Introduction to Meteorology

14 Precipitation types

Introduction

Precipitation occurs in liquid, solid or mixed forms, depending on the region, season, and atmospheric conditions. In addition to rain and snow, precipitation can be in a variety of forms of sleet, freezing rain, hail, etc., which sometimes causes considerable damage. Precipitation measurements, such as rain gauge and radar, are necessary to estimate the intensity and amount of precipitation.

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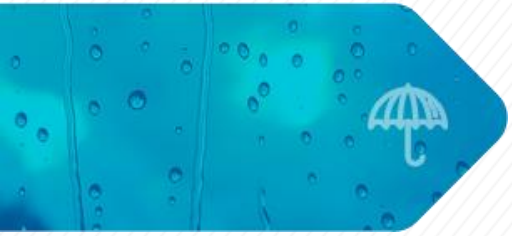


1. Types of precipitation
2. Measuring precipitation

Learning objectives

1. Describe different types of precipitation.
2. Describe the principle and method of various precipitation measurements.

Learning Activities

1. Types of precipitation

Precipitation is a phenomenon in which water droplets and ice crystals fall from the cloud to the surface. Precipitation includes rain, snow, sleet, freezing rain, snow grains, snow pellets, and hail.

1) Rain

Rain is the liquid water that reaches the ground off the clouds. In meteorology, rain is defined when the falling drop has a diameter larger than 0.5mm. Most rain falls from cumulonimbus which can generate heavy rain. Droplets with diameter smaller than 0.5 mm are called drizzle, which is produced by stratus clouds. Precipitation, which contains very small droplets that can reach the ground, is called mist.

Sometimes, the rain falling from a cloud never reaches the surface, when the low humidity causes rapid evaporation. As the drops become smaller, their falling rate decreases, and they appear to hang in the air as a rain streamer. These evaporating streaks of precipitation are called virga.

Raindrops that reach surface are seldom much larger than 5mm. This is because surface tension that holds the droplet is smaller than the friction force of the air, so large droplets are broken into small droplets. It also breaks into droplets due to the collision of raindrops.

Learning Activities

1. Types of precipitation

2) Snow

Snow is when ice particles that have grown from the clouds have reached the ground without melting. The shape of all snow crystals is hexahedral, and the size, shape, density of snowflakes depend on the temperature and humidity at which the snowflakes are formed.

The snowflake, which falls through the atmosphere with high humidity and temperature slightly above the freezing point, slowly melts. When snowflakes melt, a thin liquid film is covered on the edges. This liquid film allows snowflakes to clump together when they come in contact with other snowflakes, allowing them to create giant snowflakes of 2.5 cm in diameter or larger. On the other hand, when snowflakes pass through dry and very cold air, they fall on the ground in the form of small, powdery snow without clinging to each other. If ~~the~~ snow falls from intense cumuliform clouds, the snow is often referred to as thundersnow. A more continuous snowfall accompanies nimbostratus and altostratus clouds.

Horizontal visibility is greatly reduced when snow is raised from the ground by the wind, which is called blowing snow. The combination of drifting and blowing snow is called a ground blizzard. The blizzard is a weather condition with strong winds (greater than 15 m/s) bearing large amount of fine, dry, powdery snow that reduces visibility to less than several meters.

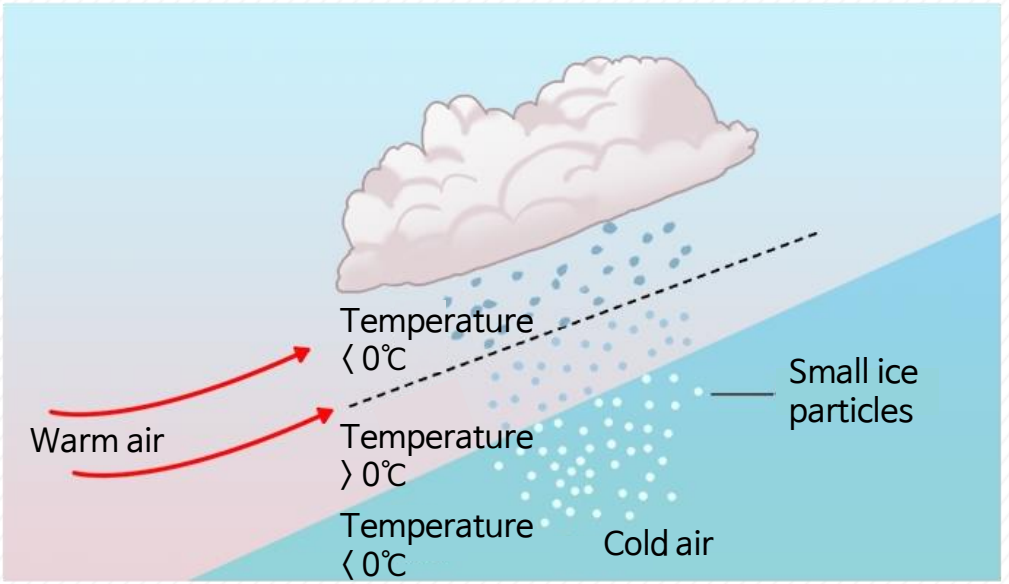
Learning Activities

1. Types of precipitation

3) Sleet and freezing rain

When a snowflake falls from a cloud, it passes through the layer above freezing and becomes a raindrop. When this raindrop goes through subfreezing air near the surface, the partially melted snowflake or cold raindrop turns back into ice and falls to the ground as a tiny transparent sleet. Sleet usually forms in the warm front. Freezing rain happens when the cold atmospheric layer near the surface is so thin that the raindrops cannot freeze before reaching the ground. Instead, the raindrops turn to supercooled water droplets.

When light rain, drizzle, or supercooled droplets strikes road surfaces or pavements, it produces ice that often appears relatively dark. Such ice is called black ice which produces extremely hazardous conditions.



〈Temperature distribution and sleet formation〉

Learning Activities

1. Types of precipitation

4) Snow grains and snow pellets

Small, transparent ice that falls from stratus clouds is called snow grains. Meanwhile snow pellets are characterized as transparent white ice grains about the size of an average raindrop. They are sometimes confused with snow grains. Unlike snow grains, snow pellets are brittle, crunchy, and bounce upon hitting a hard surface. They fall as shower especially from cumulus congestus clouds.

When the ice particle accumulates a heavy coating of rime, it is called graupel. In winter, when the freezing level is near the surface, the graupel reaches the surfaces as a snow pellet. In summer, graupel melts and reaches the surfaces as large raindrops. In large convective clouds, graupel can develop into hail.

Learning Activities

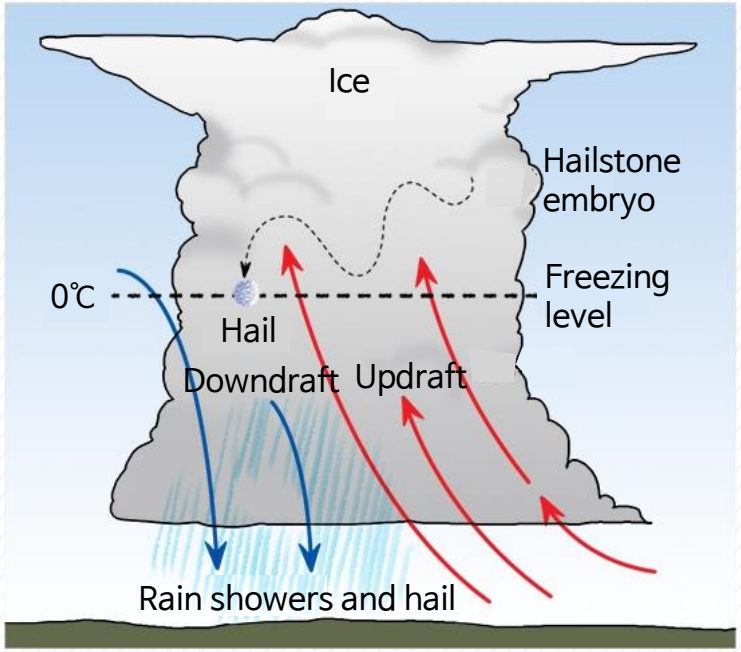
1. Types of precipitation

5) Hail

Hail is a piece of ice particle in a round or irregular shape with a diameter of 2 mm or larger. The hail size is usually between 1 and 5 cm, but sometimes hail is observed between 10 and 20 cm. Hail not only crushes cars, breaks roofs, but also damages aircraft, crops, and livestock.

The formation of hail occurs in a cumulonimbus where strong updrift of about 160 km/h meets sufficient supercooled droplets. Graupels or large frozen raindrops act as embryos which can be lifted up to the height above the freezing level by strong updraft.

Suspended aloft in clouds by the strong updraft, the hail becomes bigger in size by falling and rising repeatedly. This process repeats until the hail meets the downdraft or becomes too heavy.



〈Hail formation〉

Learning Activities

1. Types of precipitation

〈Cut section of hail〉

The cross-section of the hail reveals concentric layer of different density and opacity, which can be explained by the freezing rate of supercooled water droplets on the hail surface. When the supercooled water droplets collides with hailstones at the upper part of clouds lower than 0 ℃, the supercooled water droplet rapidly freezes forming small air bubbles in an opaque milky layer of the hail. On the other hand, at the lower part of clouds with relatively higher temperatures, the subcooled water droplet is slowly frozen on the hail surface, creating a transparent layer without air bubbles.

Learning Activities

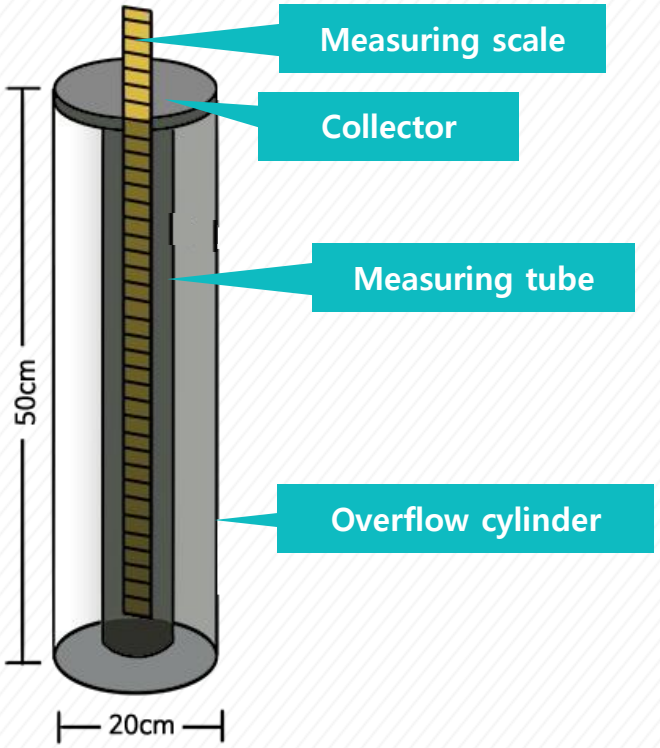
2. Measurement of precipitation

There are various instruments and methods for measuring precipitation, all of which have shortcomings and advantages

1) Measuring rainfall

Standard rain gauge is used to measure rainfall. The standard rain gauge is manufactured complying with World Meteorological Organization standards and used in each country.

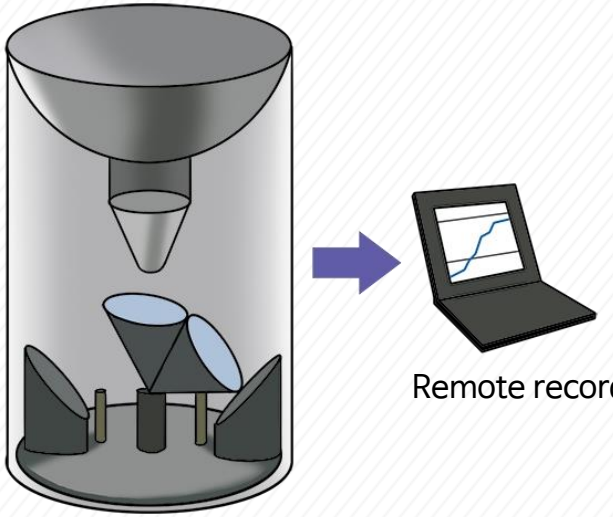
Cylindrical rain gauge of which diameter is 20 cm collects rain in a cylindrical measuring tube through the funnel-shaped collector. The diameter of this measuring tube is 1/10 of the diameter of the funnel. Measuring rainfall with rain gauge is the most primitive method because it must be directly observed at the beginning and end of rainfall and cannot be measured remotely or automatically.



Learning Activities

2. Measurement of precipitation

Another rain gauge that measures rainfall is the tipping-bucket gauge. It consists of a rainfall receiving funnel leading to two small metal buckets (collectors). The rain falls in one bucket and reaches the amount of 0.5mm, the weight of the water causes it to tip and empty itself. The second bucket immediately moves under the funnel to catch the water. When it fills, it also tips and empties itself, while the other bucket moves back beneath the funnel. Each time a bucket tips, an electric contact is made, causing a pen to register a mark on a remote recording chart. The drawback of the tipping bucket rain gauge is that during each tip, it loses some rainfall, therefore, underestimates rainfall amounts especially during heavy downpours. Remote measure of precipitation can also be made with a weighting-type rain gauges which measures rainfall amount by converting the weight to the height.



〈Tipping-bucket rain gauge〉

Learning Activities

2. Measurement of precipitation

2) Measuring snowfall

Snowfall can be measured either by the depth of the snow on the ground or by the depth of the water (water equivalent) when it is melted for a certain amount of time. In general, about 10cm of snow will dissolve to about 1cm of water. Estimation of snowfall is much less accurate than measuring rainfall using rainfall gauge. The reason is that the snow can be drifted by strong winds, and the depth of the snow may not be uniform depending on the region. Moreover, snow can be melted by surface radiation.

Learning Activities

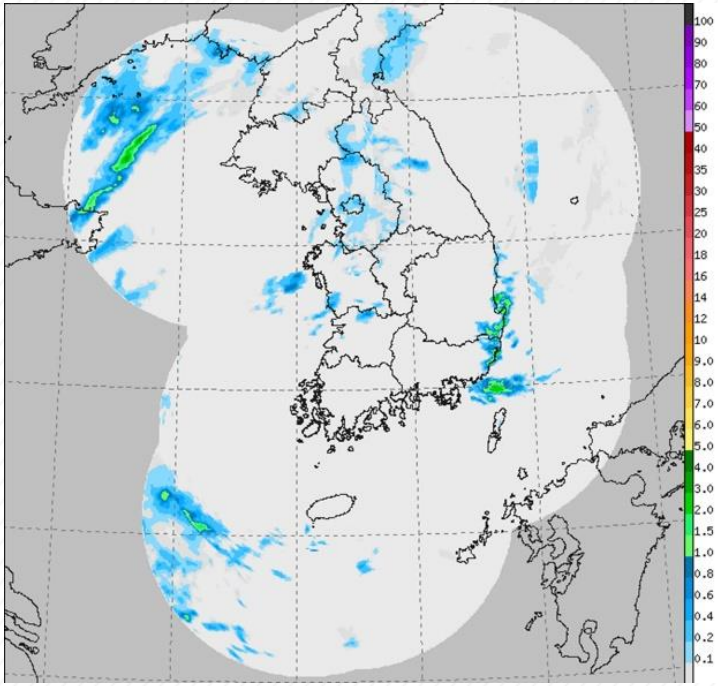
2. Measurement of precipitation

3) Weather radar

Weather radar is used to measure precipitation in a wide area. The radar sends out short microwave pulse. When this energy encounters a target, a fraction of the energy scattered back toward the transmitter is detected by a receiver.

For rainfall detection, a wavelength of 3 to 10 cm is used, which passes through small cloud droplets while being scattered by large raindrops, ice crystals or hail. Radars receive waves (radar echo) that are scattered back by cloud or raindrops. When the precipitation is severe, the echo becomes clearer enabling to measure the intensity and area of rain.

The Doppler radar, which has been in use since the 1990s, measures the intensity and area of precipitation. Using the Doppler effect, it is capable of measuring the speed at which falling rain is moving horizontally toward or away from the radar antenna. Doppler radar allows scientists to observe tornadoes and thunderstorms.



〈November 30, 2016 radar image〉

※ Source: Korea meteorological administration

Learning Activities

2. Measurement of precipitation

〈Dual-polarization radar〉
※ Source: Korea meteorological administration

The advanced type of Doppler radar is a polarimetric radar or dual-polarization radar. This radar simultaneously sends waves both horizontally and vertically to measure precipitation.

Learning Activities

2. Measurement of precipitation

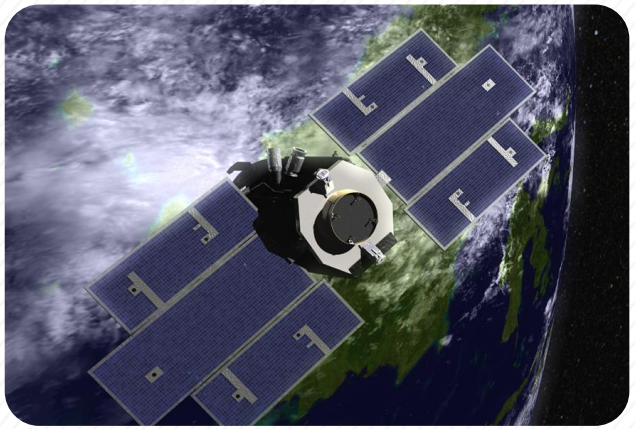
4) Satellites

〈Tropical Rainfall Measuring Mission (TRMM)〉

TRMM satellite is orbiting the Earth above 400 km. Equipped with precipitation radar, it can measure the intensity of rainfall in tropical and subtropical regions that were not accessible in the past. It can detect rainfall intensity less than 0.7mm per hour and provide a vertical profile of the intensity of rain and snow from the surface to about 20 km.

Learning Activities

2. Measurement of precipitation



〈Cloud observation satellite〉
※ Source: www.nasa.gov

The CloudSat, launched in April 2006, is circling the Earth at about 700 km and uses a wavelength of about 0.3 cm for cloud measurements. This satellite is equipped with a cloud profiling radar (CPR) that provides a vertical distribution of clouds, small cloud droplets, and ice.

Summary

1. Types of precipitation

- Precipitation occurs in liquid, solid or mixed form, depending on the region, season, and atmospheric conditions.
- Rain is the liquid water that reaches the ground off the clouds with a diameter larger than 0.5mm.
- Snow is when ice particles fallen from the clouds reaches the ground without melting.
- Sleet and freezing rain form when raindrop falls through the inversion layer. Black ices produce extremely hazardous conditions.
- Hail is a piece of ice particle in a round or irregular shape with a diameter of 2 mm or larger. Hail grows through continuous ascending and descending motion within clouds.

Summary

2. Measurement of precipitation

- Precipitation can be measured by rain gauge. There are cylindrical rain gauge, tipping-bucket gauge, and weighting-type rain gauges.
- Snowfall can be measured either by the depth of the snow on the ground or by the depth of the water (water equivalent) when it is melted for a certain amount of time.
- The amount and intensity of precipitation can be measured by weather radar and satellite.