



# Introduction to Meteorology

**32** Typhoon (1)

## Introduction



Some of the synoptic scale atmospheric phenomena can cause disasters in a short period of time, such as the thunderstorms and typhoons. Typhoons are also accompanied by heavy rain, hail, wind gusts, and lightning, which can lead to loss of lives and massive damage to property. Typhoon contains enormous energy. It is one of the most intense and destructive meteorological phenomena. Although typhoon rainfall varies by region and year, it accounts for 10~35% of annual rainfall in Korea.

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## Learning objectives



1. Describe the conditions and regions of typhoon formation.

## Learning Activities

### 1. Typhoon formation and structure

#### 1) Typhoon formation

The forcing mechanism of thunderstorms can be: unequal heating at the surface during a warm and humid summer afternoon, uplift along mountain barriers, warm air rising along a frontal zone, and converging surface winds and ascending air in a low-pressure zone.

Tropical Depression	Tropical Storm	Typhoon-Hurricane
The maximum wind speed below 17m/s	The maximum wind speed between 17~32m/s	The maximum wind speed above 33m/s

However, regarding tropical cyclones in the western Pacific Ocean, tropical cyclones with a maximum wind speed of 17 m/s or higher are usually called typhoons in Korea and Japan. Strong tropical cyclones do not occur in all tropical basins. Typhoons form over the regions with sea surface temperature warmer than 27°C. This warm sea surface is a source of energy supply to the atmosphere through evaporation.

Under the same conditions, the evaporation from the ocean surface accelerates as the water temperature increases. Typhoons dissipate over land or relatively cold water, mainly due to the lack of energy source.

## Learning Activities

### 1. Typhoon formation and structure

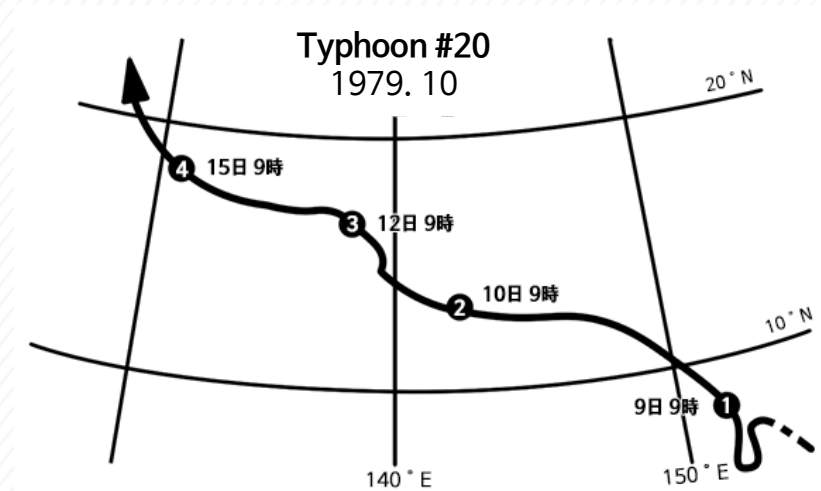
Typhoons do not develop at the equator. This is because of zero Coriolis force. As mentioned in the earlier section, the Coriolis force increases with latitude and is largest at the pole. Typhoons can only form at latitudes with sufficient Coriolis force. Most typhoons form in the latitude of  $5^{\circ}$  ~  $20^{\circ}$  north and south where both the warm sea surface temperature and Earth rotational effect play role on the genesis.

The same type of tropical cyclone is given different names in different regions of the world. In the western North Pacific, it is called a typhoon. In northern Atlantic and eastern North Pacific, it is referred to as a hurricane, in India a cyclone.

Each year about 80 tropical cyclones around the world develop, and approximately two thirds strengthen into typhoons or hurricanes.

## Learning Activities

### 1. Typhoon formation and structure



※ Source: Introduction to Atmospheric Science

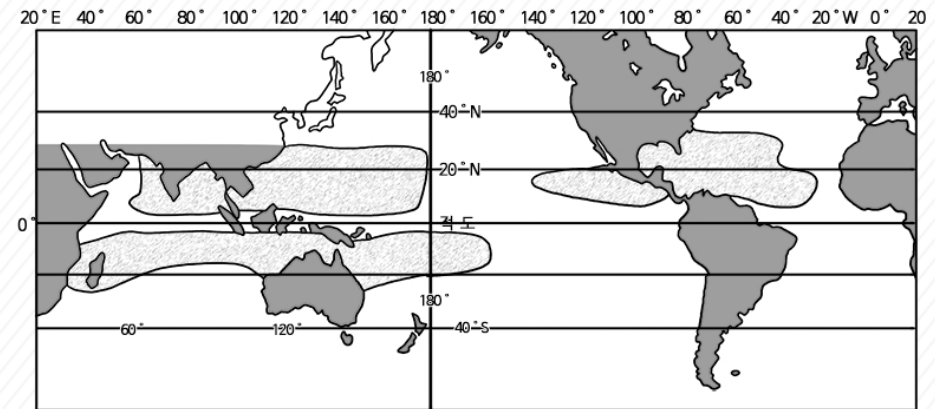
This picture is a photo from Japan's geostationary satellite showing the track of Typhoon #20, which occurred in October 1979 in the tropical western Pacific Ocean. This typhoon first formed on October 8 at 8°N, 152°E. It became a distinctive typhoon on the 10th as it moved to the northwest, and two days later it developed into a powerful typhoon with a central pressure of 870 hPa. This typhoon moved to high latitudes, passed through Japan, and died out. On average, typhoons have a lifespan of about nine days.

## Learning Activities

### 1. Typhoon formation and structure

Typhoons do not occur in all tropical basins. The tropical western Pacific is the place where typhoons develop most actively. On average, about 26 typhoons occur every year in this region, with two to three of them affecting Korea. In the western Pacific, tropical cyclones occur throughout the year, with having its active season from July to October and the maximum occurrence in August. Western Pacific tropical cyclones are known to be larger and stronger than others. This is because, from July to October, the sea surface temperature in the western Pacific warm pool reaches above 30°C.

Typical paths of the typhoon can be summarized as follows. Typhoons occur in the tropics, then move northwestward until they meet land or cold water. However, the tropical cyclone track can vary greatly depending on the region. Sometimes, typhoons show atypical tracks, such as a looping path. Such a typhoon can hardly be predicted and causes more damages. About 29% of typhoons in the western Pacific are known to have such abnormal tracks.



〈Tropical cyclone main development regions〉

※ Source: Introduction to Atmospheric Science

## Learning Activities

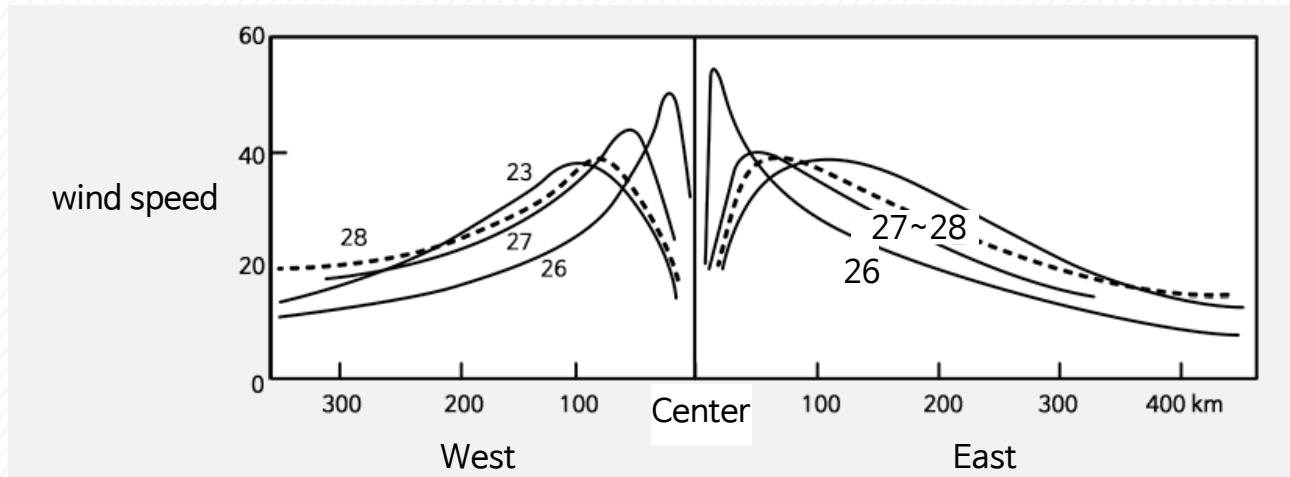
### 1. Typhoon formation and structure

#### 2) Typhoon structure

The size of a typical typhoon is about 500 km in diameter. As you can see from the satellite images, typhoons have spiral bands of deep clouds and a relatively clear sky at the center. This clear area is called the eye of the typhoon. The eye is surrounded by deep cumulus clouds, which are referred to as eyewall clouds. The center of the typhoon refers to the region of the lowest sea level pressure, which is usually below 980 hPa. Typhoon Ida's minimum central pressure dropped to a record-low 888 hPa, which passed through the Philippine islands in 1958.

## Learning Activities

### 1. Typhoon formation and structure



〈Wind speed at 700hPa in typhoon 7916〉

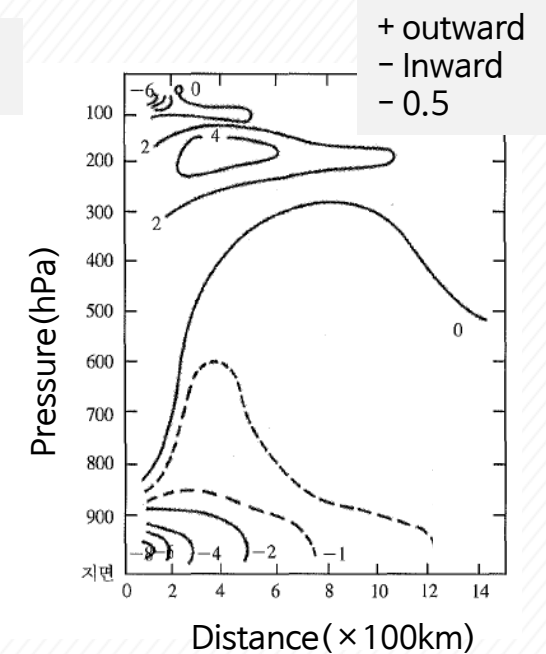
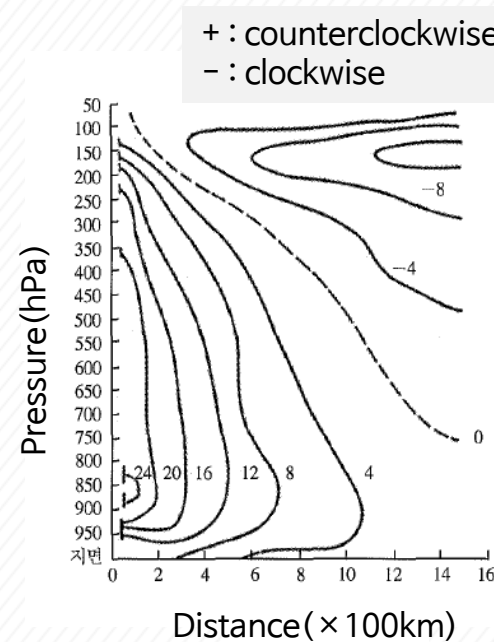
The eye is a region of mostly calm weather. However, the wind speed increases rapidly as it goes outward, and the maximum wind speed appears within 100 km from the center. Further, from the maximum wind speed region, wind speed decreases gradually. In order to see the structure of the typhoon more closely, we can examine the average tangential velocity and the radial velocity distribution in a vertical cross-section. The tangential wind velocity is wind speed of the air moving in a circular motion around the eye in a direction parallel to the tangent line. Radial velocity refers to the wind speed in the direction toward the center.

## Learning Activities

### 1. Typhoon formation and structure

The following figure shows the distribution of the average tangential and radial velocities of hurricanes observed in the western Atlantic Ocean. The hurricane wind in the entire troposphere blows counterclockwise. Clockwise wind is shown in the upper troposphere. According to the radial wind distribution, the air flows towards the center in the lower troposphere but flows outward from the center in the upper level. The radial wind becomes stronger toward the center and weak in the mid-troposphere.

Tropical cyclone has a cyclonic inward circulation in the lower-level, and anticyclonic outward circulation in the upper-level. This structure can be easily found in satellite images.



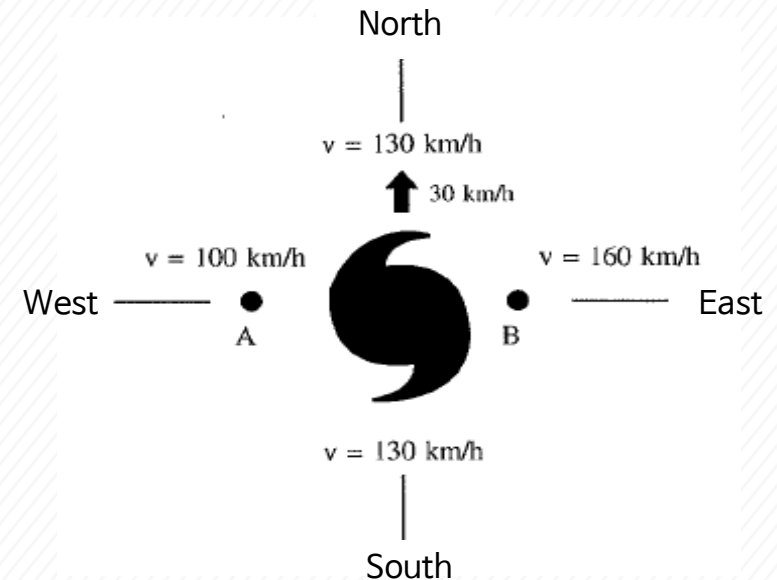
## Learning Activities

### 1. Typhoon formation and structure

Because typhoons move, there is a significant difference between the wind speed depending on the part of the typhoon. Generally, typhoon has symmetric zonal structure. If it does not move, the intensity of the surface wind changes as a function of distance from the center. When the typhoon moves, the strongest wind will be found on the right side of the typhoon, and the weakest wind on the left.

Suppose, for example, that a typhoon with a symmetrical structure and a wind speed of 130 m/h in a stationary state moves toward the north at a speed of 30 km/h. As a result, the wind speed will be 160 km/h in the right part of the typhoon and 100 km/h in the left part. Because the difference in wind speed between the left and right is considerable (60 km/h), damage can vary greatly depending on which part of the typhoon passes through. This is why more disasters occur in the area where the right side of the typhoon passes.

Another characteristic of typhoons can be found in the temperature distribution. In Typhoon Hilda, the temperature at the center was significantly higher than the surroundings, especially in the upper-level which reached 13–16°C higher. The adiabatic heating due to the descending air at the center and release of latent heat are responsible for the high temperature.



## Summary

### 1. Typhoon formation and structure

- Typhoons are strong tropical cyclones that develop over tropical oceans.
- Tropical cyclones go through three stages of development, depending on the magnitude of the maximum sustained wind speed: Tropical depression (below 17m/s), tropical storm (17~32m/s), and typhoon or hurricane (above 33 m/s)
- Typhoons form over the regions with sea surface temperature warmer than 27°C. This warm sea surface is a source of energy supply to the atmosphere through evaporation.
- Typhoons do not develop at the equator because the Coriolis force is zero.
- The size of a typical typhoon is about 500 km in diameter. Typhoons have spiral bands of deep clouds and a relatively clear sky at the center which is called the eye. The eye is surrounded by deep cumulus clouds, which are referred to as eyewall clouds.
- Since the typhoon has symmetric zonal structure, if it does not move, the intensity of the surface wind changes as a function of distance from the center. When the typhoon moves, the strongest wind will be found on the right side of the typhoon, and the weakest wind on the left.