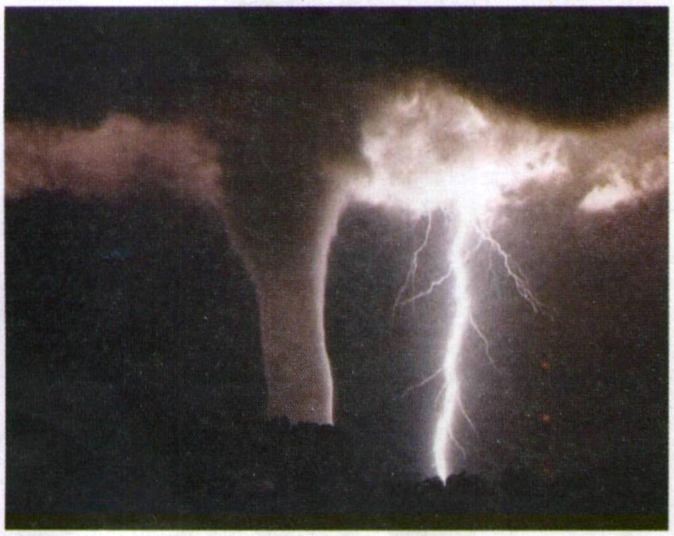
Tropical Cyclones and Tornadoes



Tropical region is considered as the region between tropic of Capricorn (23^0 South and 23^0 North) of the earth. The weather or climate characterized in this region is called tropical climate. Tropical cyclones are one of the most important tropical weather conditions. They are among the most powerful and destructive natural phenomena of our planet, and they are capable of producing very strong winds, torrential rain and sea water intrusion to the land (storm surge).

They are called as **hurricanes** in the North Atlantic and Northeastern Pacific and as **Typhoons** in the Northwestern pacific. All the other ocean basins namely, in the Indian Ocean and South Pacific Ocean, they are just termed as **tropical cyclones**. There are no evidences of formations of tropical cyclone in the South Atlantic ocean. Approximately 80-100 tropical cyclones occur in a year and they develop over the warm tropical oceans.

In the North Atlantic ocean, North and South pacific oceans and in the south Indian ocean, each cyclone is given a name during its formation. Nations around the north Indian Ocean are currently considering the naming the cyclones developing in the Bay of Bengal and in the Arabian sea. Bangladesh lost more than 300,000 lives within a few hours on 13th November, 1970 due to a tropical cyclone, and in 1992 US economy lost about 26 billion US dollars due to property damage caused by the cyclone (hurricane) Andrew.

Wind and Pressure

Tropical cyclone are low pressure systems in the tropical region. The centre pressure at the surface may be even less than 900 hecto Pascals (1 h Pa = 100 Pascals), where as the surrounding pressure is predominantly a little above 1010 hpa. This large pressure difference drives the winds from the outside to the centre. However, due to the effect of the rotation of the earth, air does not directly moves from the out side to the centre. Instead, it moves towards the centre with counterclockwise whirling in the northern hemisphere and with clockwise rotation in case of southern hemisphere. Closer the centre the pressure change along a radius is larger. Therefore the stronger winds are observed closer to the centre.

Development of Tropical Cyclones

A tropical cyclone starts with a low pressure area where the maximum sustained wind is lower than 17 knots (31 km/h) over the sea. When the surrounding air converge to the low pressure centre, the air rises. As the air is saturated with moisture (over the warm sea), rising motion results in condensation and cloud formation. The condensation of water vapour release very large amount of energy (latent heat of evaporation - nearly 2250 kJoules per kg). If the upper levels (up to about 8 km) of the atmosphere are not dry, further condensation can take place. Some part of energy released in the condensation process further warms up the rising air and the upward motion can continue to a great depth such as, 13 km. Another part of condensation energy, warms the atmosphere directly above the low pressure area if there is not large scale (regional) strong winds (in case of strong winds, the heat is horizontally transported with the wind and does not retain in the same location to warm up). As the warmer air is lighter, the surfaces pressure (centre) decreases further namely deepen further. Therefore, the pressure difference between the centre and the surrounding area increases, strengthening the wind speed. If the maximum sustained wind exceeds 31 km/h, it is said to be a depression. If this process continues, the centre pressure decreases further and the wind speed further increases. The table (1) below gives the classification of the systems related to tropical cyclones used in Sri Lanka (Slightly different classifications are used elsewhere.)

Professor William Gray detailed the necessary conditions for development of cyclones (given below) which is also suggested by the above mechanism.

(1) Warm sea (should be greater than 26 Centigrade from the surface to at least 60 m depth)

(2) Significant influence of the earth rotation (cyclone do not form within the equator and 4 degrees of latitude)

(3). No significant horizontal wind variation between the surface and about 10 km.

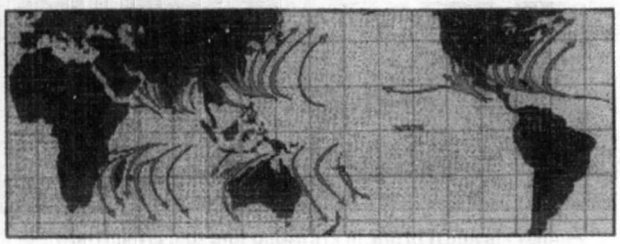
(4). Significant amount of moisture (relative humidity) between 3 and 6 km above the surface,

(5). Having some spin up in the wind field at lower atmosphere.

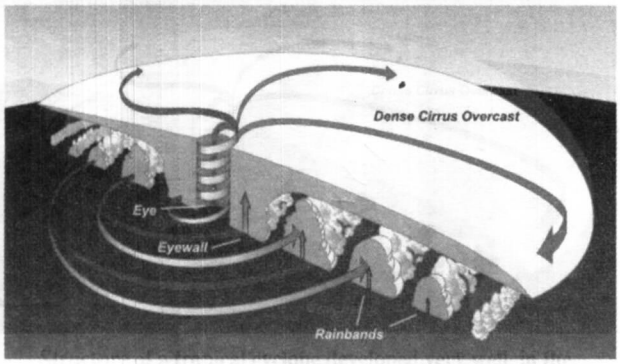
(6). Significant cooling from surface at about 6km height.

Decaying the cyclone

As the major energy source of cyclone is condensation energy, it gets weaken if either oceanic or atmospheric



Starting regions and pathways of world tropical cyclones

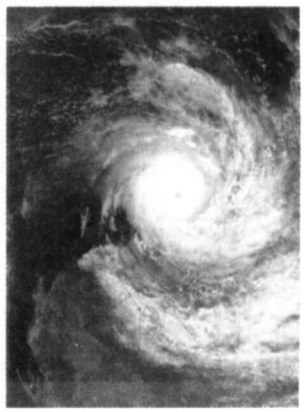


Structure of a tropical cyclone developed very well in the northern hemisphere

conditions are not sufficiently favourable to release enough condensation energy over the cyclone area. Moving over the land or cool ocean, storms fast movement, unfavourable atmospheric conditions for deep convection are some of the reasons for weakening the systems.

Structure of Cyclone

A typical well matured tropical cyclone has vortex (counter-clockwise in the northern hemisphere and clockwise in southern hemisphere) towards it's centre. While the air is whirling it also moves upward. This violent upward spiraling wind result in spiral band of clouds wrapping around the centre. The centre is basically less cloud and calm and, appears as a free of clouds in the satellite imageries. It is called the eye of the storm. The diameter of the eye may be 30-60 km. Clouds those immediately around the eye are called the eye wall clouds. They consist of vertically very tall (may be over 15 km) cumulonimbus clouds (thunder clouds) which produce intense rainfall and violent winds. All the mature cyclones may not have eyes completely by eye wall clouds especially when they are relatively less severe. Instead, partially eye wall clouds with spiral bands may appear. The effect (heavy rain and wind) of tropical cyclone may be felt to the distance even more than 500 km of the centre.



Movement of Cyclones

Tropical cyclones basically do not develop within 4 deg of the equator as the effect of earth's rotation is negligible.

Table 1 - Classifications of cyclone related systems in Sri Lanka

System	Maximum sustained Wind speed		Corresponding Dvorak Classification (T number)
	Knots	km/h	
Low pressure area	less than 17	Less than 31	Less than 1.0
Depression	17-33	31-61	1.0-2.0
Cyclonic storm	34-47	62-85	2.5-3.0
Severe cyclonic storm	48-63	86-117	3.5-4.0
Server cyclonic storm with hurricane force wind or cyclone	Greater than 64	Greater than 118	Greater than 4.5

Once a disturbance from beyond this region, it basically moves towards the west with slight deflection to the poles. Later the pole ward contribution of the motion increases. Finally they move with pole and eastward. Motion of individual cyclones, however, depends upon the large scale wind field, interaction with other neighbouring important systems etc.

Intensity of tropical Cyclone

The intensity of tropical cyclones are indicated by the T-number by Meteorologists. This has been established by vernon Dvorak based on satellite imageries. He has compared large number of satellite imageries with other meteorogical parameters, such as, centre pressure and maximum sustained wind to develop this classification. The corresponding T number for the storms classified in Sri Lanka is given in the table 1.

Forecasting cyclones

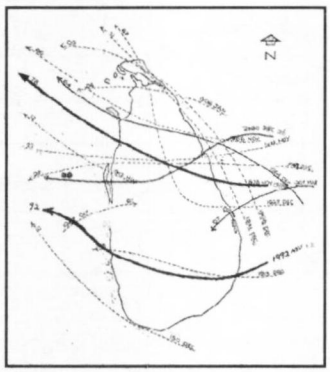
Forecasting the motion of tropical cyclones with its intensity is extremely important to minimize the human loss and property damage. It is done by the interaction between

human being and the modern techniques. Tropical cyclone itself is a devastating phenomena therefore, getting the real observation from the area is extremely difficult. However, using the satellites and modern information technology, meteorologists are in a position to obtain a lot of real time information about cyclones and issue timely warning and fairly accurate forecasts at present.

Cyclones affecting Sri Lanka

Tropical cyclones usually develop during the summer and early winter as the ocean gets warmer due to strong solar heating during the summer. Being the most active region, northwest pacific basin, the cyclone season stretches even longer period. However, in the north Indian Ocean, there are two major periods namely, during the pre-southwest monsoon (April-May) and post southwest monsoon (October-December). The splitting character of the cyclone season is a feature which is a unique only in the north Indian Ocean.

Out of two seasons, the post monsoon period is more active. As Sri Lanka is close to the equator, and in our latitudes, tropical cyclone usually moves in northwest or west wards. Therefore, it is predominantly affected by cyclones those developing in the southern part of Bay of Bengal except in case of Cyclone in October 1967 which struck near Chilaw (west coast). The eastern part of the island is more vulnerable than the western part as during the west-northwestward motion over the land the system get waken. During the period from 1881-2000, 8 and 4 cyclone have crossed in each of March and January. During the months of April and May, Sri Lanka has been badly affected by cyclones passing the vicinity of the island although there are no reports about crossing the island. During the last 50 years, four severe cyclonic storms have crossed Sri Lanka; They are in October 1967, November 1978, November 1992 and December, 2000. The heaviest damage was caused by the one in 1978 which claimed 915 human lives and heavily damaged about 185,000 houses. Technology and the learnt lessons from this event reduced the death toll to less than two digits during the cyclones in 1992 and 2000.



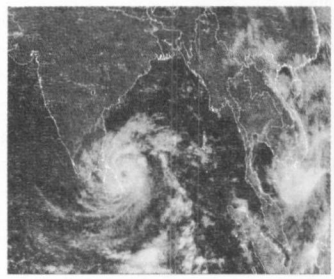
The pathways of cyclones crossed Sri Lanka during 1901 - 2000

Effect of tropical Cyclones and Steps to Minimize the Loss

Tropical cyclones are destructive due to their very strong wind, torrential rain, storm surge (sea water intrusion to the land and to the rivers largely due to strong wind) and very rough seas (due to strong winds). Therefore, forecasting the cyclone are very important for general public as well as for sea and air navigational operations for their safety.

When the cyclone alert is declared, all should be paid more attention on the weather news carefully not to go panic but to do the needful to save their lives and property.

If the area is going to be affected, tight all the unsettle tiles, roofing sheets, repair the door and windows, trim the trees near the house, remove all the valuable document and clothes with polythene and store them at a higher and safer (from strong winds and floods) place, store enough drinking water in an unbreakable vessel. Make sure the perfect working order of battery operated radio tuned to get weather news, pack the essential medicines to be taken away if evacuation is required, keep ready a hurricane lamp with kerosene oil and a lighter, flash light with batteries, some dry food such as biscuits, bread etc., untie cattle and other animal to them to go away and do the other necessary things to save.



The satellite image of the cyclone cantered Trincomalee on 20 - 02 - 2000 evening 4 o'clock.

When the cyclone warning is issued and your place is likely to be affected, you need to evacuate if you are not in a strong and elevated place. If the house is strong (concrete roof and at an elevated place, you may stay but try to get sufficient floods and water for a few days. I f you are required to evacuate, decide where (strong and elevated place) to go and what is the route you need to take, get away from beaches and get extra foods, water, battery operated radio, hurricane lamp or an emergency lamp and essential medicines, special food for kids and, patients etc..

If the centre of the cyclone passes your area, you may feel calm conditions (after strong winds) temporary only. You will experience again strong winds from the opposite direction. Therefore, do not leave your safer place until the safety about your place is announced. Moreover, authorities such as, power supply and irrigation etc., should take appropriate measures to avoid possible destruction due to the damage pf their structures by the cyclone. Once the cyclones passes, heavy rain and flood conditions may contaminate the drinking water. Therefore, it is essential to take hygienically pure drinking water.

Tornadoes

A tornado is a violent storm with strong wind whirling around a small area of extremely low pressure, usually characterized by dark funnel shape clouds causing damage along it's path. The damage is caused by extremely strong winds (may be more than 300 km/h) spinning around the centre and ability of sucking the objects upwards. Violent tornadoes can lift heavy objects, such as, trucks, roofing sheets etc. The tornado is also called "twister" as it has highly rotating nature. Tornadoes often break or fall trees which eventually damage the property near by.

In the central and southern parts of United States, they frequently develop (annually about 1000 tornadoes). Some of the localized severe storms reported from other part of the world may be having tornado type air motion. As the tornadoes are very tiny and short lived, most of them may not have been reported as they do not have frequent and high resolution information techniques as US does.

In Sri Lanka recent damage survey studies of the strong wind affected areas suggests that some of them have shown some features of tornado. During the two inter-monsoon months namely, in the March, April, October and November, deep convection can cause formation of vertically well develop clouds mainly during the afternoon. Almost in every year, there are occasions of reporting strong winds during this period. During the southwest monsoon (May to September) period too damaged due to strong winds are reported Not all, but a few localized strong winds may have been due to formations of tornadoes. However, without proper inspection of the damage area, prior to the alteration of evidences they cannot be confirmed.

A tornado is associated with mostly one or two covective type clouds (cumulus or cumulonimbus). Below the clouds, there is a violently rotating air column including mostly the bottom part of the clouds. This rotation often is seen as a funnel.

The size of tornado is only a few hundred meters but its path may be about one kilometer. Most tornadoes last for only a few minutes; but only a few tornadoes have lived about an hour. Limitation of it's size and the lifespan also limit the affecting area. However, the same reason limits our understanding about it.

Very unstable conditions due to large temperature, humidity, and wind variation are favourable for tornado development. However, the mechanisms of tornados have not been fully understood. In the southeastern sector of United States (Colorado, Oklahoma etc.), where they frequently develop and the frequent satellite and radar techniques give prompt information about the tornado which will allow the people to safer shelter. In addition, the favourable conditions for tornado development are also forecast. However, it is extremely difficult to make accurate forecast about tornado well in advance. Therefore, preventive measures should be taken immediately when the least information indicates the possibility of striking the place.

Waterspout

If tornado type strong sucking effect is experienced over a reservoir or a sea, a narrow column of water is lifted towards the clouds. This is called waterspout which may also move over the land and become a tornado depending on it's energy. On contrary, tornado may become a waterspout if it moves over a water body. As water is lifted, aquatic lives such as fish may also be lifted and drop somewhere. This strange thing is sometime called as 'shower of fish'. In addition, waterspout can harm the boats and ships.

How to protect from Tornado

As tornado cannot be forecast, it is Vital how to identify the environment in case of tornado and take immediate measures if tornado is suspected. A tornado can make roaring sound and funnel shape dark pendant from clouds may be visible. The object may lift and light objects may spin around the center just above the surface. When such thing are felt, running immediately to a strong shelter (under a concrete roof or slab) may save the life. After passing the tornado, main power cables should not be touched as fallen trees may damage the live lines.

Table 2- Comparison between Tropical Cyclones and Tornadoes.

	Tropical Cyclone	Tornadoes
Type	Whirl wind	Whirl wind
Size (Horizontal extent-diameter)	More than 500 kilometers	100s of meters
Covective cells (Cumulonimbus clouds)	Dozens	Mostly one
Life time	Longer than a week	Mostly less than 10 minutes
Favourable Winds for generation	Not much change vertically	Large change vertically
Generation area	Warm sea	Primarily over the land
Horizontal temperature	Not much change	Significant change
Rain	Torrential over a large area	Nil or for a short period
Damage	Floods, landslides, storm surge and wind damages	Only wind damage over the a limited area

Most wind damage are often referred as cyclones by the public and media. Therefore, it is worth of comparing tornadoes and tropical cyclones (cyclones).

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