3.7 Precipitation / snow water equivalent (SWE), snow survey (snow depth, snow weight)

Precipitation is the quantity of condensed atmospheric water vapor that is deposited on the earth's surface within a given time, usually expressed in height above a flat surface. Precipitation occasionally distinguishes between rainfall in water form and snowfall in snow form. Although snowfall is the process of solid snow precipitating, its quantity is converted into the amount of water and expressed in mm, as for rainfall.

Snow that does not melt but accumulates on the ground constitutes snow cover. As snow cover exerts substantial effects on the surrounding environment, various observations are carried out on snow cover. This chapter discusses the snow depth and the snow weight.

3.7.1 Precipitation (rainfall / snowfall)

Types of instruments

Tipping bucket rain gauges and standard rain gauges are used commonly for measuring precipitation.

Tipping bucket rain gauge

Rainwater entering from a cylindrical intake mouth is poured through a funnel into a tipping bucket. Precipitation is measured by the tip frequency (Photo 3.7-1).

Tipping bucket rain gauge



Photo 3.7-1 Appearance and structure of a tipping bucket rain gauge.

Standard rain gauge

A cylindrical water bucket is buried and rainwater entering from the intake mouth is collected in a container within the bucket. The water is then gauged with a graduated measuring cylinder.

As is the case of rainfall, snowfall is measured by a tipping bucket rain gauge, which however requires devices for melting snow and preventing the snow volume from being underestimated under the influence of wind.

Spilt water tipping bucket

To measure snowfall, the bucket is filled with heated water on which snow falls and melts. The amount of water spilt from the bucket is measured by the tipping bucket to determine the water equivalent of the snow. The bucket must be provided with oil regularly to prevent heated water from evaporating from the surface.

Measuring method

A rain gauge must be installed such that it is level and at least four times as far away from any objects (e.g., buildings, trees) as the objects are high. Such a requirement is difficult to satisfy in a forest. To address this problem, trees are usually felled. But in the case where trees are felled, the growth of surrounding trees likely triggers a drastic change in rainfall measurements. For this reason, age-related changes are monitored and effects of environmental changes on installation places are evaluated by placing an auxiliary tipping bucket in the mid-section of a meteorological observation tower, where the observation is little affected by trees, and by carrying out observations at more than one point.

The smooth movement of a tipping bucket rain gauge must be ensured. Pulse data put out at each tip are confirmed. Regular maintenance should be exercised by lubricating junctions and moving parts.

In a snowy region, rain gauges need to be protected from snow by removing snow during the winter or by installing a gauge at a height above the snow cover. When the heater cannot melt snow fast enough to keep up with extremely heavy snowfall, the bucket top may become filled with snow, to which close attention should be paid, particularly in a deep snow-covered area. Once the bucket top is filled up with snow, data are unobtainable for a long time. When heavy snowfall is expected, the heater should be set at a higher temperature.

In seasons other than winter, the spilt water tipping bucket may become infested with bugs if it is filled with water, which hampers operation. Except in winter, measurement should be performed with an ordinary tipping bucket rain gauge.

Tips!

The tipping bucket sends a switch-controlled rectangular-wave signal, which is prone to noise. As a chattering-prevention measure, a small-capacity condenser is put between the two output terminals. Or, to deal with chattering noise, data registered on the data logger continuously in a short time (approx. 1 sec.) can be regarded as one datum.

Tips 3.7-1

Tips!

For snowfall measurement, a windshield should be placed around the tipping bucket to prevent a wind-induced reduction in the catching rate. The size of the windshield is not standardized but depends heavily on the wind velocity and snow quality of the measuring site. In one windy area, for example, the placement of more than one windbreak plate with a height exceeding 2 m was suggested for one tipping bucket. Usually, the reliability of data is significantly improved by enclosing the snow gauge within a cylinder that is two or three times the size of the bucket cylinder and raising its top about 20 cm higher than the bucket.

Tips 3.7-2

Calibration

A tipping bucket is calibrated with water that is gauged using a graduated measuring cylinder. The tipping bucket seldom deviates from the norm enough to need re-calibration.

3.7.2 Snow survey (snow depth, snow weight)

Types of instruments

During a snow season, continuous observation of snow accumulation is practiced extensively to gain information on snowfall.

Snow depth

To visually determine snow depth, a snow gauge is used. Automatic measuring instruments include a laser type and an optical type, in addition to the ultrasonic type that is employed by AMeDAS, Automated Meteorological Data Acquisition System. Ultrasonic sensors and laser sensors are installed above the snow surface to measure the distance from the sensor to the snow surface (Photo 3.7-2). Optical sensors measure the snow depth based on the principle light does not penetrate beyond a certain depth.



Photo 3.7-2 Snow depth measured by ultrasonic snow gauge. (Tohkamachi Experimental Station)

Snow water equivalent

A snow pillow (metal wafer) containing an anti-freezing solution is placed at the measuring site and the snow weight is measured on the basis of the change in pressure on the snow pillow with the help of a snow cover weight meter. As another method, a cylinder of known cross section is inserted into a snow layer down to the soil boundary. Samples collected from all the snow layers are weighed, from which the snow water equivalent is calculated.

Measuring method

As is the case of a rain gauge installation site, snow cover is observed on the level in an area free from obstructions such as trees.

In addition to measurement by a stationary snow gauge, it is desirable to carry out the periodical multi-point measurement using a snow sampler. Through multi-point sampling, spatial variation can be evaluated and the snow density can be determined from snow depth and weight. Although various snow samplers are commercially available, a handmade device can serve the purpose.

When using a snow pillow to measure the snow weight, the measurement weight may often be underestimated as a result of snow bridging over the pillow if the snow volume is too large for the size of the snow pillow. According to past research, it is ideal for the length on a side of a snow pillow to correspond to the maximum snow water equivalent. The length of the snow pillow should be based on expected value of maximum snow weight.

Calibration

Melting snow creates gaps around snow gauging posts and poles, which causes measurement errors. The snow depth should be gauged with a sounding rod, and any necessary measurement corrections must be made.