Introduction to Meteorology

33 Typhoon (2)

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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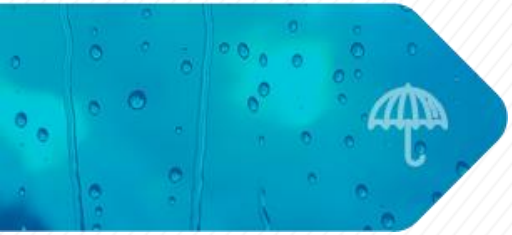


1. Life span of typhoon and damages

Learning objectives

1. Describe the structure and life span of the typhoon.
2. Describe damage caused by typhoons.

Learning Activities

1. Life span of typhoon and damages

1) Life span: development and dissipation

A typhoon is a vortex with a vast amount of air and moisture rotating at a high rate. At the center, it has a significantly higher temperature than its surroundings. When a huge amount of water vapor condenses, a tremendous amount of latent heat is released. This ~~heat~~ energy will heat the air inside the typhoon, bring about strong convection and pressure gradient. As a result, the heat energy will be converted into kinetic energy and develop strong winds. In other words, a typhoon is a heat engine that uses water vapor for fuel. Consequently, typhoons form in warm tropical basins of rich water vapor.

The development process of the typhoon is as follows.

Typhoon forms with tropical depression → **Friction makes the surface wind to blow inward** → **Inward wind (radial wind) can be observed**

Once the air converges near the center, the converging air will rise. As this air rich in water vapor rises upward, a large amount of water vapor will condense releasing latent heat. The warmer air will gain upward buoyancy and generate cumulonimbus up to the tropopause. After reaching the top of the troposphere, the vigorous updraft spreads outward without going any further. With the development of strong convection, the sea level pressure at the center decreases. Therefore, in order to supplement the air aloft that escapes from the center, the flow of air toward the center becomes stronger in the lower layer.

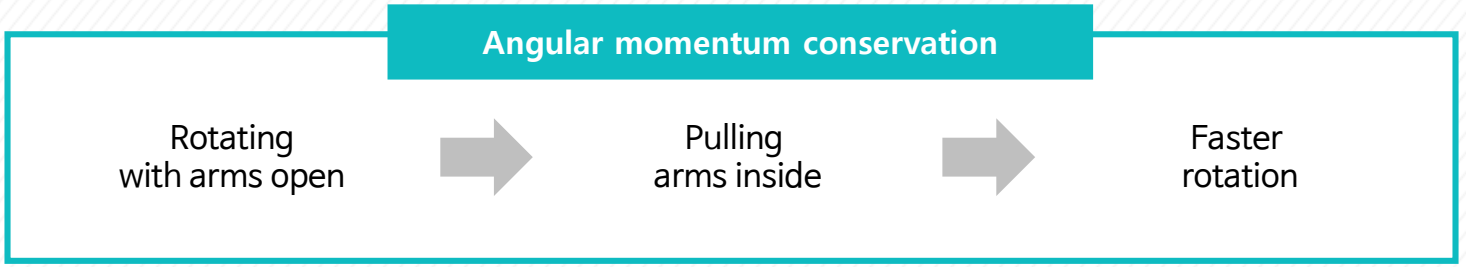
Because of the enough amount of moisture, this process easily leads to the development of tropical cyclone. However, this does not solely account for the development of typhoons with maximum wind speeds of tens of meters per second.

Learning Activities

1. Life span of typhoon and damages

Consider the principle of angular momentum conservation to account for typhoon development. The law of conservation of angular momentum is that the angular momentum of a system remains constant unless external torques act on it. That is, if the tangential velocity of an air mass at a distance R from the center is V, the angular momentum RV of an object of a unit mass must be constant. According to this principle, the tangential velocity must be changed to conserve the angular momentum when the radius of rotation changes without applying any other force to the object.

This angular momentum conservation is easily found when a figure skater executes a strong spin.



Strong winds in the typhoon are also explained by this principle, in particular, the conservation of absolute angular momentum must be considered.

Learning Activities

1. Life span of typhoon and damages

If the cyclonic circulation strengthens, the flow toward the center becomes stronger due to the surface friction leading to more moisture transport to the center. Eventually, the air and moisture convergence around the center becomes large, and the tropical cyclone intensifies into a typhoon. On the other hand, if the wind becomes very large near the center of the typhoon with a small radius of curvature, the centrifugal force becomes more dominant than the Coriolis force, and a cyclostrophic wind occurs.

The air coming from the outside to the center cannot reach the center of the typhoon, but it rises strongly in the eyewall cloud area and induces heavy rain. In the eye, a downward current makes a clear weather. Typhoons dissipate under these conditions: when the sea surface temperature is low, when it lands on the continent, and when reaching a region of atmospheric conditions that make the typhoon difficult to maintain its intensity.

Learning Activities

1. Life span of typhoon and damages

2) Damages caused by typhoon

The damages caused by typhoon are divided into three types as follows.

Wind damage	Storm surge	Flooding by heavy rain

The maximum wind speed of typhoon observed in Korea is 51 m/s in Ulleungdo on September 25, 1992, and there are a few typhoons with strong winds over 40 m/s. Such intense winds are mainly observed at the southern coast (Ulleungdo and Seogwipo) and other islands, and the damage caused by strong winds is also expected to be worse in these areas.

Globally, the most severe damage from typhoons comes from storm surges. A storm surge is a coastal flood or tsunami-like phenomenon of rising water commonly associated with the strong wind in typhoon. When a well-developed typhoon passes, storm surge with a height of about 5 meters can develop. When storm surge affects the coast, coastal areas are quickly submerged. In 1900, about 5,000 lives in Galveston (Texas) were lost by a destructive storm surge of more than 10 meters in height. Although the advance in forecast skill of tropical cyclone significantly reduces the number of casualties in recent years, economic losses are increasing.

Learning Activities

1. Life span of typhoon and damages

Since typhoons induces enormous amount of rain, much of the damage is from flooding. About 250 mm of rainfall is common in areas where typhoons pass, and rainfall persists even after the wind weakens. For example, when typhoon Agnes passed the Korean Peninsula in 1981, 547 mm/day rainfall was observed in Jangheung. For typhoon Gladys in 1991, 439 mm/day of rainfall was observed in Busan. Considering that the average annual precipitation in the South Korea is 1274 mm, the amount of daily precipitation by these typhoons is huge.

Korea is affected directly or indirectly by 2~3 typhoons every year. There was a year when typhoon had never passed and a year with seven typhoons. In Korea, the annual economic damage due to typhoons is about 100 billion won and 67 people become victims by typhoons, which is the most significant damage caused by weather disaster. The biggest damage to Korea after 1950 is caused by typhoon Sarah (849 deaths, 2,500 injured) in September 1959 and typhoon Thelma (500 billion won property damage) in 1987.

Summary

1. Life of typhoon and damages

- A typhoon is a vortex with a vast amount of air and moisture rotating at a high rate. At the center, it has a significantly higher temperature than its surroundings.
- When a huge amount of water vapor condenses, a tremendous amount of latent heat is released. This heat energy will heat the air inside the typhoon, bring about strong convection and pressure gradient. As a result, the heat energy will be converted into kinetic energy and develop strong winds.
- Typhoon is a heat engine that operates by using water vapor as fuel. Because of this, typhoons form in warm tropical basins of rich water vapor.
- Typhoon development can be understood by the principle of angular momentum conservation.