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Comparison of Tipping-Bucket Rain Gauges in Natural Rainfall Conditions

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On August 2014 three-hour rainfall amount exceeded 200 mm in Hiroshima City, which raised serious damage and loss of life by landslides and debris flows. High-resolution rapid-scan weather radar monitoring systems are obviously effective to mitigate damage by such sediment disaster induced by heavy rain. Radar-estimated rainfall rate has been calibrated by tipping-bucket rain gauges(TBRs) measurement, but there are few comparison studies between radar and TBRs at very high rainfall rate because of localness and scarceness of heavy rain phenomena. Furthermore, accuracy of most of TBRs installed in Japan and Asian rain countries are not guaranteed over 100 mm rainfall rate.

To make sure validity of rainfall rate measured by typical TBRs at high rainfall rate, two field comparisons were carried out in Japan and India. Three resolution types of TBRs, 1.0-, 0.5- and 0.2-mm, were tested at Shionomisaki, Japan and at Cherrapunji in Indian state of Meghalaya, which holds world records of maximum rainfall amount for a month and a year. About 4-month measurement beginning on June 16, 2013 at Shionomisaki and beginning on April 28, 2014 in Cherrapunji were done.

Accumulated rainfall measured by the three different resolution TBRs for the comparison period were 1258.0 mm for 1.0-mm resolution type, 1244.5 mm for 0.5-mm type, and 1209.4 mm for 0.2-mm type at Shionomisaki, while those were 8643.0 mm, 8379.5 mm and 8154.0 mm, respectively at Cherrapunji. It means 1 and 4 percent deficit of rainfall amount measured by 0.5-mm and 0.2-mm resolution TBRs compared to 1.0-mm TBRs at Shimonoseki, and 3 and 6 percent deficit at Cherrapunji, which implies higher resolution TBRs measure less rainfall amount than lower ones.

Frequency of 80 mm/h or higher rainfall intensity estimated by tipping rate of the 1.0 mm TBR were 5 percent (72 cases) at Shimonoseki and 14 percent (1249 cases) at Cherrapunji, while cases of 200 mm/h or higher intensity were 3 and 15, respectively. Maximum rainfall intensity at Shionomisaki was 225mm/h and that at Cherrapunji was 300mm/h.

0.2-mm resolution TBRs measure 1.0 mm rainfall intensity by five tippings, however, number of tippings for 1.0 mm rainfall at higher intensity than 80 mm/h were frequently less than five, which means underestimation for heavy rain. Similarly 0.5-mm TBRs measure 1.0 mm rainfall intensity by two tippings and showed no underestimation for rainfall intensity ranging from 80 mm/h to 200 mm/h. But there were some underestimated cases for higher intensity than 200 mm/h.

In conclusion we found higher resolution TBRs underestimated at higher rainfall intensity than 80 mm/h in two field comparisons. Lower resolution TBRs are recommended to measure rainfall accurately at locations where heavy rain is possible.

Keywords: tipping-bucket rain gauges, local heavy rain, meteorological observation, India