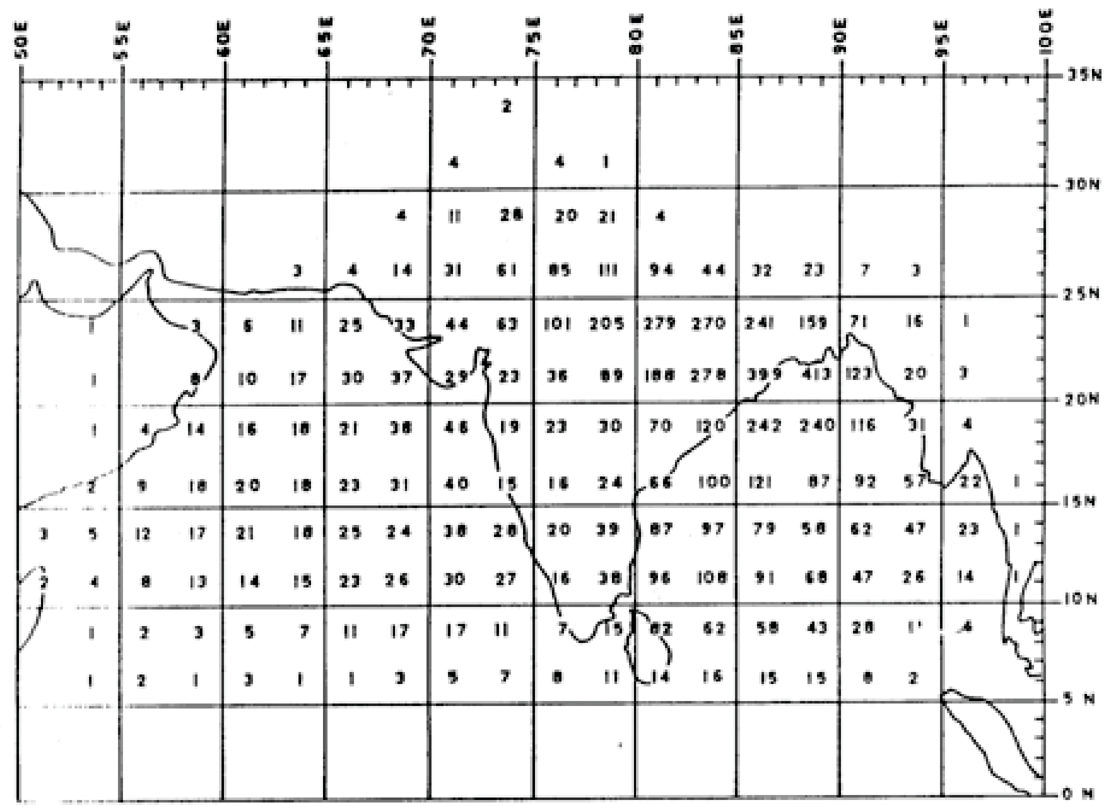


Fig 9.2: Number of tropical cyclones passing through each 2.5 deg. lat.-long. Box during the period from 1877-1974 (McBride 1995).

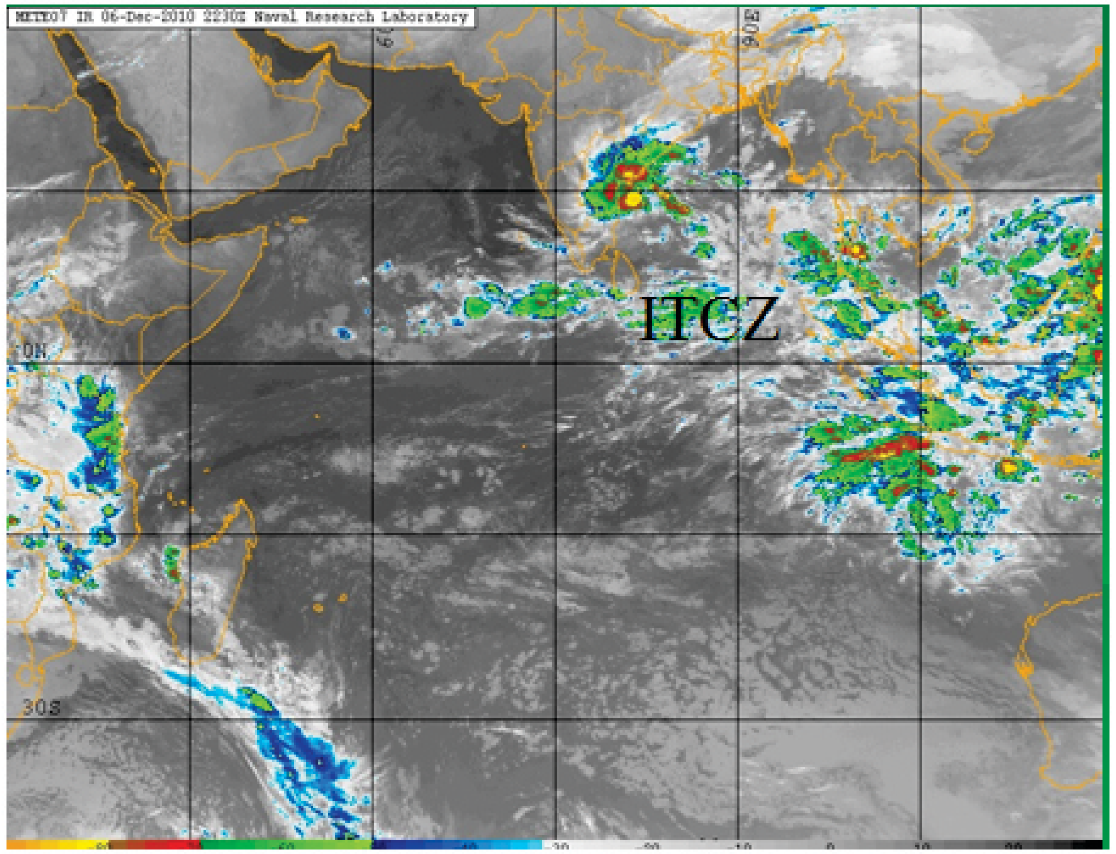


Fig 9.3 Inter Tropical Convergence Zone (ITCZ) lies just south of Sri Lanka

9.1.4 Frequency

The frequency of cyclones in the Bay of Bengal is about five to six times more than the frequency of cyclones in the Arabian Sea. As an average about four to five cyclonic storms develop in the Bay of Bengal every year.

The tropical cyclones originating in the Bay of Bengal show a bi-modal pattern peaking in November and May (McBride, 1995). Of the two peaks, the peak occurring in November is more pronounced than the peak in May.

According to literature and historical data, a definite frequency of landfall of

Table 9.1: Number of cyclones/cyclonic storms that reached the coasts of Sri Lanka in different months during the period 1881-2011

Month	Number	Year
January	01	1906
February	-	-
March	02	1907, 1925
April	01	1939
May	-	-
June	-	-
July	-	-
August	-	-
September	-	-
October	01	1967
November	06	1912, 1922, 1925, 1966, 1978, 1992,
December	08	1908, 1913, 1919, 1931, 1964, 1967, 1980, 2000

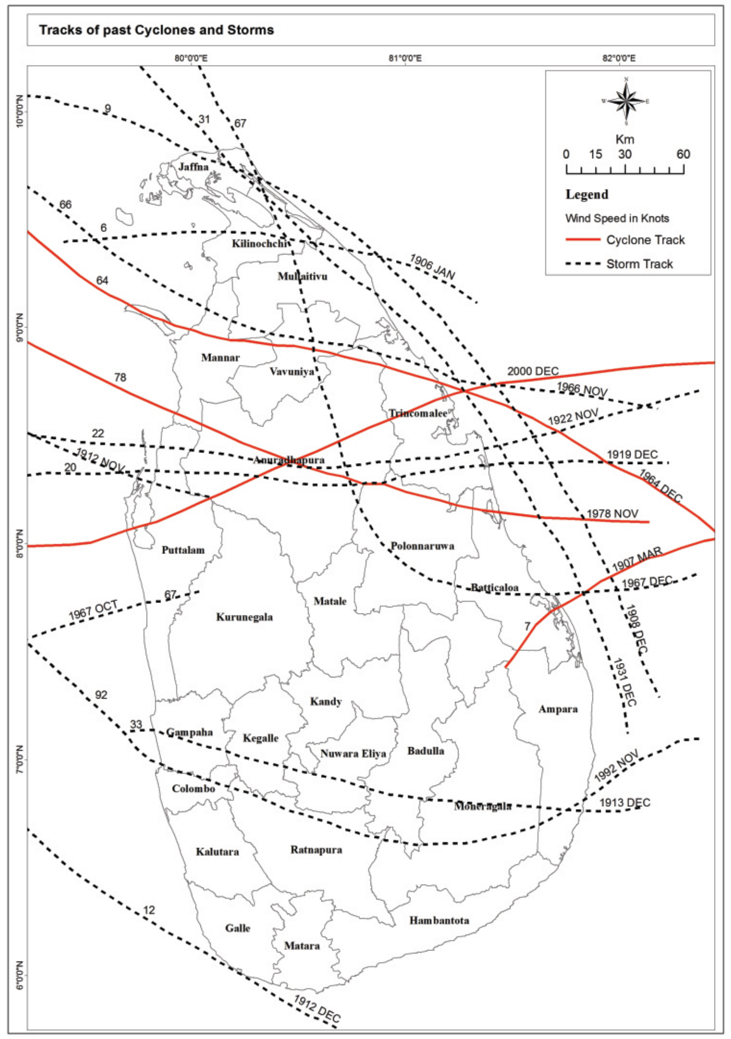


Fig.9.4: Cyclones/cyclonic storms that hit the coasts of Sri Lanka during the period 1881-2011

cyclones in the landmass of Sri Lanka has not been identified. There has not been sufficient evidence to demonstrate a firm return period either. Almost all cyclones crossing Sri Lanka coast enter the land area through the eastern coastline. During the past 130 year period (1881-2011), only eleven cyclonic storms and eight severe cyclones have crossed the coast of Sri Lanka. Moreover, six out of the eight severe cyclones had landfall on the east coast during the months of November and December while one severe cyclone had landfall on west coast during November. Seven out of eleven cyclonic storms have also made landfall during the months of November and December. The other five (one severe cyclone and four cyclonic storms) were in the months of January, March, April and October. It is clear that landfall severe cyclones or cyclonic storms cross Sri Lankan coast mostly during November and December (Table 9.1, Fig 9.4 & Fig. 9.5).

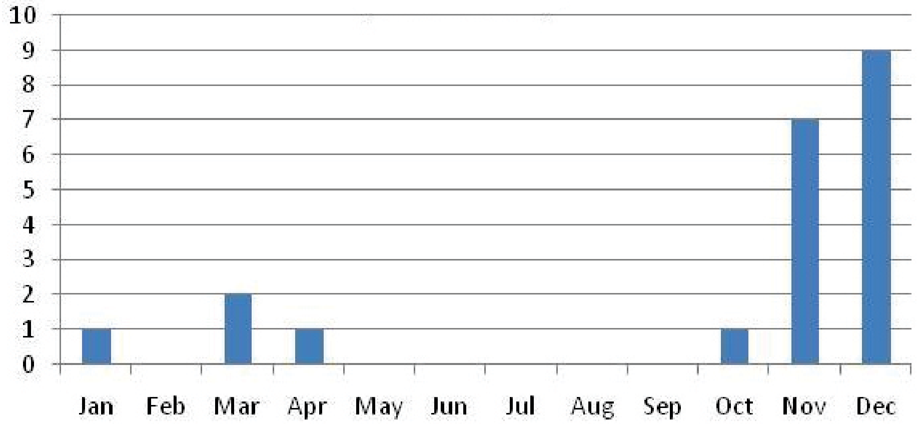


Fig 9.5: Month-to-month variation of CS and SCS landfall in Sri Lanka1881 – 2011

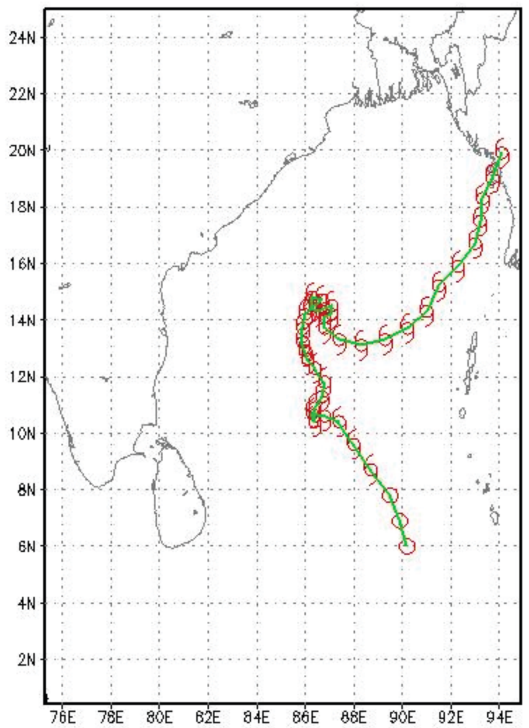


Fig 9.6: Track of tropical cyclone 01B in the Bay of Bengal during 11-19 May 2003.

9.1.5 Impacts

Although the number of tropical cyclones in the Bay of Bengal is small, they are the most deadly (McBride, 1995). Most of the tropical cyclones forming in the Bay of Bengal hit the coast of India and West Bengal, causing heavy loss of life and property. The shallow waters of the Bay of Bengal, the low flat coastal terrain, and funneling shape of the coastline lead to devastating losses of life and property due to the surge from storms of even moderate intensity.

The impact of a cyclone is highest on the landmass of its landfall. However, the land masses nearest to an active cyclone also get badly affected due to the feeder-bands of the cyclone and this can result in gale-force winds, flash floods and severe thunderstorms.

Sri Lanka, an island in the North Indian Ocean, get affected by cyclones if they landfall or when passing nearby or when a system have wide feeder bands. That is why whenever tropical cyclones develop in the Bay of Bengal below latitude 10°N, cyclone alert bulletins and warnings are issued by the Sri Lanka Meteorological Department.

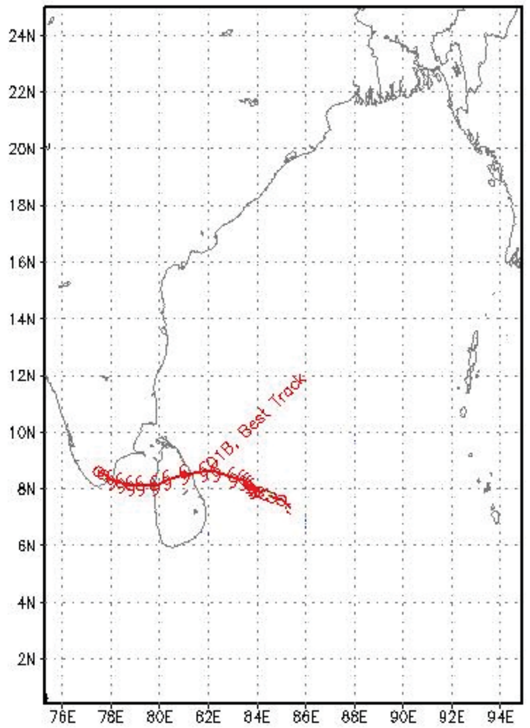


Fig 9.7: Track of tropical cyclone 04B in the Bay of Bengal during 23-28 Dec. 2000

For instance, when tropical cyclone 01B developed in the Bay of Bengal on 11 May 2003 and drifted slowly northward (as shown in Fig. 9.6), when its nearest approach was approximately 600 km to the east coast of Sri Lanka, devastating impacts were experienced in Sri Lanka. The impacts included torrential downpours leading to worst floods in the recorded history in certain regions, and a large number of landslides. It also accounted for 276 deaths with 19 missing, 9,136 houses fully destroyed and 30,385 houses partially damaged (Department of Meteorology, May 2003). Moreover, the impacts were sustained for about a week, with several stations recording the highest ever daily rainfall in Sri Lanka on 17 May. Eventually, the tropical cyclone moved northward across the east central coast of India and made landfall on the west central coast of Myanmar on 19 May.

The tropical cyclone in year 2000 (named as 04B by Joint Typhoon Warning Center (JTWC)) was the strongest TC strike Sri Lanka since 1978 and the recent landfall severe cyclonic storm (Fig 9.7) 9 years after the strike of earlier cyclone of November 1992 (WMO/TD-No. 1082, Report No. TCP-46). The fourth tropical storm in the Bay of Bengal in year 2000 and it hit eastern coast of Sri Lanka at peak strength, then weakened slightly while crossing the island before hitting and dissipating over southern India on December 28. It produced heavy rainfall and strong winds over the northern and eastern part of Sri Lanka, damaging and destroying thousands of houses as well as many properties of the country.

Tropical cyclone 07B located in the Indian Ocean in year 2008 and it made landfall Sri Lanka as a depression and rapidly weakening while it was moving over the country.

9.1.6 Classification of Cyclonic Disturbances

As stated earlier, tropical cyclones are known by many terms in the world such as cyclones, typhoons, hurricanes etc. Though tropical cyclones are different by terms across basins, they are classified according to their wind speed. The classifications of cyclonic disturbances (Tropical Revolving Storms or Vortices) in the Bay of Bengal and the Arabian Sea region for the exchange of messages among the regional countries are given in Table 9.2: (WMO/TD-No. 84, No. TCP-21, 1999).

9.1.7 Cyclone Warning System in Sri Lanka

It is not difficult to predict reasonably the weather due to a well-defined weather system like a cyclone. In general, methods of forecasting are (a) subjective methodology and (b) objective approach. In the former, more experienced Meteorologist will come out with a more accurate forecast while in the other, the method is independent of the person who processes and analyses.

By analyzing surface and upper-air information, a 3D picture of the atmosphere is created along with other supplementary information such as, cloud imageries, tephigram etc. Making use of Climatology and persistence of weather systems, a Meteorologist can subjectively forecast expected weather. Satellite cloud imagery (Dvorak technique is used to analyze the satellite imagery) gives the present state of the cloud cover. With the animation of these sets of pictures, and along with the other surface and upper air observations, potential areas of development of weather and their progress could be recognized.

Table 9.2: Classifications of cyclonic disturbances for the Bay of Bengal and the Arabian Sea region

Weather System	Maximum Wind Speed
1 Low pressure area	Wind speed less than 17 kt (31 km/h)
2 Depression	Wind speed between 17 and 33 kt (31 and 61 km/h)
3 Cyclonic storm	Wind speed between 34 and 47 kt (62 and 88 km/h)
4 Severe cyclonic storm	Wind speed between 48 and 63 kt (89 and 118 km/h)
5 Very severe cyclonic storm	Wind speed 64 and 119 kt (119 and 221 km/h)with a core of hurricane winds
6 Super cyclonic storm	Wind speed 120 kt and above (222 km/h)

Numerical weather prediction is the science of predicting the weather using "models" of the atmosphere and computational techniques. Present situation in the form of grid point data are prepared first. Then in the Model correct equations and assumptions are made. Then the time integration for a very short period of may be after 45 seconds is performed. Output products will be given in every three hours up to 168 hours at present. The product is again grid point values for meteorological parameters but for a future time. Manipulating the huge datasets and performing the complex calculations necessary to do this on a resolution small enough to make it accurate requires some of the most powerful super computers in the world. The Storm surge model developed by Institute of Information Technology and Management (IITM) New Delhi and tuned by Sri-Lankan Meteorologists is ready to run for storm surge forecasting.

If the cyclone is over 600km from the coast, general information about the cyclone is included in the normal weather forecast issue to mass media.

If the cyclonic storm is about 550 km off the coast, the Department issues a cyclone alert bulletin. This bulletin indicates the distance of storm centre from the coast, expected wind speed and direction of movement, and the expected maximum surface wind. This bulletin is issued every 12 hours.

When the tropical storm is 300 km off the coast, a cyclone warning is issued every 6 hours. Point of land-fall and areas likely to be affected are additional information that is included in these warnings.

When the tropical storm is 200 km off the coast and if the land-fall is indicated the frequency of cyclone warning bulletin is increased to 3 hours

Colour coding system has been introduced (in 2007) by the Department of Meteorology for the easy understanding of weather bulletins (Fig 9.8)

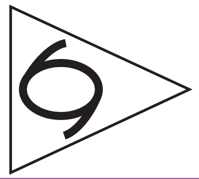
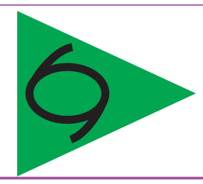
SIGN	ALERT STATUS	DESCRIPTION	ACTION REQUIRED
	Information	Likely formation of a cyclone storm[2]	Information only and listen for regular weather updates
	Alert	Cyclonic item has formed and approaching[1]	Be vigilant and listen for regular weather updates. Act according to the relevant official instructions Possible evacuation in high risk areas
	Warning	Cyclonic storm making land fall	Possible evacuation in high risk areas and listen for regular weather updates. Act according to the relevant official instructions
	Threat is over	Cyclonic storm threat is over	Cyclonic item threat is over however, associated threats such as rainfall need to be monitored. Act according to the official instructions

Fig 9.8 Clour coding for cyclones alert and warnings

9.2 Methodology

The hazard analysis study was performed considering entire Sri Lanka as the study area. The methodology section consists of availability of data, and a brief description of the domain considered as the study area and the model used in preparation of hazard profile maps of Sri Lanka.

9.2.1 Available Data

The data on cyclones, crossed over Sri Lanka for the period 1881 – 2011 have been collected from historical data from Sri Lanka Department of Meteorology and "The Impact of Tropical Cyclones on The Coastal Regions of SAARC Countries and Their Influence in The Region" SMRC–No. 1, SMRC Publication 1998.

These tropical cyclones have been categorized in to two groups:

i. Cyclonic Storms and
ii. Severe Cyclonic Storms

The data of the two categories are given in table 9.1 and monthly graphical variation of landfall of cyclones is given in Fig. 9.5.

The information on all the tropical cyclones and depressions data, which have crossed the coast of Sri Lanka or have reached within 100 km of the coastline during the period 1891 - 2007 are collected and summarized. They have been grouped in to three categories:

I. Depression (Dep)
ii. Cyclonic Storms (CS) and
iii. Severe Cyclonic Storms (SCS)

The above data are given in table 9.3, 9.4 and 9.5 and their individual tracksare given in the appendix 1

The frequencies of depressions, cyclonic storms and severe cyclonic storms crossing the coastline of Sri Lanka during the past 130 year period have been summarized. As discussed earlier, the most of TC's crossed over Eastern and Northeastern coast of the Sri Lanka during November and December.

Table 9.3: Depressions data, which were crossed and in the vicinity of Sri Lanka for the period 1891 – 2007

NO	Date	C/N/A	Coast	Location
1	1923-01-06	c	SC	Dikwella
2	1923-12-17	n	WC	Wennappuwa
3	1926-11-08	n	WC	Mampuri
4	1931-12-09	n	SC	Hikkaduwa
5	1934-01-23	c	EC	Kalmunai
6	1936-12-31	c	EC	Punnaikudu
7	1938-03-20	n	EC	Trincomalle
8	1939-01-07	c	NC	Kankasanturai
9	1942-04-24	c	NC	Poonaryn
10	1945-11-06	c	EC	Trincomalle
11	1945-12-04	c	EC	Putumattalan
12	1947-02-25	c	EC	Nelaveli
13	1952-12-07	c	NC	Valvedditturai
14	1953-11-23	n	NC	Jaffna
15	1957-12-25	a	EC	
16	1959-11-28	n	NC	Jaffna
17	1960-11-10	n	NC	Jaffna
18	1961-01-10	c	EC	Kuchchiveli
19	1963-12-02	c	EC	Muttur
20	1965-11-04	c	NC	Chulipuram
21	1968-12-12	c	EC	Manalkadu
22	1970 11 19	n	NC	Jaffna
23	1972-12-20	n	EC	
24	1973 12 14	c	EC	Chemmalai
25	1973-12-26	c	EC	Thalankudah
26	1977-11-24	c	EC	Chittandikudi
27	1982-12-03	c	NC	Manalkadu
28	1983-12-22	c	SC	Komputukki
29	1986-01-08	n	EC	Ampara
30	1994-11-04	n	NC	Jaffna
31	2005-11-20	c	EC	Kumpurupiddi

Table 9.4: Cyclonic Storms data, which were crossed and in the vicinity of Sri Lanka for the period 1891 - 2007

NO	Date	C/N/A	Coast	Location
1	1906-01-15	c	EC	Vadduvakallu
2	1908-12-30	c	EC	Nelaveli
3	1912-12-17	n	SC	Hambantota
4	1913-12-15	c	EC	Tettativu
5	1919-12-29	c	EC	Kallar
6	1925-03-12	c	WC	Veddukkaddu
7	1925-11-06	c	EC	nintavur
8	1930-05-05	a	EC	
9	1939-04-12	c	EC	Komari
10	1966-11-08	c	EC	Trincomalee
11	1967-10-20	c	WC	Boraessa
12	1967-12-04	c	EC	Kallar
13	1980-12-12	c	EC	Nilaveli

Table 9.5: Severe Cyclonic Storms data, which were crossed and in the vicinity of Sri Lanka for the period 1891 - 2007

NO	Date	C/N/A	Coast	Location
1	1907-03-08	c	EC	Tirukkovil
2	1912 11 19	c	WC	Navatkadu
3	1922 11 25	c	EC	Punaidi
4	1931-12-22	c	EC	Kalkudah
5	1955 11 29	n	NC	Jaffna
6	1964 12 17	c	EC	Chilavattai
7	1978-11-18	c	EC	Patchenai
8	1992-11-11	c	EC	Komari
9	2000-12-23	c	EC	Uppurai

Note:
c = Crossed
SC = South Coast
n = Near
WC = West Coast
a = Along the Coast
NC = North Coast
EC = East Coast

The Cyclones are classified according to wind speed in their circulation. Therefore wind speeds were obtained for each grid with a resolution of 10km which was generated using the Weather Research and Forecasting (WRF) Model. The initial and lateral boundary conditions to a limited area model are usually provided from the large scale analysis of different NWP centers in the world. The National Centers for Environmental Prediction (NCEP) and the National Center for Atmospheric Research (NCAR) reanalysis data have been used to provide the initial and lateral boundary conditions to the WRF model experiment. Where the resolution of the global Reanalysis Model is T62 (209 km) with 28 vertical sigma levels and is available at 6 hour intervals.

9.2.2 Study Area and the Model

The study was conducted for the entire country and the model evaluations were performed for the domain (Fig. 9.9) bounded by longitude 76°E to 90°E and latitude 02° to 14°N.

This study is carried out to prepare wind hazard map for Sri Lanka and it is needed to find every 10km grid box wind speed all over the country. For this purpose, the tracks of all the cyclonic disturbances which formed in the Bay of Bengal and either crossed the coast of Sri Lanka or moved away within 100 kilometers of the coastline have been considered. After identifying such disturbances, the NCEP/NCAR re-analysis data for such events have been downloaded and incorporated into the Non hydrostatic Meso-scale Model (NMM) dynamic core of Weather Research and Forecasting (WRF) model at a spatial resolution of 10 x 10 km, for the period of 1958 to 2010. After

executing the model, the maximum wind speed at each grid cell over Sri Lanka has been extracted to develop the output. The Joint Typhoon Warning Center (JTWC) Best Track data were used for verification and created a factor to get the average maximum wind speed per each grid over the desired period.
The WRF-NMM (version 3) developed by National Center for Environmental Prediction (NCEP)/National Oceanic and Atmospheric Administration (NOAA), is designed to be a flexible, state-of-the-art mesoscale model. It is a fully compressible, non-hydrostatic model with a hydrostatic option (Janic, 2003, Sujata et al, 2012). The WRF-NMM model version 3 supports a variety of capabilities. Some of these are as follows:

- Real-data simulations
- Non-hydrostatic and hydrostatic (runtime option)
- Full physics options
- One-way and two-way nesting
- Application ranging from meters to thousands of kilometers
- Digital filter initialization

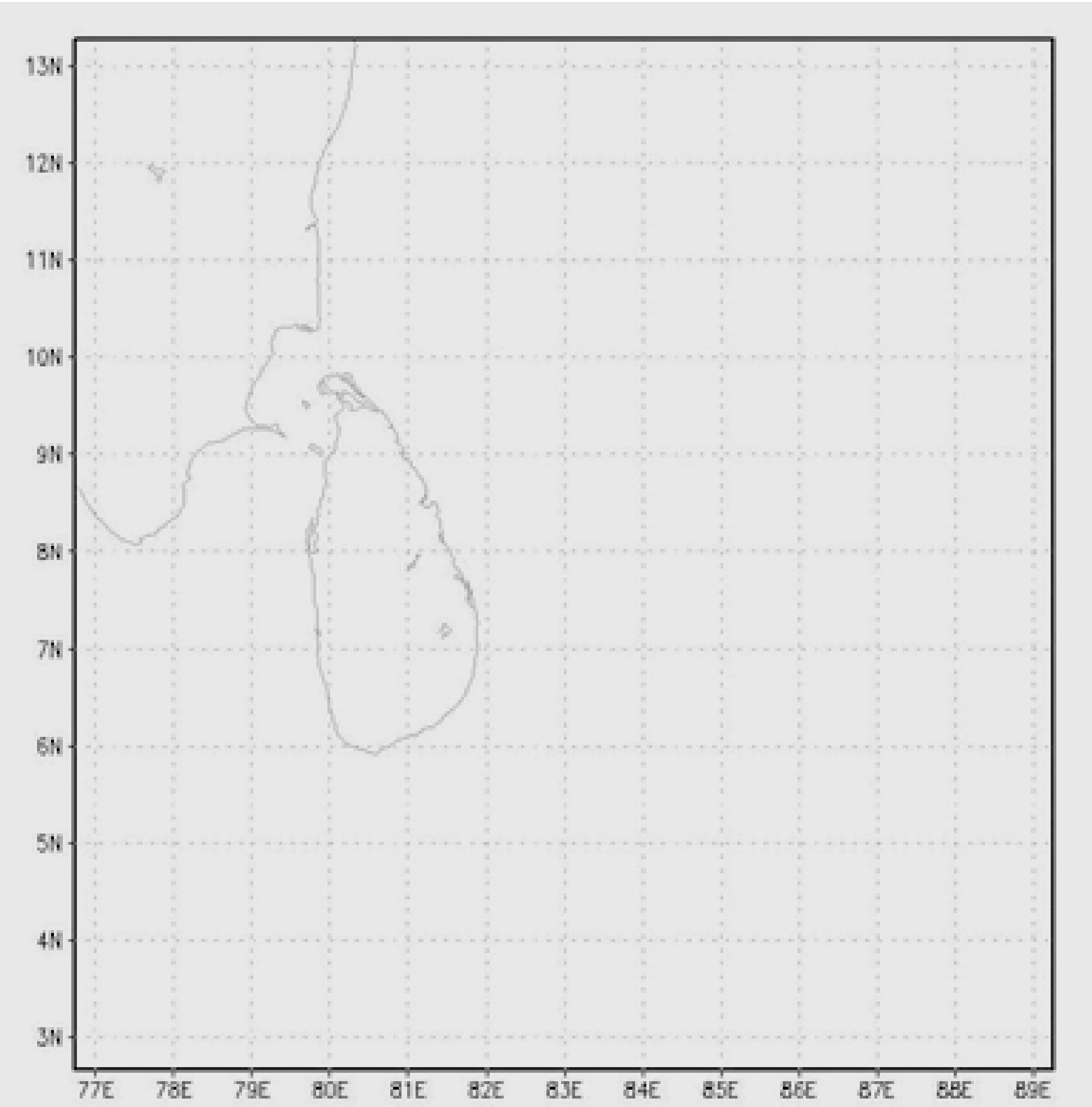


Fig 9.9 Domain to which the WRF model was performed

Coarse resolution reanalysis data was downscale to the 10km resolution using WRF model and find every 10km grid box wind speed for cyclones crossed or vicinity of Sri Lanka for the period 1958-2010. Average all model outputs wind speed for every 10km grid points and produced average wind hazards susceptible map for Sri Lanka (Fig. 9.10). From the all model outputs it is found the maximum wind speed for all 10km grid boxes and mapped it and created the maximum wind hazards susceptible map (Fig. 9.11).

9.3 Hazard Profile

During the 130 year period between 1881 and 2011, eleven cyclonic storms and eight severe cyclones have crossed the coast of Sri Lanka. Even though tropical cyclone crossing Sri Lanka is not very frequent, the impacts are severe particularly in the eastern coastal areas. The developed wind hazard map shows that the maximum wind speeds of the order of 65 knots (120 km/h) are experienced in the western, east-north-eastern and northwestern regions.

In the present study, using the described model, the average wind hazard map and the maximum wind hazard susceptible map (Fig 9.10 & 9.11) have been produced. In practice, these maps can be utilized to identify areas having potential for experiencing strong winds during cyclonic situations. Identification of the vulnerable areas followed by properly managed evacuations can result in better managing the disasters.

9.4 Conclusion

Estimated maximum winds depicted in given maps tallies well with the observations available with the Department of Meteorology. They show the proneness of wind hazard of the country and can be used in developing building codes etc., in the case of constructing multi-story structures (especially in and near the coastline), in addition to alerting vulnerable population during cyclonic situations. As the districts in eastern, north-eastern and northern areas of Sri Lanka are prone to strong winds, it is very necessary to take this fact into consideration when new development projects are planned and implemented in these areas.

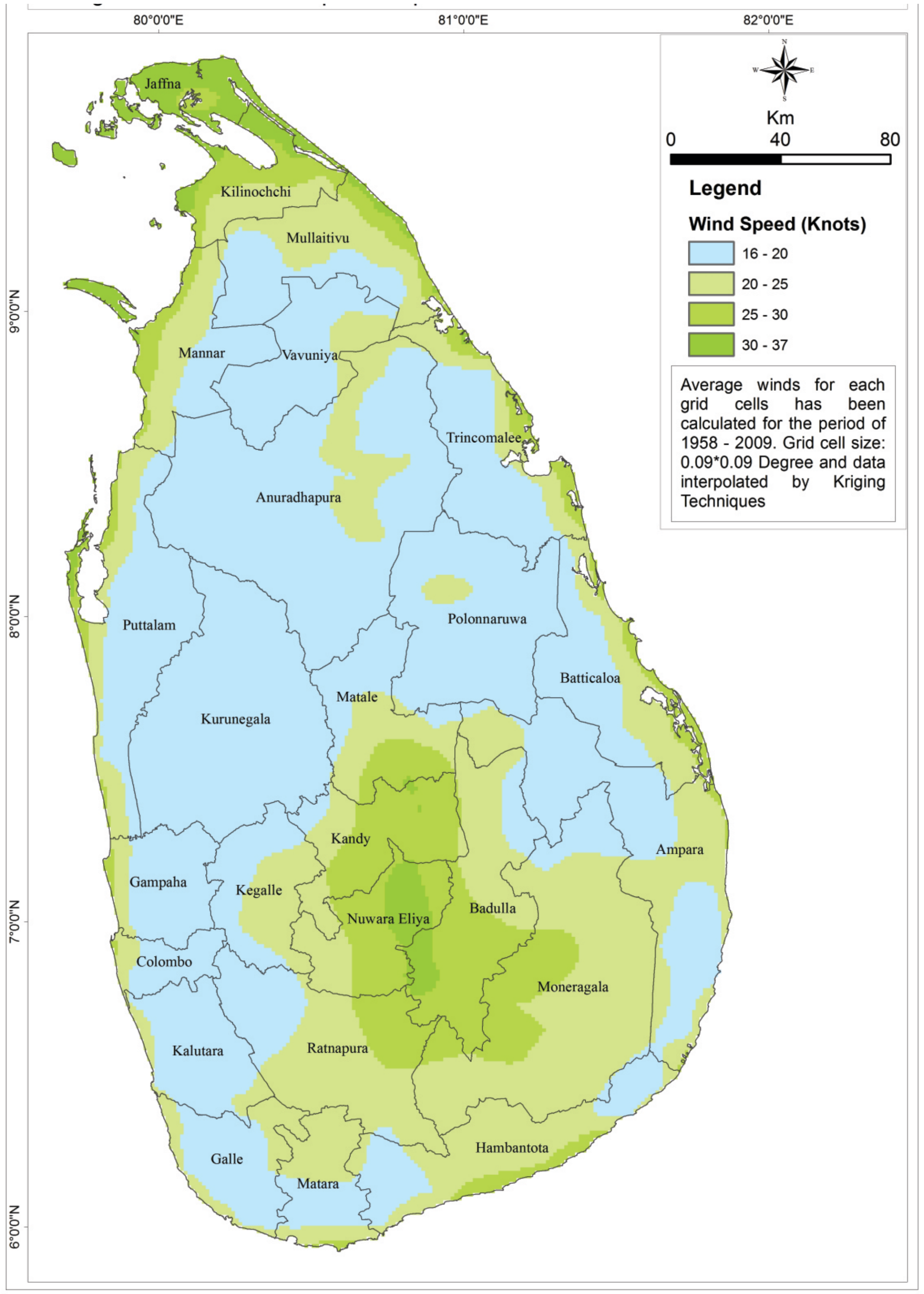


Fig 9.10. Average wind hazards map of Sri Lanka for the period of 1958-2009

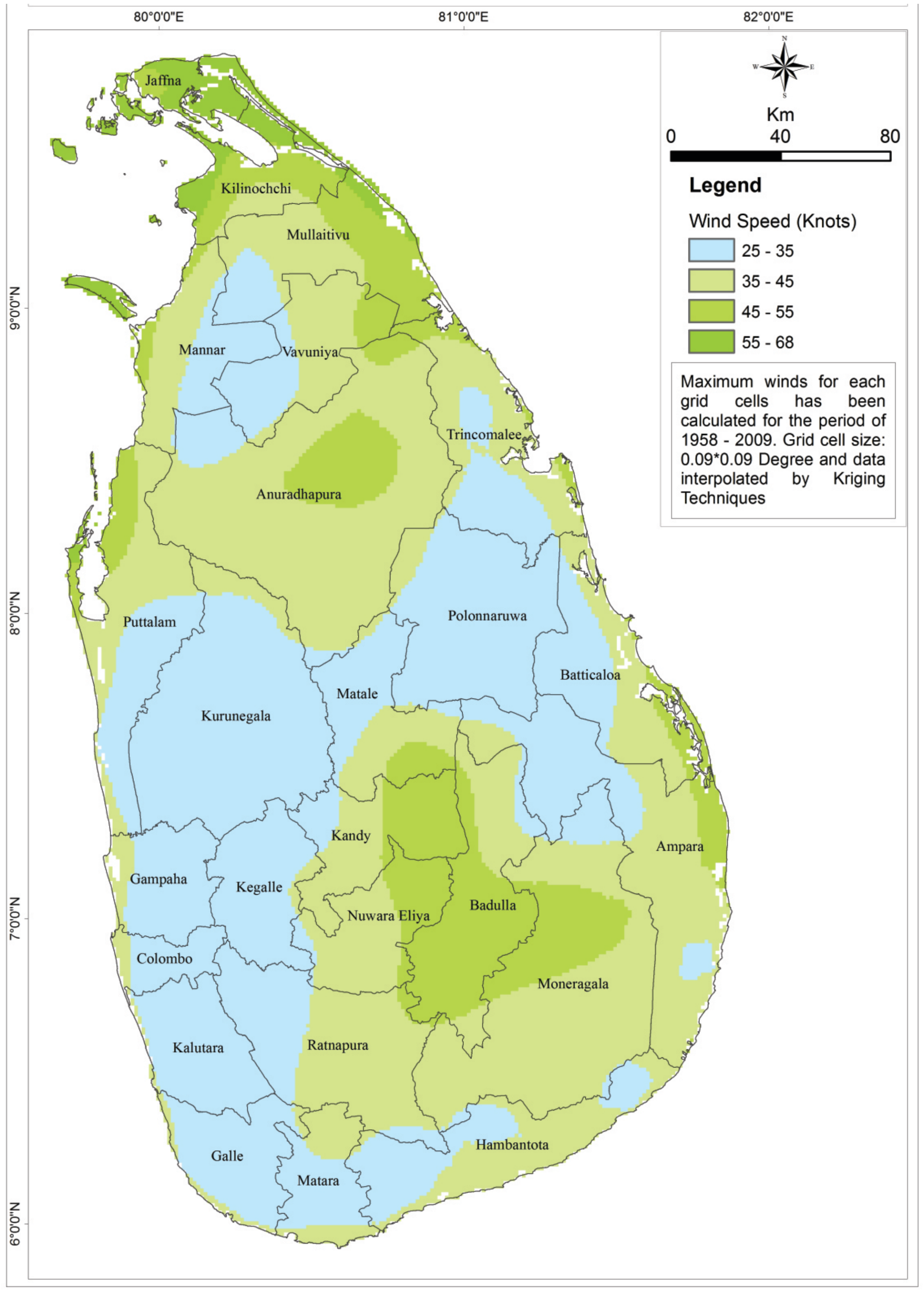


Fig. 9.11. Maximum sustained wind speed map when TC crossed or vicinity of Sri Lanka

9.5 Recommendations

The damages experienced due to cyclones are mostly due to associated strong winds and to torrential downpours. The damage due to storm surge in Sri Lanka is not very heavy especially due to the bathymetry of the east coast. The damage caused due to each cyclonic disturbance varies, based especially on its strength and the landfall position; it is extremely important and valuable if different maps are prepared for different landfall locations/strengths thus improving the utility of this information for disaster management purposes. However as noted briefly before, the limited availability of cases (e.g. only 19 situations during 130 years) become a limitation for such a study. Hence it is proper and justifiable to explore the possibility of using synthetic data for developing such scenarios. Joint studies in this direction may be originated in collaboration with other agencies (both local and overseas) to develop maps/scenarios with more useful information.

9.6 Limitations

There are limitations in models such as initial value, truncation errors etc. Especially energy transport systems like transient eddies are also not considered in the present Global Models. Limitations in down-scaling procedures are also significant. For example under squall lines or during tornadic situations, the results of the model become less reliable. Only 19 cyclones have crossed Sri-Lanka and this number may not be sufficient for a proper mappings.

9.7 References

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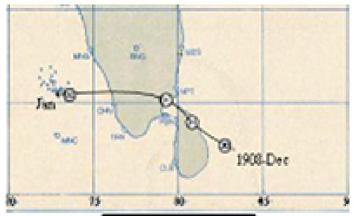
Appendix 9.1: Draft Tracks of Depressions, Cyclonic Storms and Severe Cyclonic Storms influencedSri Lanka (Cyclone eAtlas - IMD, 2008)


15-01-1906


8-03-1907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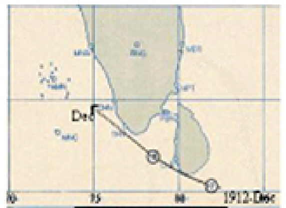
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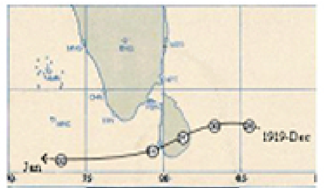
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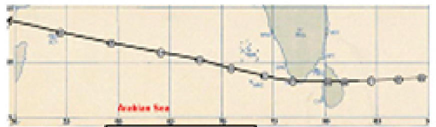
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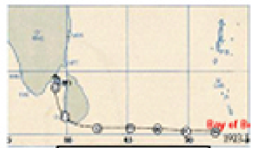
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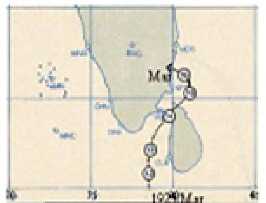
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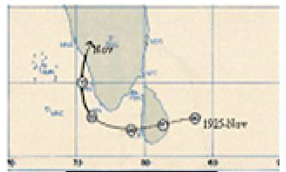
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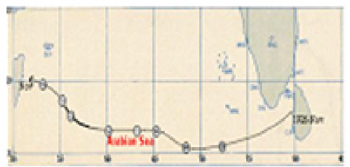
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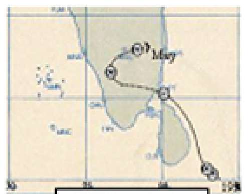
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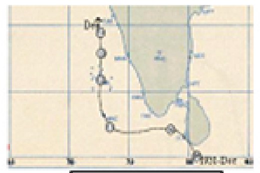
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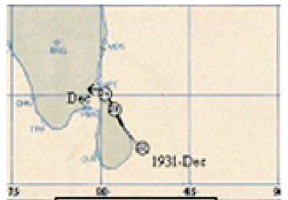
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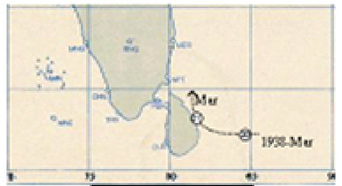
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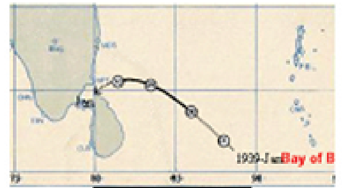
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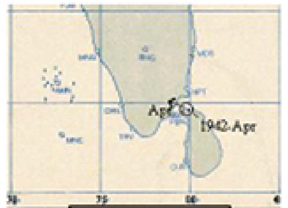
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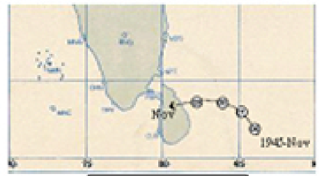
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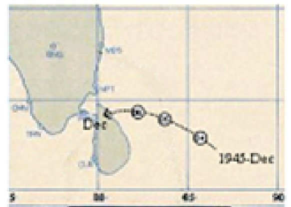
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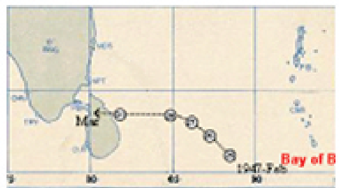
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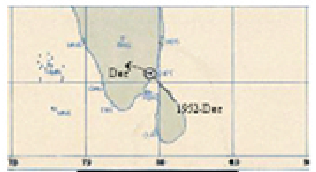
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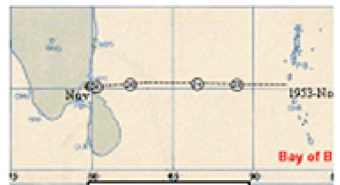
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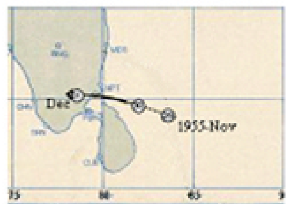
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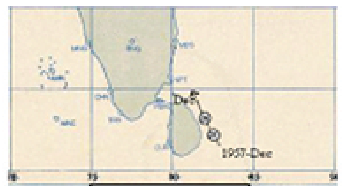
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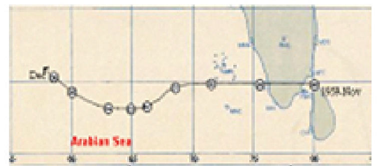
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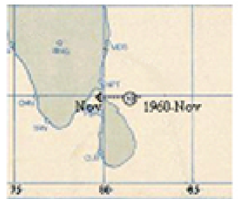
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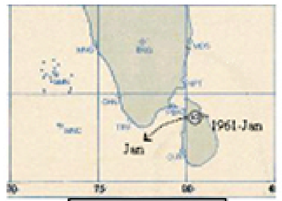
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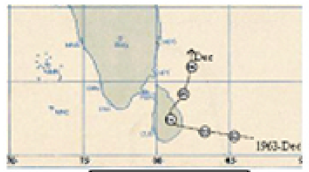
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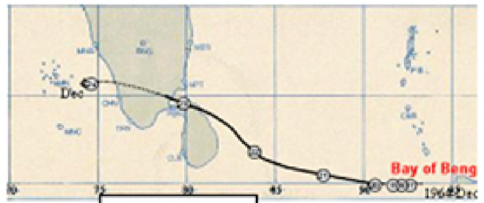
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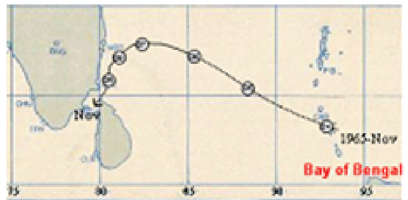
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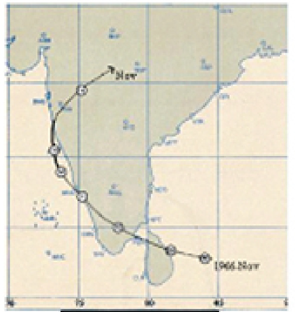
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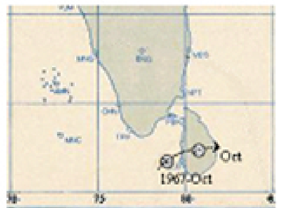
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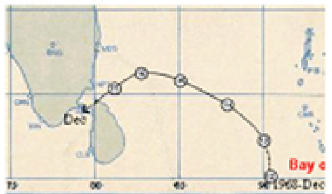
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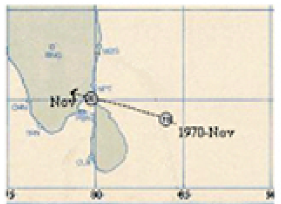
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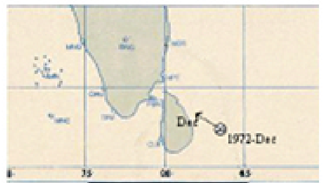
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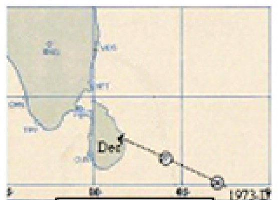
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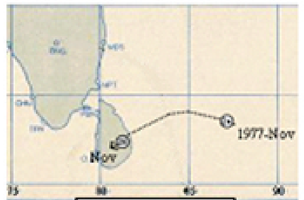
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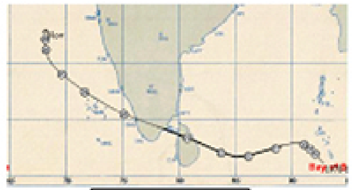
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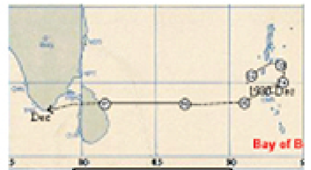
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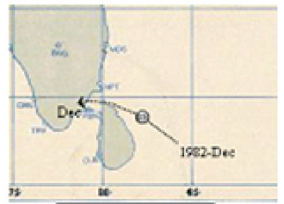
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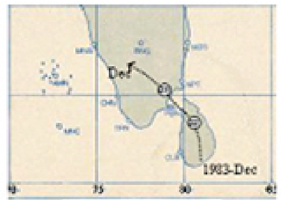
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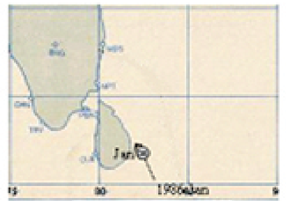
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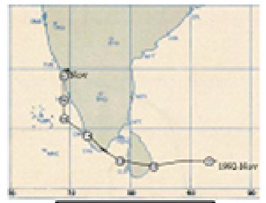
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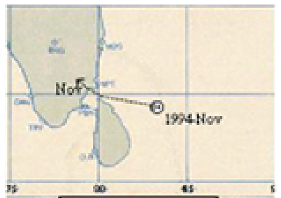
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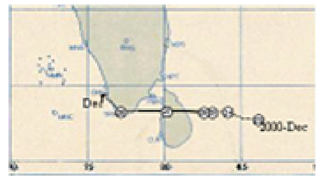
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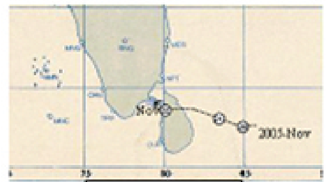
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