15. CYCLONE

Introduction of Cyclones

Cyclone is a system of low atmospheric pressure in which the barometric gradient is steep. Cyclones represent circular fluid motion rotating in the same direction as the Earth. This means that the inward spiralling winds in a cyclone rotate anticlockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere of the Earth. Most large-scale cyclonic circulations are centred on areas of low atmospheric pressure. The cyclones can be tropical cyclones or temperate cyclones (extra-tropical cyclones).

Basic difference between Tropical Cyclone and Extra-tropical Cyclone

The term "tropical cyclone" is used to refer to warm-core, low-pressure systems that develop over tropical or subtropical oceans. This definition differentiates tropical cyclones from extra tropical (midlatitude) cyclones that exhibit a cold-core in the upper troposphere and often form along fronts in higher latitudes. Subtropical cyclones are hybrid systems that exhibit some characteristics of tropical cyclones and some characteristics of extra-tropical cyclones.

Tropical cyclones extract much of their energy from the upper layer of the ocean, while extratropical cyclones derive much of their energy from the baroclinic temperature gradients in which they form.

Tropical Cyclones

The tropical cyclone is a system of low pressure occurring in tropical latitudes characterized by very strong winds. Here are the important notes which you must note about the Tropical Cyclones:

Distribution

- The tropical cyclones are found over the North Atlantic Ocean, Southern Atlantic Ocean, the eastern, central and western North Pacific Ocean, the central and western South Pacific Ocean and the northern and southern Indian Ocean.

Formation in Low Pressure areas

- All tropical cyclones are formed in areas of low atmospheric pressure in the Earth's atmosphere. Minimum Pressure is at centre
- The pressures recorded at the centers of tropical cyclones are among the lowest that occur on Earth's surface at sea level.

Driver is the Large Heat of Condensation

- Tropical cyclones are driven by the release of large amounts of latent heat of condensation, which occurs

when moist air is carried upwards and its water vapour condenses. This heat is distributed vertically around the center of the storm. Thus, at any given altitude, environment inside the cyclone is warmer than its outer surroundings.

Eye is the sinking air

- There is an area of sinking air at the center of circulation, which is known as Eye. Weather in the eye is normally calm and free of clouds, although the sea below it may be extremely violent. Eye is normally circular in shape, and is typically 30-65 km in diameter.

Stadium Effect

- The mature tropical cyclones sometimes exhibit an outward curving of the eye wall's top, making it resemble an arena football stadium. It is called Stadium Effect.

Greatest Wind speeds are at eye walls

- Greatest wind speeds in a tropical cyclone is found at the eye wall, which is a circle of strong thunderstorms that surrounds the eye. Here, the clouds reach the highest, and precipitation is the heaviest. The heaviest wind damage occurs where a tropical cyclones eye wall passes over land. Source of the huge Energy
- Primary energy source is the release of the heat of condensation from water vapour condensing, with solar heating being the initial source for evaporation. So a tropical cyclone can be visualized as a giant vertical heat engine supported by mechanics driven by physical forces such as the rotation (Coriolis force) and gravity of the Earth. Inflow of warmth and moisture from the underlying ocean surface is critical for tropical cyclone strengthening.

Impact of Earth's Rotation

- The rotation of the Earth causes the system to spin (Coriolis Effect) giving it a cyclonic characteristic and affecting the trajectory of the storm. In Northern Hemisphere, where the cyclone's wind flow is counterclockwise, the fastest winds relative to the surface of the Earth occur on the eastern side of a northward-moving storm and on the northern side of a westward-moving one; the opposite occurs in the Southern Hemisphere, where the wind flow is clockwise.

Movement of Clouds

- In Lower troposphere, motion of clouds is toward the center. At upper-level, there is outward flow of clouds.

Formation in Northern Atlantic Ocean

- Northern Atlantic cyclone season occurs from June 1 to November 30, sharply peaking from late August

through September. The statistical peak of the Atlantic hurricane season is 10 September.

Formation in North East Pacific

- The Northeast Pacific Ocean has a broader period of activity, but in a similar time frame to the Atlantic. Formation in North West Pacific
- The Northwest Pacific sees tropical cyclones year-round, with a minimum in February and March and a peak in early September.

Formation in North Indian basin

- Storms are most common from April to December, with peaks in May and November.

Formation in Southern Hemisphere

- Tropical cyclone year begins on July 1 and runs all year-round and encompasses the tropical cyclone seasons, which run from November 1 until the end of April, with peaks in mid-February to early March.

Requirements for formation:

- Water temperatures of at least 26.5 °C down to a depth of at least 50 m, so that it may cause the overlying atmosphere to be unstable enough to sustain convection and thunderstorms.
- Rapid cooling with height, so that it may cause release of the heat of condensation that powers a tropical cyclone.
- High humidity
- Low amounts of wind shear as high shear is disruptive to the storm's circulation.
- A distance from the Equator is necessary, which should be at least 555 km or 5° of latitude, so that it allows the Coriolis effect to deflect winds blowing towards the low pressure center and creating a circulation. Because the Coriolis effect initiates and maintains tropical cyclone rotation, tropical cyclones rarely form or move within about 5° of the equator, where the Coriolis effect is weakest.
- A pre-existing system of disturbed weather.

Movement

Coriolis Effect causes cyclonic systems to turn towards the poles in the absence of strong steering currents. The pole ward portion of a tropical cyclone contains easterly winds, and the Coriolis effect pulls them slightly more pole ward. The westerly winds on the Equatorward portion of the cyclone pull slightly towards the equator, but, because the Coriolis effect weakens toward the equator, the net drag on the cyclone is pole ward. Thus, tropical cyclones in the Northern Hemisphere usually turn north (before being blown east], and tropical cyclones in the Southern Hemisphere usually turn south (before being blown east] when no other effects counteract the Coriolis Effect.

High speed of rotation

- It is caused by Coriolis effect as well as energy released by heat of condensation.

Fujiwhara effect

When two cyclones approach one another, their centers will begin orbiting cyclonically about a point between the two systems. The two vortices will be attracted to each other, and eventually spiral into the center point and merge. When the two vortices are of unequal size, the larger vortex will tend to dominate the interaction, and the smaller vortex will orbit around it. This phenomenon is called the Fujiwhara effect.

Impact on passing over land

We should note that the deep convection is a driving force for tropical cyclones. The convection is strongest in a tropical climate; it defines the initial domain of the tropical cyclone. This is a major difference between the Tropical cyclones with other mid-latitude cyclones as the later derive their energy mostly from pre-existing horizontal temperature gradients in the atmosphere. To continue to drive its

heat engine, a tropical cyclone must remain over warm water, which provides the needed atmospheric moisture to keep the positive feedback loop running. When a tropical cyclone passes over land, it is cut off from its heat source and its strength diminishes rapidly. The moving over land deprives it of the warm water it needs to power itself, quickly losing strength. Thus, most strong storms lose their strength when the pass on to land, but if it manages to move back to ocean, it will regenerate.

Impact of passing over cold water

When a tropical storm moves over waters significantly below 26.5 °C, it will lose its strength. This is because of losing its tropical characteristic of the warm core.

Project Stormfury

The United States Government attempted in 1960s and 1970s to artificially weaken the Cyclones. During this project, Cyclones were seeded with silver iodide. It was thought that the seeding would cause supercooled water in the outer rainbands to freeze, causing the inner eye wall to collapse and thus reducing the winds. The Hurricane Debbie lost as much as 31% of its strength, when seeded with Silver Iodide in this project but Debbie regained its strength after each of two seeding forays. So, it was not a good idea. There were some more ideas applied which were as follows:

- Cooling the water under a tropical cyclone by towing icebergs into the tropical oceans and covering the ocean in a substance that inhibits evaporation
- Dropping large quantities of ice into the eye at very early stages of development (so that the latent heat is absorbed by the ice, instead of being converted to kinetic energy that would feed the positive feedback loop)
- Blasting the cyclone apart with nuclear weapons.
- A Project called Project Cirrus involved throwing dry ice on a cyclone.
- None of the idea was very much practical because the tropical storms are too large and too momentary.

Naming of Cyclones

Tropical cyclones are classified into three main groups, based on intensity: tropical depressions, tropical storms, and a third group of more intense storms, whose name depends on the region. If a tropical storm in the North-western Pacific reaches hurricane-strength winds on the Beaufort scale, it is referred to as a typhoon. If a tropical storm passes the same benchmark in the Northeast Pacific Basin, or in the Atlantic, it is called a hurricane. Neither "hurricane" nor "typhoon" is used in either the Southern Hemisphere or the Indian Ocean. In these basins, storms of tropical nature are referred to simply as "cyclones".

Types of the Tropical Cyclones

There are three kinds of Tropical cyclones:

- Tropical Depression: A tropical depression is a system with low pressure enclosed within few isobars and with the wind speed of 60 kmph. It lacks marked circulation
- Tropical Storm: It is a system with several closed isobars and a wind circulation of 115 kmph.
- Tropical Cyclone: It is a warm core vortex circulation of tropical origin with small diameter , circular shape and occurs in oceanic areas.

Anticyclones

An 'anticyclone' is opposite to a cyclone, in which winds move into a low-pressure area. In an anticyclone, winds move out from a high-pressure area with wind direction clockwise in the northern hemisphere, anti-clockwise in the southern hemisphere. Such a high pressure area is usually spread over a large area, created by descending warm air devoid of moisture. The absence of moisture makes the dry air denser than an equal quantity of air with moisture. When it displaces the heavier nitrogen and oxygen, it causes an anti-cyclone.

Tornado

Basically, hurricanes and typhoons form over water and are huge, while tornados form over land and are much smaller in size. A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud. In the United States, twister is used as a colloquial term for tornado.

What is it?

Technically, a tornado is a rotating column of air that is in contact with both the surface of the earth and a cloud, which is generally cumulonimbus and occasionally cumulus. Most tornadoes have wind speeds less than 110 miles per hour and travel several kilometers before dissipating.

How it is formed?

First the rotating cloud base lowers. This lowering becomes a funnel, which continues descending while winds build near the surface, kicking up dust and other debris. Finally, the visible funnel extends to the ground, and the tornado begins causing major damage.

Where they are seen?

Tornadoes have been observed on every continent except Antarctica.

How they are detected?

Tornadoes can be detected before or as they occur through the use of Pulse-Doppler radar by recognizing patterns in velocity and reflectivity data.

What is Fujitsa Scale?

Fujita scale rates tornadoes by damage caused, and has been replaced in some countries by the updated Enhanced Fujita Scale. An F0 or EF0 is the weakest tornado, while F5 or EF5 is the strongest tornado.

What is Torro Scale?

TORRO scale ranges from a TO for extremely weak tornadoes to T11 for the most powerful known tornadoes.

Funnel Cloud as predecessor

Tornadoes often begin as funnel clouds with no associated strong winds at the surface, although not all evolve into a tornado. However, many tornadoes are preceded by a funnel cloud. Most tornadoes produce strong winds at the surface while the visible funnel is still above the ground, so it is difficult to discern the difference between a funnel cloud and a tornado from a distance.

Infrasonic signature

Tornadoes produce identifiable inaudible infrasonic signatures. Due to the long distance propagation of low- frequency sound, efforts are ongoing to develop tornado prediction and detection devices with additional value in understanding tornado morphology, dynamics, and creation.

Electromagnetic Spectrum

Tornadoes emit on the electromagnetic spectrum. There are observed correlations between tornadoes and patterns of lightning.

When they occur?

Tornadoes are most common in spring and least common in winter. Spring and fall experience peaks of activity as those are the seasons when stronger winds, wind shear, and atmospheric instability are present. Tornado occurrence is highly dependent on the time of day, because of solar heating. Worldwide, most tornadoes occur in the late afternoon, between 3 pm and 7 pm local time, with a peak near 5 pm.

Temperate Cyclones

Temperate cyclones are generally called depressions. The have low pressure at the centre and increasing pressure outwardly. They are of varying shapes such as circular, elliptical. The formation of tropical storms as we read above are confined to oceans, the temperate cyclones are formed over land and sea alike. Temperate

Cyclones are formed in 35-65° North as well as South Latitudes. While the tropical cyclones are largely formed in summer and autumn, the temperate cyclones are formed in generally winter. Rainfall in these cyclones is low and continuous not as furious as in case of tropical cyclones.