Introduction to Meteorology

30 Thunderstorms (1)

Introduction

There are many extreme weather events that cause disasters in a short period.
A typical example is thunderstorms. A thunderstorm producing heavy rain, hail, gust and lightning results in loss of lives and massive property damages.
The thunderstorm is a storm with heavy rain and thunder. This phenomenon occurs when the atmosphere is unstable, and moist air rises locally so that it releases latent heat. Air in the cloud warmed by the latent heat release further increases the upward buoyant force and triggers strong convection. Thus more low-level moisture condensation occurs by a strong updraft. Because the air that is rapidly raised by convection cannot go over the tropopause, it spreads out horizontally resulting in an anvil cloud. Convection develops vertically to the tropopause by strong updraft. A convective cloud with an anvil is called a cumulonimbus (or cumulus).
In the mature cumulus, heavy rain develops as warm and humid air rises rapidly and condenses. Also, the ice process plays an important role as cloud reaches the tropopause.

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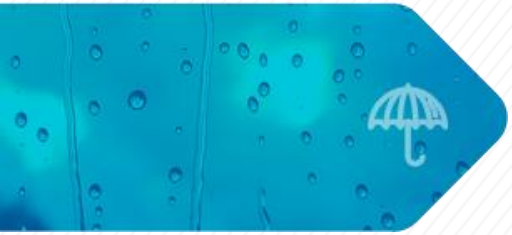


1. Characteristics and types of thunderstorms

Learning objectives

1. Describe the characteristics of thunderstorms.

Learning Activities

1. Characteristics and types of thunderstorms

A thunderstorm is a rain accompanied by lightning and thunder. It is mainly caused by the cumulonimbus. The thunderstorm can be classified as an ordinary thunderstorm (single cell) and multicell thunderstorm. The top is a flat anvil cloud.

Heavy rain, lightning, and hail are present near the surface. Strong downdraft causes gusts near the surface.

These thunderstorms consist of one or more convective cells. The convective cell is a strong updraft zone with a horizontal scale of about 10 to 100 km^2. Due to cloud and precipitation, it appears as a strong echo in weather radar images.

There are three types of a thunderstorm: single cell, multicell, and supercell. Multicell and supercell are relatively long-lasting and can cause significant damage through rain, hail, lightning, and tornadoes. It belongs to a severe storm.

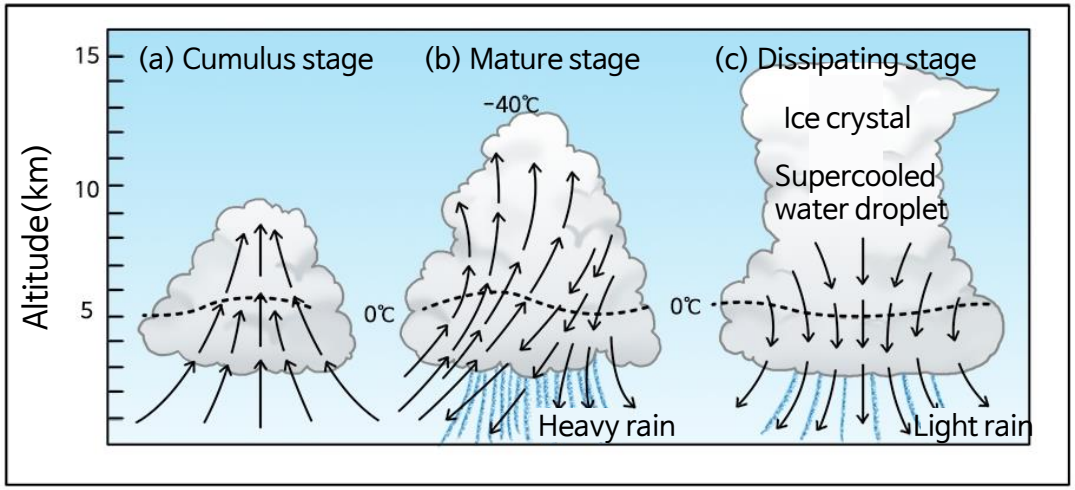
Learning Activities

1. Characteristics and types of thunderstorms

1) Single cell thunderstorm

Single cell thunderstorm is the most basic constituent of thunderstorms and mesoscale convective systems. It includes one strong updraft area and the accompanying precipitation. The development process is generally well understood. It is essential for the understanding of severe storm and mesoscale convective systems. The following three stages can explain the life cycle of single cell thunderstorms: cumulus, mature and dissipating stages.

The cumulus stage is the process of the cumulus development. In this stage, there is updraft but precipitation is not yet developed. The convection continues to grow into a deep convective mature stage. The updraft speed is about 10-40 m/s. It results in a rapid development of cloud and heavy rain. As air ascends, downdraft develops in the rain area.



〈The life cycle of a single cell thunderstorm〉

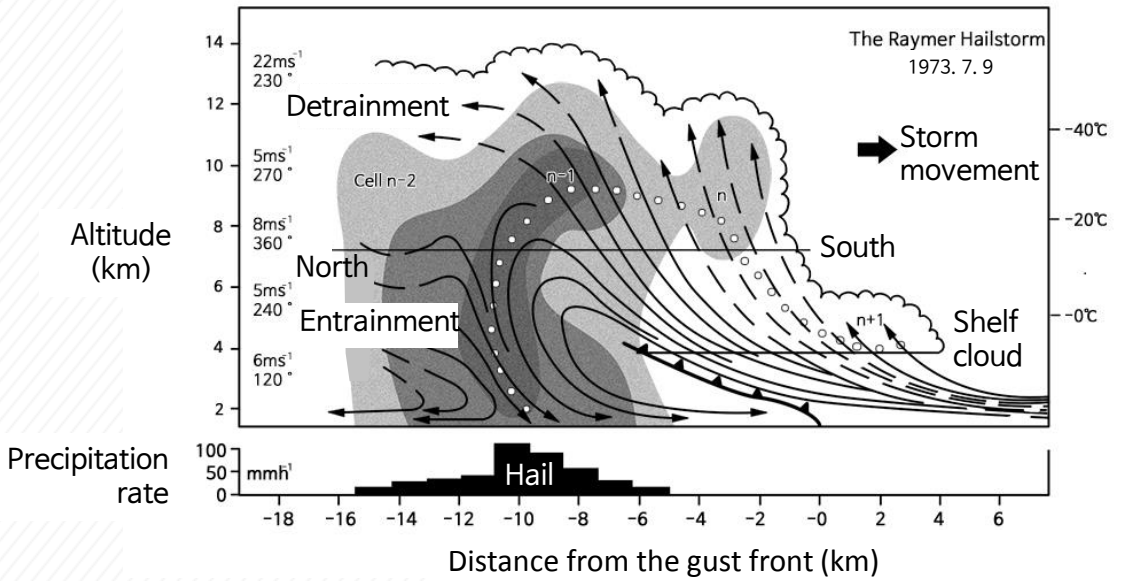
※ Source: Introduction to Atmospheric Science

Learning Activities

1. Characteristics and types of thunderstorms

For the development of downdraft, evaporation plays an important role. The air becomes colder and heavier due to the evaporation, loses its upward buoyancy, and begins to descend as a downdraft. It is often called the cold downdraft. When the downdraft reaches the surface, the air spreads out, forming a gust front which is necessary for severe storm development.

After the storm enters the mature stage, precipitating area enlarges, and the storm begins to dissipate. At this stage, because of the precipitation and downdraft, the moisture supply no longer occurs, so the convection becomes weaker, and thunderstorm dissipates. The life time of a single cell thunderstorm is about 45 to 60 minutes. The mature stage lasts about 15 to 30 minutes.



Learning Activities

1. Characteristics and types of thunderstorms

The width of the precipitation area of a thunderstorm is not large. Single cell thunderstorms are accompanied by strong rain and gusts but are less violent because of their short life spans and small size. Single cell storm forms in a region with weak vertical shear. In Korea, this type of thunderstorm often occurs in a calm and humid summer afternoon.

Learning Activities

1. Characteristics and types of thunderstorms

2) Multicell thunderstorms

Thunderstorms that contain a number of cells are called multicell thunderstorms and their horizontal scale is several tens of kilometers. Each cell undergoes a different stage of development. The cold downdraft created in each cell merges into one large gust front. The gust front induces strong convergence and updraft in front of the storm and creates a new cell.

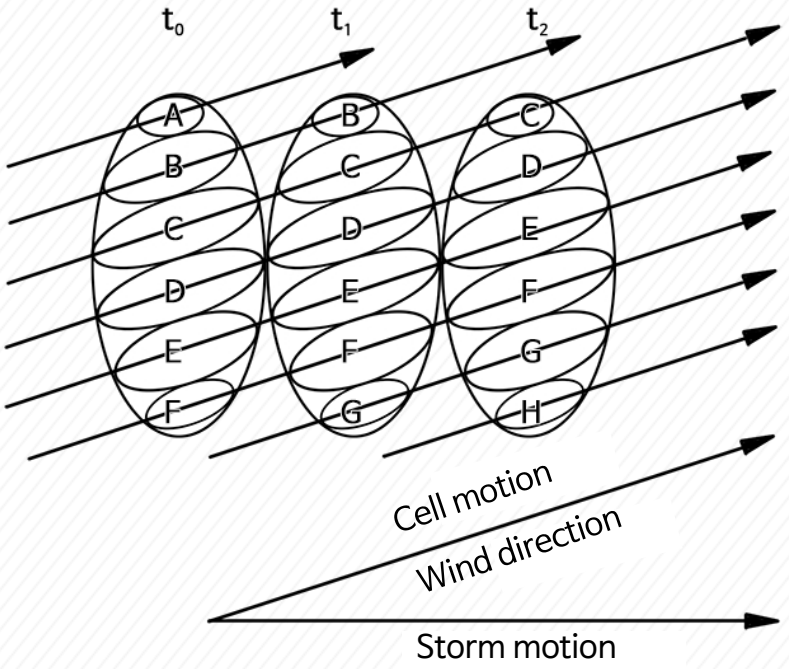
A strong updraft of a warm and humid air occurs at the front of the thunderstorm and flows toward the back of the thunderstorm in the upper layer. Since areas of updraft and precipitation are separated, new cells can continue to form.

Below the mid-troposphere, relatively dry air from the surroundings flows into the thunderstorm and contributes to the development of strong downdraft.

Learning Activities

1. Characteristics and types of thunderstorms

The movement of multicell thunderstorms is different from the direction of the average wind. The figure shows a movement of a multicell thunderstorm. In this case, it is assumed that the multiscale storm consists of six cells.
The direction of movement of each cell is the same as the wind direction. At the right end of the thunderstorm, new cells will continue to develop. At the left end, on the contrary, cells dissipate. As a result, the thunderstorm travels to the right differing from the direction of the average wind. The direction of movement of the individual cells is typically not the same as the direction of propagation of the multicell complex.



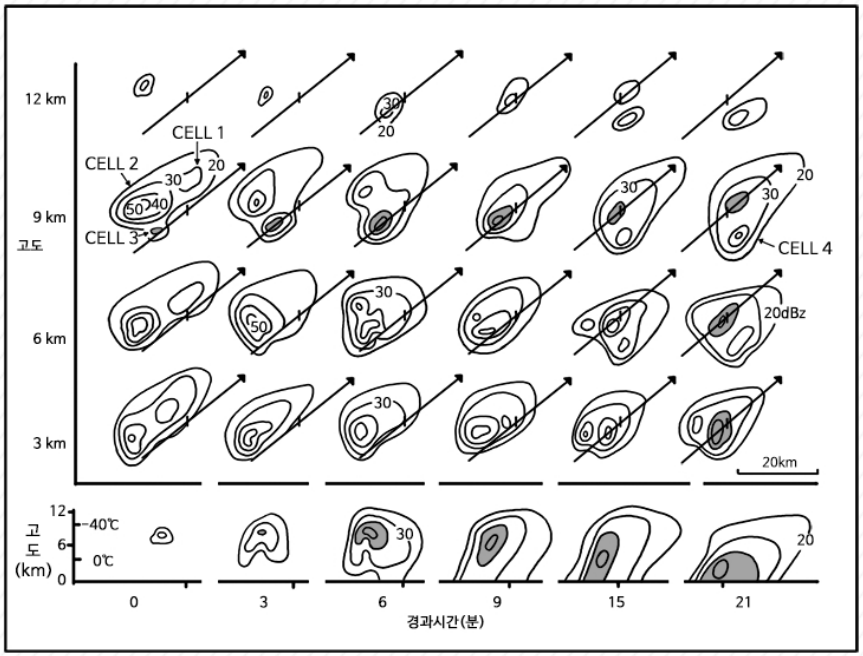
〈Movement of multicell thunderstorm〉
※ Source: Introduction to atmospheric science

Learning Activities

1. Characteristics and types of thunderstorms

Such propagation of multicell storm was revealed in weather radar images below. Thunderstorms at an altitude of 9 km are initially composed of three cells. During the observation period, cell 3 is generated, and it develops into the main cell and dissipates.

Multicell thunderstorms tend to form in an unstable atmospheric condition with strong vertical wind shear. Each cell has a short life span like single cell thunderstorm. However, the multicell storm can be sustained longer because new cells continue to form. Therefore, it causes significant damages. The precipitation area is approximately 10 to 50 m. Thunderstorms that bring heavy rain in Korea belong to this type.



〈Vertical cross-section of multicell a thunderstorm from radar image〉

※ Source: Introduction to atmospheric science

Learning Activities

1. Characteristics and types of thunderstorms

3) Supercell thunderstorm

Supercell thunderstorms are the most threatening storms which often accompany devastating hailstones and tornadoes.

It is a highly organized convective system as one large cell and lasts for hours. It develops under an unstable atmosphere with strong vertical wind shear, but it is less frequent than other types of storm.

Summary

1. Characteristics and types of thunderstorms

- A thunderstorm is a heavy rainfall accompanied by lightning and thunder.
- It is mainly induced by the cumulonimbus. A thunderstorm can be classified as an ordinary thunderstorm (single cell) and multicell storms.
- Thunderstorms consist of one or more convective cells.
- The convective cell is a strong updraft zone with a horizontal scale of about 10 to 100 km^2.
- Due to cloud and precipitation, it appears as a strong echo in weather radar image.
- There are three types of a thunderstorm: single cell, multicell, and supercell.
- Multicell and supercell are relatively long-lasting and can cause significant damage through rain, hail, lightning, and tornadoes. It belongs to a severe storm.