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Estimation of Rain Rate from Phased Array Weather Radar Using X-Band Polarimetric Radar Measurements

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Estimation of Rain Rate from Phased Array Weather Radar Using X-Band Polarimetric Radar Measurements

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1.Introduction

・Recently, **in a dam basin** for hydraulic power generation that Kansai Electric Power manages, **sudden floods with local heavy rain occur frequently**.

・Therefore, difficulty of the dam operation increases, and the **need for accurate short term rainfall prediction** technique becomes higher.

・To improve the accuracy of short term rainfall prediction, it is **necessary to observe precipitation distribution in and around of the dam basin with high resolution and high accuracy.**

・X-band phased array weather radar (PAWR) can observe with high temporal and spatial resolution. However, PAWR can observe only reflectivity (Z_h).

・In general, rain rate (R) can be estimated from Z_h using fixed Z-R relations ($Z_h = BR^{\beta}$). However, Z-R relations vary widely due to variations in drop size distribution (DSD).

・It is difficult to retrieve the DSD from non-polarimetric radar (PAWR), While the DSD can be retrieved by using not only Z_h but also polarimetric radar parameters .

・**we have developed rain rate estimation method from PAWR using DSD information retrieved by X-band polarimetric radar information network (XRAIN*).**

* XRAIN is x-band polarimetric radar network operated by Ministry of Land, Infrastructure and Transport and Tourism (MLIT) in Japan.

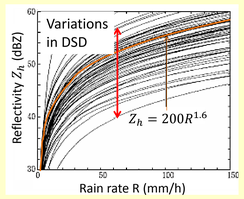


Fig. Z-R relations (after Battan 1973)

Table. Specificatios of PAWR and XRAIN

	PAWR	XRAIN
Spatial resolution	100m	250m
Temporal resolution	30seconds	5minutes
Observation range	60km	80km
Observed parameters	Z_h	Z_h, Z_{DR}, K_{DP} and others

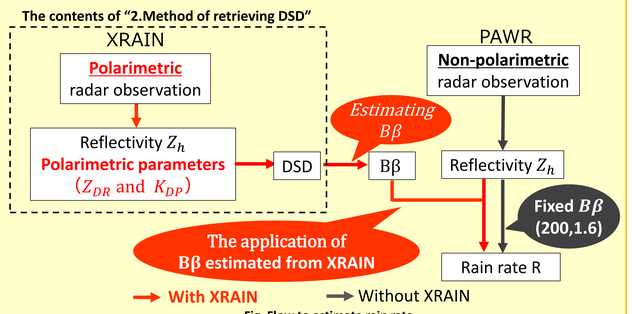


Fig. Flow to estimate rain rate

2.Method of retrieving DSD

In this study, DSD is retrieved by

YM method for heavy rainfall data ($K_{DP} > 0.5$) and CG method for light rainfall data ($K_{DP} \leq 0.5$).

(1) CG method (Zhang et al., 2001)

・DSD is retrieved from Z_h and Z_{DR} using empirical formulas obtained from disdrometer observation.

・ The retrieval accuracy tends to decrease in heavy rainfall case due to the rainfall attenuation.

(2) The method proposed by Yamaguchi et al., 2012 (YM method)

・DSD is retrieved from Z_h and K_{DP} using empirical formulas obtained from disdrometer observation.

・The retrieval accuracy tends to decrease in light rainfall case due to the variations of K_{DP}.

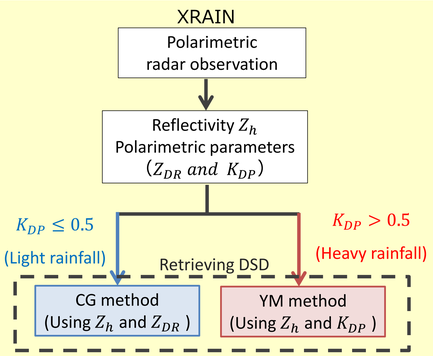


Fig. Flow to estimate DSD

3.Data

The ground observation points(Miyama(M), Honjyo(H), Syuchi(S)) near Wachi dam are surrounded with high elevation area. Therefore, we used PAWR data at altitude 4km.

In addition, we used XRAIN product rainfall data(XPRD)* at the same altitude for true value.

*XPRD is directly estimated rainfall from Z_h and K_{DP} using the empirical formula.

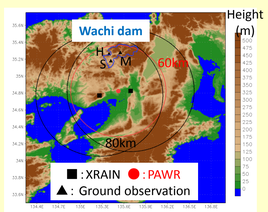


Fig. Map of Osaka

4.Target events

We selected following 4cases that local heavy rainfall had occurred in the Wachi dam basin.

Table. List of target events.

No.	Period (JST)	The cause of rain
1	2015/7/9 01:00～06:00	Stationary front
2	2015/7/28 16:00～21:00	Unstable atmosphere
3	2015/8/17 14:00～18:00	Low pressure
4	2015/9/1 15:00～20:00	Stationary front

5.Results

(1) Time change of Z-R relation

The right figure shows examples of time series of estimated $B\beta$ from XRAIN and XPRD.

Results are as follows:

・B value take low value in the time of heavy rainfall and is high in the time of light rainfall.

・By using XRAIN data, we can express the variations of Z-R relation due to variations of the DSD.

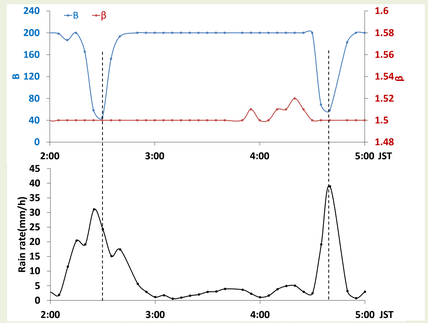


Fig. Time series of Bβ and rain rate(XPRD) (date:2015/7/9)

(2)Comparison of rainfall estimation accuracy

We compared estimation accuracy of 10 minutes rainfall between the method with XRAIN and without XRAIN.

Results are as follows:

・The method without XRAIN showed significant underestimation at all points.

・**By the method with XRAIN, RMSE decreased at all points (especially at miyama).**

・Correlation coefficient of the method with XRAIN at Miyama and Syuchi are slightly greater than the method without XRAIN.

・Correlation coefficient of both methods at Honjyo was less than other points (especially the method with XRAIN).

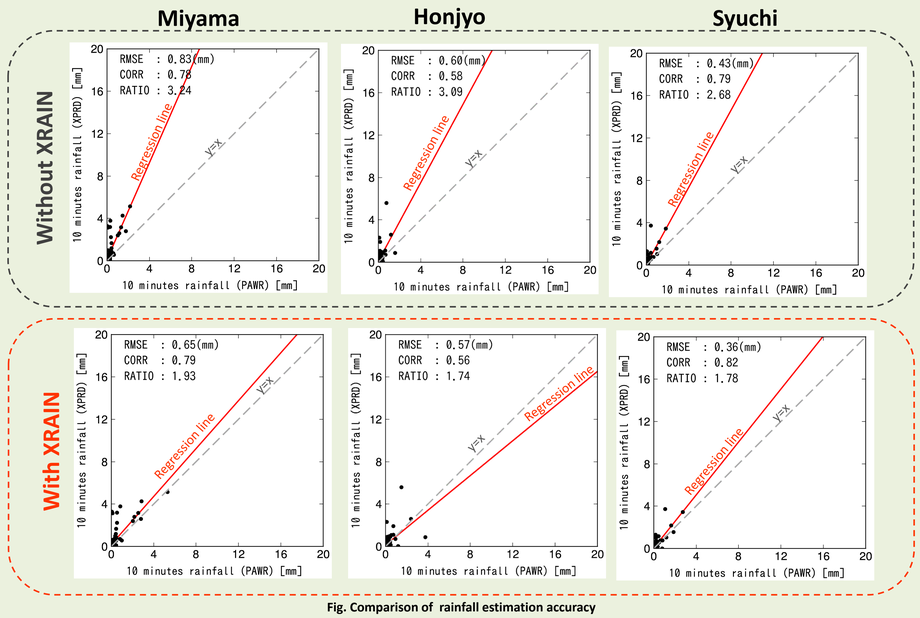


Fig. Comparison of rainfall estimation accuracy

(1)RMSE(Root Mean Squared Error)

$$RMSE = \sqrt{\frac{\sum(F_i - A_i)}{N}}$$

(2) CORR(Correlation coefficient)

$$CORR = \frac{\sum(F_i - \bar{F})(A_i - \bar{A})}{(\sum(F_i - \bar{F})^2(\sum(A_i - \bar{A})^2))^{1/2}}$$

(3)RATIO

RATIO > 1 : Underestimation

RATIO < 1 : Overestimation

$$RATIO = \frac{\sum A_i}{\sum F_i}$$

$F_i : R(PAWR)$ $A_i : R(XPRD)$

$\bar{F} : Averaged\ R(PAWR)$

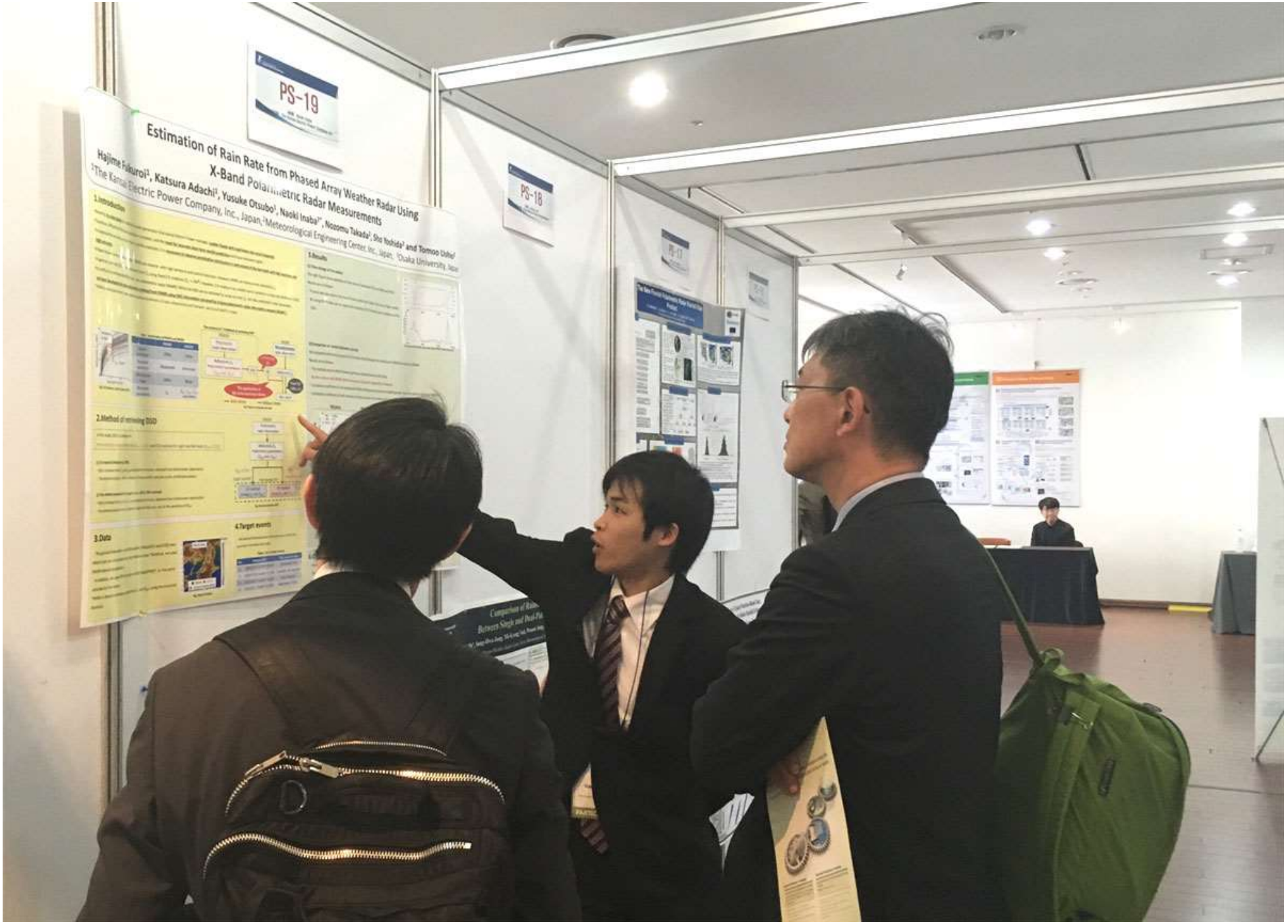
$\bar{A} : Averaged\ R(XPRD)$

$N : The\ number\ of\ data$

6.Conclusion and future works

・We have developed a rain rate estimation method from PAWR using DSD information retrieved by XRAIN. As a result of application to Wachi dam basin in Japan, the new method showed improving underestimation against fixed Z-R relation ($B = 200, \beta = 1.6$).

・We will develop short time prediction method using 3D high resolution radar data observed by PAWR.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