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The Importance of Data Quality Control in Disaster Prevention and Mitigation

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Summary and Purpose of Document

Every year, Japan is affected by storm and flood damage resulting from heavy rain, heavy snow, high waves, storm surges and so on caused by typhoons, extratropical cyclones and fronts. When hazardous weather conditions are expected, JMA delivers a variety of simple messages including warnings, advisories and bulletins to the general public and disaster prevention authorities.

Heavy rain warnings/advisories and flood warnings/advisories provide information on sediment-related disasters, floods and inundation. The criteria for these warnings and advisories are the amount of rainfall, the soil water index and the runoff index.

JMA uses the radar/raingauge-analyzed precipitation, which is calibrated radar data by accurately measuring raingauges data, for forecast operations.

Anomalous values observed using raingauges or radar can contaminate radar/raingauge-analyzed precipitation data, which are used as criteria for warnings and advisories. Such values may therefore obstruct forecast operations.

Quality control for observed data is therefore important for smooth forecast operation.

1. Meteorological characteristics and natural disasters of Japan

1.1 Meteorological characteristics of Japan

Japan is located on the eastern edge of the Asian continent, and has a temperate climate with four distinct seasons.

In wintertime (from December to February), developed extratropical cyclones over the Pacific Ocean and dominant Siberian anticyclones bring snowfall to the Sea of Japan side of the country.

Conversely, in summertime (from July to August), Pacific anticyclones cover Japan and bring clear skies to the whole country along with temperatures of over 30°C. Sometimes these conditions spawn thunderstorms.

In spring and autumn, extratropical cyclones and moving highs pass over Japan alternately. Rains falls around the front of these extratropical cyclones.

In the rainy season (known as the Baiu in Japan) from June to July, the Baiu front has a tendency to bring in heavy rains. In another rainy season in September, the Akisame front also tends to bring in heavy rains.

In summer and autumn (from August to October), typhoons sometimes hit Japan.

Figure 1 shows typical seasonal weather maps.

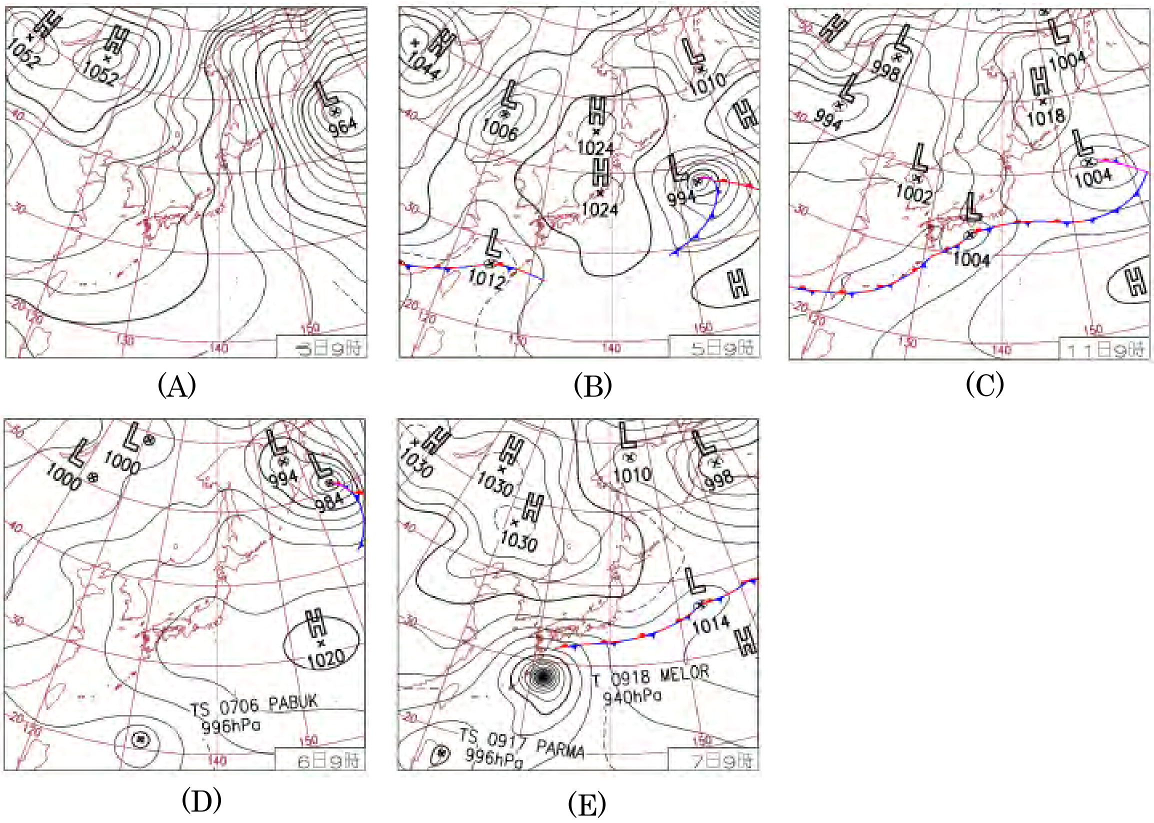

Figure 1. Typical seasonal weather maps

(A) Winter (Jan. 3, 2009) (B) Spring (Mar. 5, 2009) (C) Baiu (Jun. 7, 2006)
(D) Summer (Aug. 6, 2007) (E) Autumn with typhoon (Oct. 7, 2009)

1.2 Natural disasters in Japan

Heavy rains occur when a front such as the Baiu stalls over Japan and when extratropical cyclones or typhoons hit the country.

Heavy snow may fall on the Sea of Japan side when developed extratropical cyclones over the Pacific Ocean and dominant Siberian anticyclones are present, causing upper cold air to move southward.

Storm winds and high waves occur when developed extratropical cyclones and typhoons approach Japan.

In recent years, related disasters have resulted in about 100 fatalities or people unaccounted for, mostly as a result of gusting winds, floods and snow disasters.

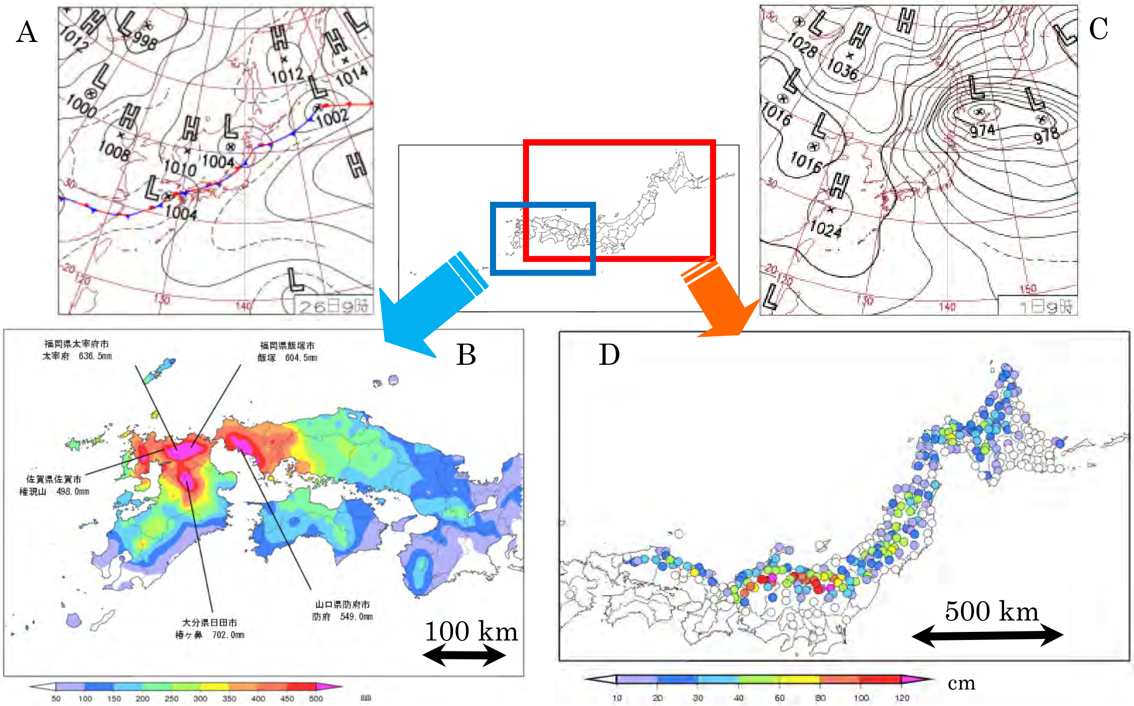

Figure 2. Examples of heavy rain and heavy snow

Figures A and B show a heavy rain event that occurred from July 19 to July 26, 2009, resulting in 30 people killed or unaccounted for.

Figure A shows a weather map for July 26, 2009.

Figure B shows cumulative rainfall from July 19 to July 26, 2009.

Figures C and D show a heavy snow event that occurred from Dec. 31, 2009 to Jan. 1, 2010, resulting in a number of injuries.

Figure C shows a weather map for Jan. 1, 2010.

Figure D shows cumulative snowfall from Dec. 31, 2009 to Jan. 1, 2010.

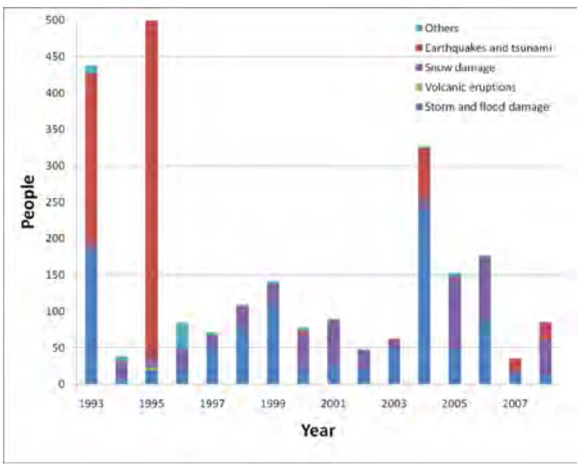

Figure 3. Temporal sequence showing numbers of fatalities and missing people

This figure shows the number of fatalities and missing people resulting from natural disasters such as storm/flood damage, volcanic eruptions, snow damage, earthquakes, tsunami and so on in recent years. In 1995, the Hyogoken Nambu earthquake (also known as the Great Hanshin-Awaji Earthquake) occurred, killing over 6,000 people. (Reference: White Paper on Disaster Management 2009)

2. Information for severe weather preparedness

2.1 Information delivered by JMA

Every year, Japan is affected by storm and flood damage resulting from heavy rain, heavy snow, high waves, storm surges and so on caused by typhoons, extratropical cyclones and fronts. When hazardous weather conditions are expected, JMA delivers a variety of simple messages including warnings, advisories and bulletins to the general public and disaster prevention authorities.

Warnings and advisories for the relevant municipalities are issued whenever forecasters expect weather elements such as rainfall, wind speed, wave height and tide level to meet the trigger criteria.

Currently, JMA issues warnings and advisories for 1,777 municipalities to support the activities of disaster prevention agencies.

2.2 Criteria for heavy rain warnings/advisories and flood warnings/advisories

Here we look at heavy rain warnings/advisories and flood warnings/advisories. These provide information on sediment-related disasters, floods and inundation, which account for a large number of fatalities and missing people.

A heavy rain warning or advisory is issued when sediment-related disasters and inundation caused by heavy rains are feared, while a flood warning or advisory is issued when a rise in water levels and flooding caused by heavy rain, persistent rain and snowmelt water may occur.

The criteria for these warnings and advisories are the amount of rainfall, the soil water index and the runoff index.

The more rain seeps underground, the higher the risk of sediment-related disasters such as debris flow, slope failure and so on. The soil water index is used to estimate the amount of water in soil, and indicates the risk of sediment-related disasters.

Additionally, rainwater accumulates in rivers and runs downstream over time. The runoff index shows the risk of flooding from the amount of rainwater in the drainage basin and the time of flow.

To calculate these indices, precipitation values with a high level of quantitative accuracy are needed.

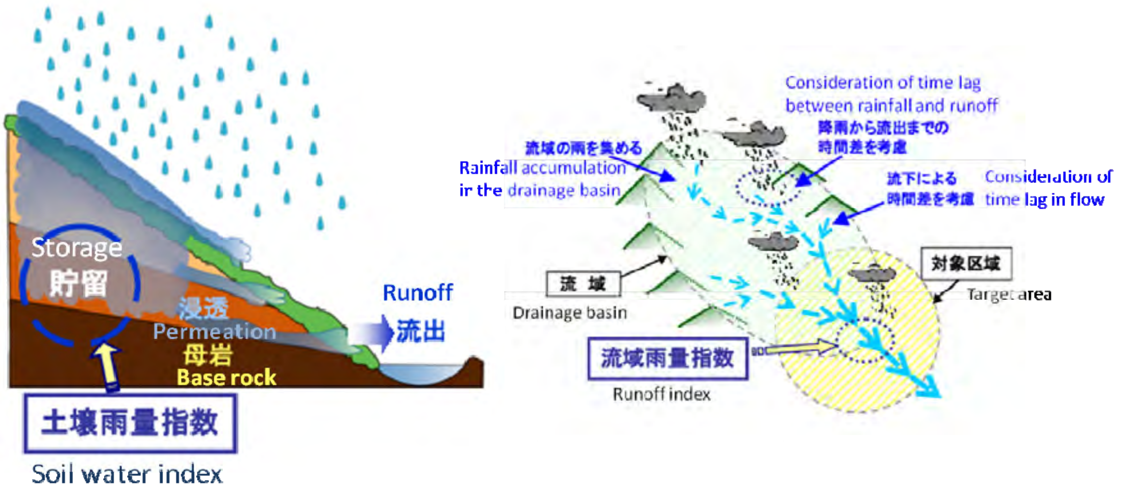

Figure 4. Visual outlines of the soil water index and the runoff index

(Left) The soil water index indicates the amount of rainwater stored in soil.

(Right) The runoff index indicates the flow of rainwater accumulating in the drainage basin and its downstream flow over time.

3. Rainfall data for forecasting operations

3.1 Precipitation observation equipment

The basic types of equipment for observing precipitation are raingauges and radar. An advantage of raingauges is that they measure actual amounts of precipitation, while a disadvantage is that they can observe precipitation only at single points. An advantage of radar is that it observes large areas at a higher spatial resolution than the raingauge network, and a disadvantage is that it may produce readings different from those of rainfall observed on the ground as it does not measure the amount of rainfall directly.

One-hour cumulative rainfall measured using raingauges and one-hour accumulated echo intensity measured using radar for the same hour are shown in Figure 5. These images indicate that raingauges can observe rainfall only at single points, while radar can observe echoes with no spatial gap. The one-hour cumulative rainfall amount measured using raingauges is different from the one-hour accumulated echo intensity measured using radar.

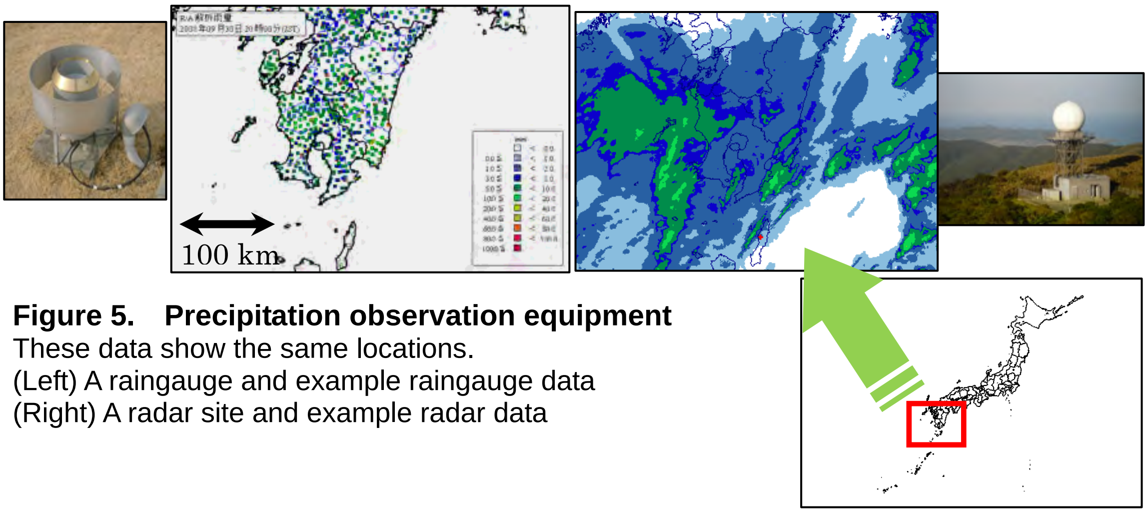

Figure 5. Precipitation observation equipment

These data show the same locations.

(Left) A raingauge and example raingauge data

(Right) A radar site and example radar data

Raingauges measure rainfall amounts automatically, and JMA collects data from around 10,000 such units belonging to JMA, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and local governments every 10 minutes or every hour. The number of units means that a raingauge is located in every 7-km grid on average. Figure 6 shows the location of raingauges in Japan (only part of the country is shown due to space limitations). Red squares are JMA raingauges, blue squares are MLIT raingauges, and green squares are local government raingauges.

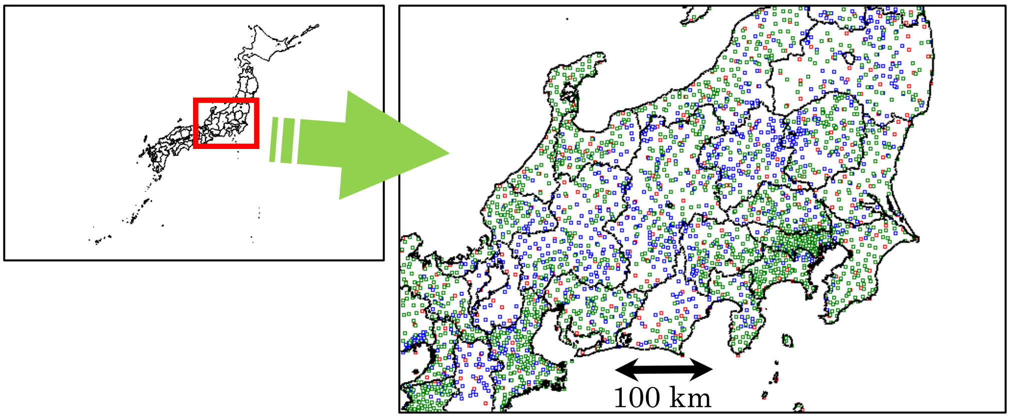

Figure 6. Locations of raingauges

This figure shows part of Japan. Red squares are JMA raingauges, blue squares are MLIT raingauges, and green squares are local government raingauges.

JMA collects data from 46 C-band radars run by JMA and MLIT. The grid size of the data is 1 km. Figure 7 shows the location of each radar site. Red circles are JMA radar sites, and white triangles are MLIT radar sites.

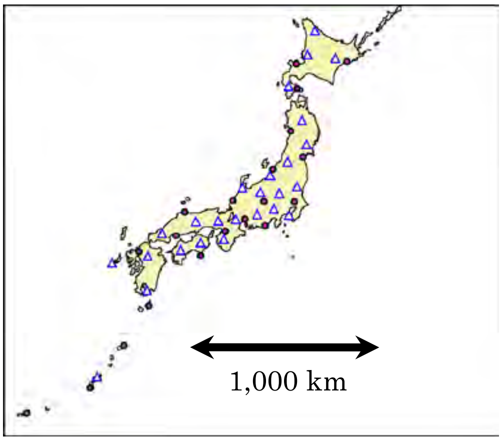

Figure 7. Locations of radar sites
Red circles are JMA radar sites, and white triangles are MLIT radar sites.

3.2 Radar/raingauge-analyzed precipitation

For the issue of warnings or advisories, accurate data on rainfall amounts over and around Japan are required, including for areas where no raingauges are located. Such accurate data are also necessary to create the soil water index and runoff index. JMA uses the radar/raingauge-analyzed precipitation, which is calibrated radar data by accurately measuring raingauges data, for forecast operations.

Precipitation amounts observed using radar generally do not match those observed using raingauges, and are therefore calibrated with raingauge data. For the convenience of forecasters, these calibrated radar data are then made into a single composite data set.

This composite data set is known as radar/raingauge-analyzed precipitation, which indicates precipitation with high dimensional accuracy and is issued every 30 minutes with a spatial resolution of 1 km.

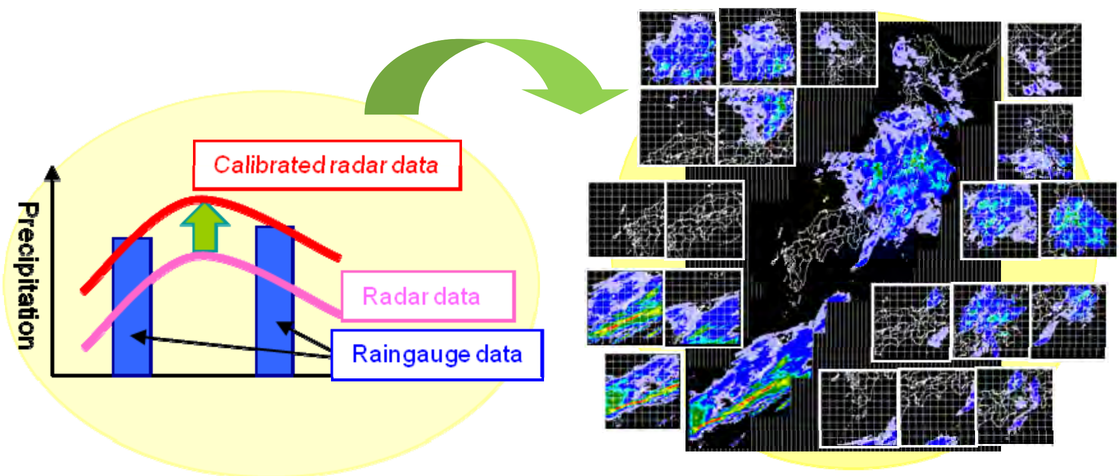

Figure 8. Development of radar/raingauge-analyzed precipitation data
(Left) Radar data are calibrated with raingauge data.
(Right) The calibrated radar data are made into a single composite data set.

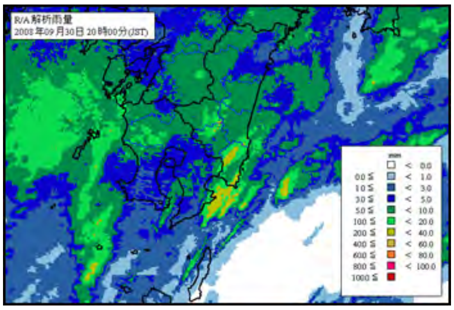

Figure 9.　Example of radar/raingauge-analyzed precipitation
Radar/raingauge-analyzed precipitation is a composite data set indicating precipitation with high dimensional accuracy, and is issued every 30 minutes with a spatial resolution of 1 km. This image and those in Figure 5 show the same time and area.

4. The importance of quality control for rainfall data

Anomalous values observed using raingauges or radar can contaminate radar/raingauge-analyzed precipitation data, which are used as criteria for warnings and advisories. Such values may therefore obstruct forecast operations.

The following issues may cause anomalous values:

(1) Observation of non-precipitation data due to inappropriate performance of raingauge inspections.
(2) Observation of measurements that are higher or lower than the true values due to influences related to the raingauge installation site.
(3) Observation of inappropriate data due to raingauge blockages.

(1) is seen when a raingauge is inspected to ascertain proper operation. If the general public sees the anomalous data, they feel strange and observation data could lose its trust. . If inspections are carried out correctly, such anomalous values will not arise.

(2) is seen if a raingauge is installed near a structure such as a wall or on a pole. Walls can obstruct rainfall, and as a result raingauge measurements may be lower than the true values. Similarly, if water runs from a roof onto a raingauge, the recorded value will be higher than the true value. Raingauges in such locations should be moved to a suitable place or not used.

(3) is seen when a raingauge's funnel becomes blocked. Even if it rains heavily around the raingauge, it cannot observe this precipitation because of the blockage. Conversely, if the blockage is removed, the water sitting in the funnel will suddenly flow into the measuring part of the raingauge, causing it to record a value that is higher than the true value at the wrong time. Such anomalous values may occur at any time, so forecasters need to judge whether or not raingauge data are correct.

Forecasters must avoid the issuance of warnings or advisories based on anomalous data. To this end, quality control of raingauge data is performed by setting an upper data limit so that anomalous data are not returned. This limit must be decided carefully; if it is inappropriate, data showing large amounts of rainfall may be regarded as anomalous even if they are correct. The heavier it rains, the higher the risk of disasters becomes. However, the judgment of data showing heavy rainfall as anomalous means that forecasters cannot identify such increased risk.

Also important are metadata showing information such as the location of raingauges, observation intervals, units and so on. As an example, if the location of a raingauge is wrong, even if it observes heavy rain correctly, forecasters will misidentify the location of the precipitation.

As described above, it is clear that quality control for AWS (automatic weather station) data is important. It should also be noted that the importance of quality control for manual observation is the same as that for automatic observation.

Forecasters require accurate, prompt observation data, making it important to obtain correct measurements at fixed times and report them quickly.