Case study on the Accuracy Assessment of the rainrate from the Precipitation Radar of TRMM Satellite over Korean Peninsula

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Abstract

The Tropical Rainfall Measuring Mission(TRMM) is a United States-Japan project for rain measurement from space. The first spaceborne Precipitation Radar(PR) has been installed aboard the TRMM satellite. The ground based validation of the TRMM satellite observations was conducted by TRMM science team through a Global Validation Program(GVP) consisted of 10 or more ground validation sites throughout the tropics.

However, TRMM radar should always be validated and assessed against reference data to be used in Korean Peninsula because the rainrates measured with satellite varies by time and space. We have analyzed errors in the comparison of rainrates measured with the TRMM/PR and the ground-based instrument *i.e.* Automatic Weather System(AWS) by means of statistical methods.

Preliminary results show that the near surface rainrate of TRMM/PR are highly correlated with ground measurements especially for the very deep convective rain clouds, though the correlation is changed according to the type and amount of precipitating clouds. Results also show that TRMM/PR instrument is inclined to underestimate the rainrate on the whole over Korea than the AWS measurement for the cases of heavy rainfall.

I. Introduction

The Tropical Rainfall Measuring Mission (TRMM) Satellite was launched in November 1997, carrying into orbit the first space-borne Precipitation Radar(PR)(Simpson *et al.*, 1988). Satellite observation of rain can provide information about the global rainrate and such information is essential for evaluating the global climate.

The TRMM radar should always be validated against reference data. The ground-based estimates used as a reference in evaluation of tropical rainfall estimates based on the TRMM observations. Studies have been made intensively for improvement in the accuracy of precipitation estimates by radar and satellites. Ohsaki *et al.*(1999) had analyzed the error on the comparison between rainrates measured by a spaceborne radar and by ground-based instruments, and Ciach *et al.*(1997) had studied the ground validation of the Tropical Rainfall Measuring Mission. Joss and lee(1995) had compared the radar gauge rainrates to operational precipitation profile corrections. Makihara(1996) had improved radar estimates of precipitation by comparing data from radars and rain gauges.

Validation of the rainfall measured with TRMM has been accomplished through Ground Validation Program(GVP), which is based on the ground-based systems consisting of weather radars and rain gauge networks at several location around the world. However, the rainrate data of TRMM/PR over Korea should be validated and assessed to be applied to Korea Peninsular, because rainrate varies according to the space and time.

In this study, we access the TRMM/PR rainrate over Korean Peninsular by comparing ground-based rain gauges data from Automatic Weather System using the statistical approaches.

II. Data and Method

A possible way of validating the rainrates measured with the TRMM Precipitation Radar is a statistical approach that uses the rainrate measured by rain gauges. Though this instrument measures only the point rainrate, it can measure the rainrate more accurately than radar can, because it measures rain directly. To assess the accuracy of TRMM/PR rainrate over Korean Peninsula, the rain gauge network of the Automated Weather System(AWS) is used. AWS has about 400 rain gauge stations distributed over all of Korean Peninsula with a spacing of one station per about 18 km, measuring 1 minute precipitation amounts and transmitting the data to KMA headquarters in almost real time. In general, the accumulated AWS rainfall data are used to compare the statistical parameters, because the accuracy of rain gauge is actually not enough to produce the reliable one minute rainfall data (Nystuen *et al.*, 1996). Thus the AWS rainfall accumulated for 10, 30 and 60 minutes are transferred to rainrate.

On the other hand, the TRMM passes the south area of Korean Peninsula once a day and PR measures the instantaneous rainrate with the spacial resolution on the surface of about 4.3 km. We average the TRMM/PR rainrates included within a circle with 10 km radius centered in the one AWS rain gauge stations as Fig. 1, because the spacial resolution of TRMM/PR is different from that of AWS.

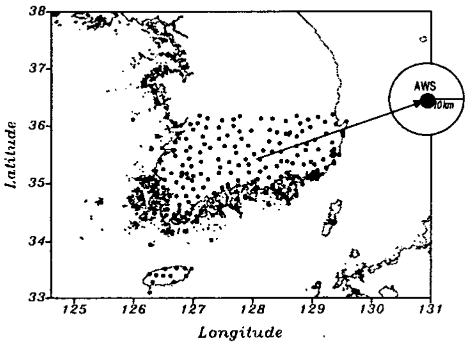

Fig. 1. The research area in this study. The circles represent the AWS stations below 36° N latitude in Korean Peninsula.

The research area is selected as Fig. 1 because the TRMM satellite measure the rainrate within ±35° latitude belt with the period of 96 minutes. The AWS stations corresponded to the research area are about 225 stations. The rainrates over 3 mm/hr are compared because the AWS rain gauges are accumulated.

We estimate the correlation between the rainrate of TRMM/PR(R_trmm) and AWS rainrate (R_aws). We also analyze the errors between R_trmm and R_aws by means of statistical methods such as Root Mean Square Error(RMSE), Adjusted RMSE and Bias. The selected heavy rainfall cases are the Mt. Giri on July 31 and the 9th Typhoon Yanni on September 30, 1998.

III. Case Studies

Two heavy rainfall cases *i.e.* Mt. Giri and 9th Typhoon Yanni are analyzed to access and validate the TRMM/PR rainrate over Korea. We evaluate the correlation coefficent between R_trmm and R_aws. The compared R_aws is accumulated for 10, 30 and 60 minutes and R_trmm are the rainrate on the near surface, 2km and the averaged between 2 to 4 km. Results from the two cases show that 30 accumulated AWS rainrate(R_aws_30min) is most well correlated with the near surface rainrate measured from TRMM/PR. Figure 2 represent the correlation distribution between R_trmm and R_aws_30min according to rainrates for two cases. For the Mt. Giri heavy rainfall case, the correlation coefficients on the near surface, 2 km and between 2- 4km are 0.89, 0.84 and 0.80. For the 9th Typhoon Yanni case, the correlation coefficients are 0.72, 0.68 and 0.62, respectively. These mean that the correlation coefficient decrease with the height and differ from the precipitating type.

On the other hand, the results of error analysis are as Table 1, which represent only the near surface rainrate from TRMM/PR and AWS for two cases. For the Mt. Giri heavy rainfall case, the mean rainrate from TRMM/PR and AWS is 8.92 and 15.19 mm/hr, and for the Typhoon yanni case the mean rainrate is 7.81 and 17.65(mm/hr). Comparing for two cases, the correlation coefficient for the Mt. Giri heavy rainfall case are more than that for the Typhoon Yanni case though the RMSE for the Mt. Giri heavy rainfall case is more than for the Typhoon Yanni. However, the Bias for the Mt. Giri case is less than for the Typhoon Yanni case.

Table. 1 The inter-comparison of TMRM/PR rainrate on the near surface and AWS rainrate.

parameters / cases	mean rainrate(mm/hr)		Bias (mm/hr)	RMSE (mm/hr)	Adjusted RMSE	Ratio Sat./AWS	correlation coefficient
	TRMM	AWS					
Mt. Giri ('98.7.31)	8.92	15.19	-6.27	19.94	19.13	0.59	0.89
Typhoon Yanni ('98.9.30)	7.81	17.65	-9.85	13.22	8.82	0.44	0.72

The rainrate ratio is simply the mean satellite rainrate divided by the mean ground based rainrate. Therefore ratios > 1 indicate an "overestimates". In table 1, the ratios for two heavy rainfall cases are all below 1 and it indicates the TRMM/PR underestimate the rainrate than AWS.

The case studies show that the rainrate of TRMM/PR correlates well to the AWS rainrate and the accuracy of rainrate measured from TRMM/PR is varied according to the precipitation type and height. In this presentation, we also analyze the correlation and errors according to the rainrate amount and rain type for two heavy rainfall case.

IV. Summary

The rainrates measured from TRMM PR over Korean Peninsula are compared with AWS rain gauges by means of statical methods to access and validate the accuracy. The selected heavy rainfall cases are Mt. Giri on July 31 and the 9th Typhoon Yanni on September 30, 1998.

As the preliminary results, TRMM/PR instrument is inclined to underestimate the rainrate on the whole than the AWS measurements. However, near surface rainrate of TRMM/PR are highly correlated with ground measurements especially for the very deep convective cloud case, though the correlation is changed according to the type and amount of precipitating clouds. The correlation coefficients for the Mt. Giri and the 9th Typhoon Yanni heavy rainfall cases are 0.89 and 0.72, respectively. The errors between TRMM/PR and AWS rainrate are also changed dependently on the rain types and patterns.

In the future, the quantitative accuracy for the TRMM/PR rainrate will be analyzed according to the patterns of raining clouds through many rainfall case studies.

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References

Ciach G. J., W. F. Krajewski, E. N. Anagnostou, M. L. Baeck, J. A. Smith, J. R. McCollum and A, Kruger, 1997. Radar Rainfall Estimation for Ground Validation Studies of the Tropical Rainfall Measuring Mission, *J. Appl. Meteor.*, 36 : 735-747

Joss J. and R. Lee, 1995. The Application of Radar-Gauge Comparisons to Operational Precipitation Profile Corrections, *J. Appl. Meteor.*, 34 : 2612-2630.

Makihara Y., 1996. A Method for Improving Radar Estimates of Precipitation by Comparing Data from Radars and Raingauges, *J. Meteor. Soc. Japan,* 74, 4 : 459-480.

Nystuen J.A., J. R. Proni, P.G. Black and J. C. Wilkerson, 1996. A comparison of automatic rain gauges. *J. Atoms. Oceanic Technol.*, 13: 62-73

Ohsaki Y., K. Nakamura and T. Takeda, 1999. Simulation-Based Error Analysis on the Comparison between Rainfall Rates Measured by a Spaceborne Radar and by Ground-Based Instruments, *J. Meteor. Soc. Japan,* 77, 3 : 673-686.

Simpson J., R. A. Houze Jr., 1997. A proposed Tropical Rainfall Measuring Mission(TRMM) satellite. *Bull. Amer. Meteor. Soc.*, 69 : 278-295.

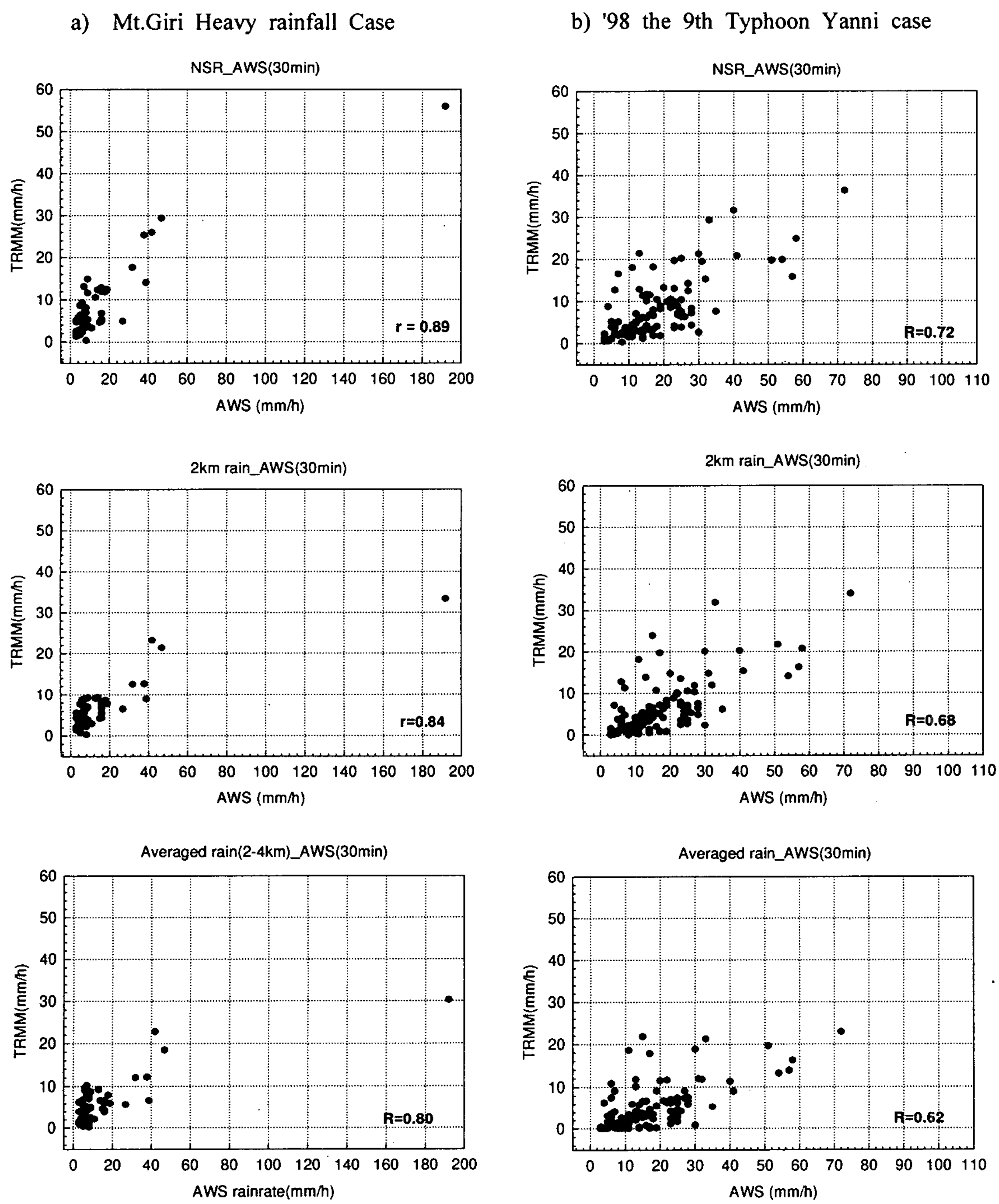

Fig. 2. These diagrams represent the correlation between TRMM/PR rainrate and AWS 30 minutes accumulated rainrate for two cases.