RAINFALL MEASUREMENTS WITH RAINGAUGES INSTALLED IN VARIOUS LOCATIONS

JAPAN METEOROLOGICAL AGENCY

1. I

Japan Meteorological Agency (JMA) operates about 1,300 automatic weather stations, among which about 1,100 stations are unmanned. Observed data is automatically collected by the Automated Meteorological Data Acquisition System (AMeDAS) and goes through quality control before its distribution to users. Not only JMA but also non-JMA organizations in Japan, such as relevant Ministries and local governments run their own weather stations. To make the most of existing resources, JMA, in cooperation with these organizations, started collecting precipitation data from their automatic weather stations in 2003, the number of which amounted to 7,000 in 2004. Quite a few raingauges at these stations are however installed on the roofs or in the vicinity of buildings, while those of JMA are situated on the flat ground with sufficient space. Table 1 shows various locations of the rain gauges operated by local governments in and around Tokyo. In order to clarify characteristics of rainfall measurements with raingauges installed at various environments, a field experiment was conducted.

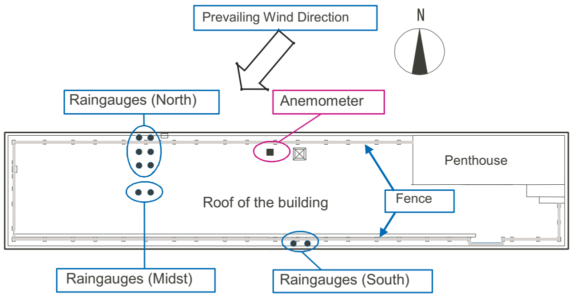
Location	Ratio(%)
On the roof of a building	57
On the roof of an instrument box	23
On the top of a pole or on the arm attached to a pole	8
On the ground	12

T 1. Ratio of the number of raingauges installed in various locations

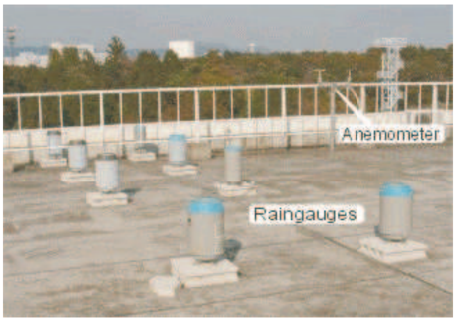
2. E

The experiment was conducted with the raingauges installed on the roof of and around the building of the Meteorological Instrument Center (MIC) of JMA and at some other possible locations, such as near the trees or on the top of the meteorological instruments boxroom. The size of MIC building is about 16m (north-south) by 70m (east-west) and 11m in height. Around MIC, the prevailing wind direction during rain is northeasterly. The details of the experiment is described bellow.

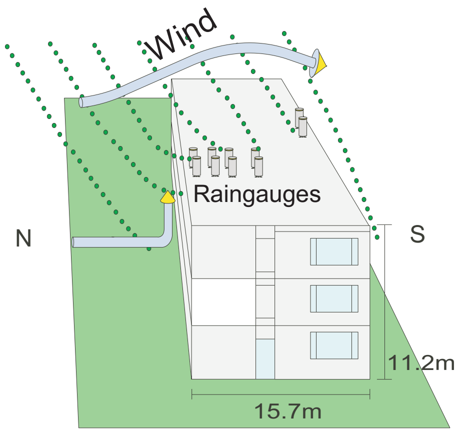
2.1. **On the roof of a building.** Pairs of raingauges were installed side by side at 1m, 3m, 5m and 8m apart from the northern end and 1m apart from the southern end on the roof of the MIC building as shown in Figures 1, 2 and 3. An anemometer was also installed near the raingauges to observe wind velocity and directions. The purpose of the installing dual raingauges was to avoid missing of data in case of mechanical failure and to mitigate inherent errors of the raingauges.



F 1. Arrangement of the raingauges on the roof of the buildings

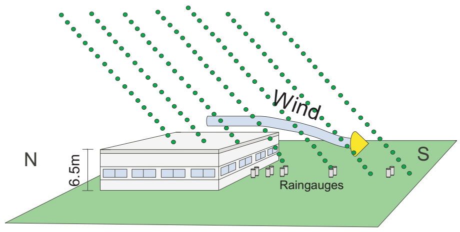


F 2. Raingauges and the anemometer installed on the northern part of the roof



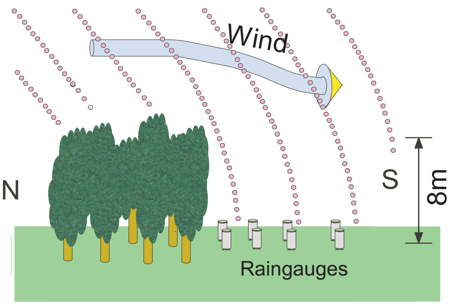
F 3. Schematic view of the experiment on the roof of the building

2.2. **On the ground in the leeward of the building.** Pairs of raingauges were installed side by side on the ground at the distance of 1m, 3m, 6m and 12m from the southern end of the other building as shown in Figure 4.



F 4. Raingauges in the leeward of the building

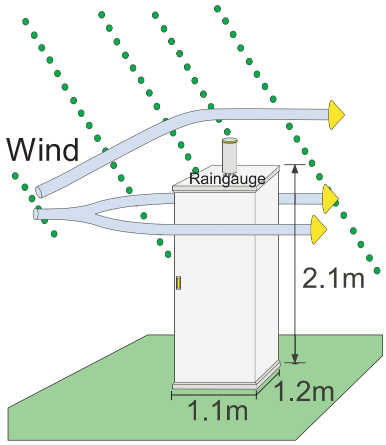
2.3. **On the ground in the leeward of trees.** Pairs of raingauges were installed side by side on the ground 1m, 3m, 5m and 8m apart from the southern end of trees of about 8m in height as shown in Figure 5.



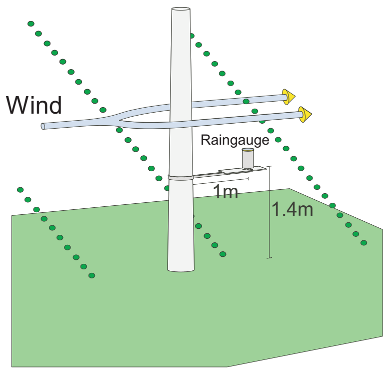
F 5. Raingauges in the leeward of trees

2.4. **On the top of a meteorological instrument box room.** As shown in Figure 6, a raingauge was installed on the top of a steel box (1.1m in width, 1.2m in length, 2.1m in height) designed in order to install observational instruments on it.

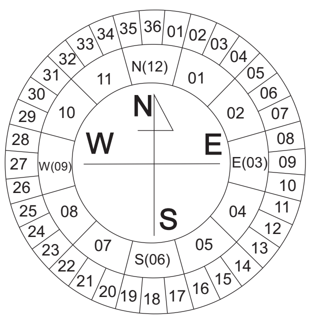
2.5. **On the arm attached to a pole.** A raingauge was installed on the arm (1.4 m in height from the ground) attached to a pole as shown in Fig.7. Other meteorological sensors, such as thermometer or hygrometer etc., are to be installed on the top or the other part of the pole. All the raingauges of above (1)-(5) were duly calibrated before the experiment. Rainfall data were collected with data-loggers connected to the raingauges and recorded on memory cards. The collected data were classified by rainfall intensities and wind velocities and directions. Windshields were not attached to the raingauges and the height of their orifices was 50cm from the ground level, which is the standard height used by JMA. In this report, the wind direction is expressed by 12 directions as shown in Figure 8.



F 6. A raingauge on the meteorological instrument box room



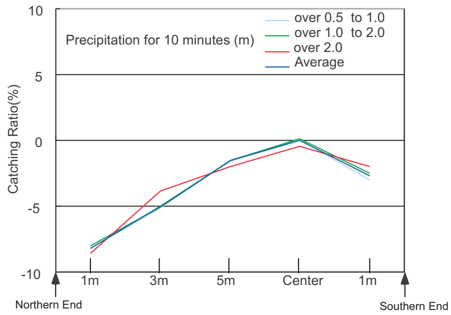
F 7. A raingauge on the arm attached to the pole



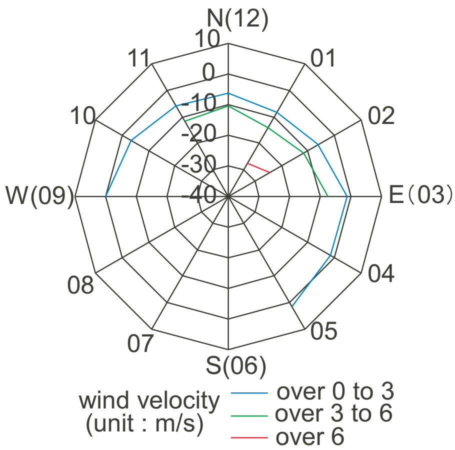
F 8. Expression of wind directions

3. R

3.1. **On the roof of a building.** Figure 9 shows that rainfall amounts measured by the raingauges installed at the distance of 1m, 3m and 5m from the northern end of the roof



F 9. Depressions of catchment on the building

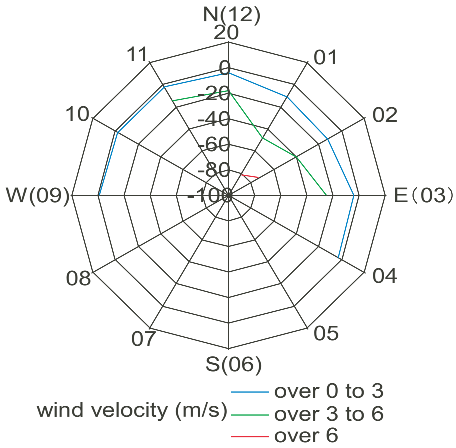


F 10. Depression of catchment for the various wind conditions at 1m apart from the northern end of the roof of the building

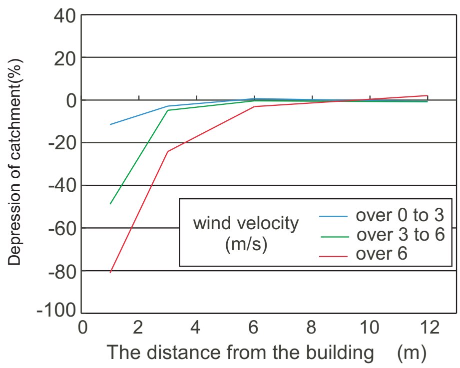
are less than the reference, which was on the ground, by 8%, 5% and 2%, respectively on average. These deficits are called "depression of catchment" hereafter in this report.

Meanwhile, the rainfall amounts measured by the raingauges installed at 8m apart from the northern end, which was located at the center of the roof, are almost equal to the reference. The depression of catchment becomes more clear when high wind velocity . For example, Figure 10 shows that the northern-end raingauge measured 25% less in the case of strong winds over 6m/s.

3.2. **On the ground in the leeward of the building.** On the ground in the leeward of the building, the raingauges nearer to the building observed less rainfall amount. Figure 11 shows the depression of catchment of raindrops measured with the raingauges installed 1m from the building in the case of various wind directions and velocities. Figure 12 shows relationships between the depression of catchment and the distance from the building for various wind velocities in wind direction 01. The raingauges installed 1m from the building show significant depression of catchment in strong windy case.



F 11. Same as Fig.10 but at the distance of 1m apart from the building to the leeward



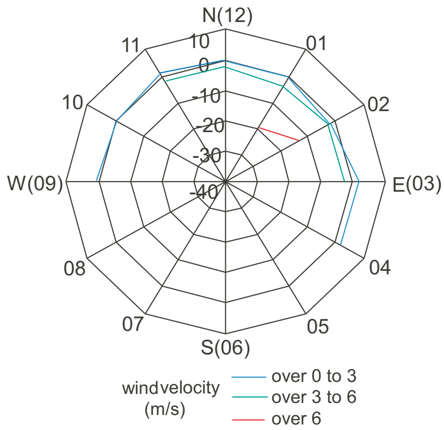
F 12. Variation of the depression of catchment with the distance from the building and wind velocity in wind direction of 01

3.3. **On the ground in the leeward of the trees.** Figure 13 shows the depression of catchment measured by the raingauge installed at the distance of 1m from the trees for several wind directions and velocities. Figure 14 shows the relationships between the depression of catchment and the wind velocity in wind direction 01.

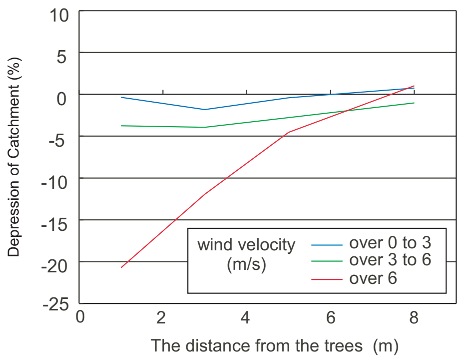
In the case of weak wind, these figures shows that the depression of catchment were not large in any positions and wind directions.

Figure 14 shows that the catchment by the raingauges installed 1m from the trees was slightly more than that of 3m. It can be thought that the raindrops kept in leaves blown into the raingauges by wind.

3.4. **On the top of a meteorological instrument box room.** The raingauge installed on the top of the box measured with slight depression of catchment in weak wind. In the case of somewhat strong wind from the directions of 01 and 02, the catchment decreased 4 to 5% as shown in Figure 15.



F 13. Same as Fig.10 but at the distance of 1m apart from the trees to the leeward



F 14. Variation of the depression of catchment with the distance from the trees and wind velocity in wind direction of 01

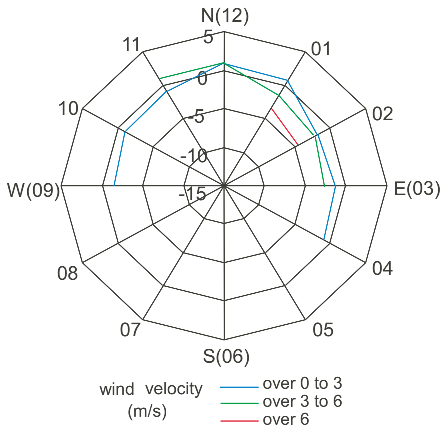
3.5. **On the arm attached to a pole.** The raingauge installed on the arm attached to a pole showed 2 to 3% depression of catchment on the average, and the catchment decreased 5 to 6% in wind directions 01 and 02 as shown in Figure 16.

4. C

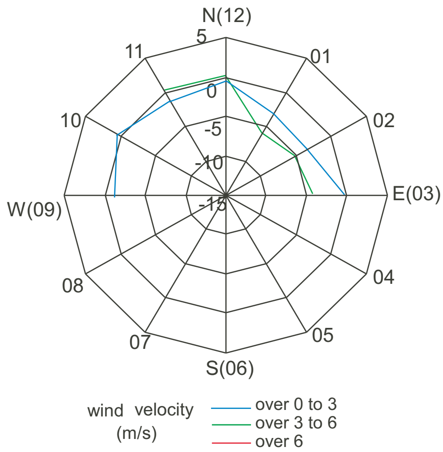
The main cause of the erroneous measurements of rainfall on the roof is thought to be the updraft off the sidewall of the building. The updraft is strong at the roof edges and thus decreases the catchment. While, the raingauges in the center of the roof, which is close to the reference, show that proper measurements can be performed at the center of the roof of the building if the rooftop was sufficiently large.

The raingauges installed in the leeward of the building or the trees receive the effect like eaves for sheltering from the rain. In order to reduce this effect, it is necessary to install the raingauges far enough away from them.

The raingauges installed on the top of the boxroom and on the arm attached to the pole indicated somewhat smaller amount than the reference.



F 15. Same as Fig.10 but at the top of the boxroom



F 16. Same as Fig.10 but on the arm attached to the pole

Results of this experiment suggest that the negative impact of obstacles such as a building or trees is not negligible in rainfall observation and the impact is dependent on locations and wind directions. The impact is particularly significant when the wind is strong and stirred by obstacles in the proximity of the raingauges.