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RDCA Index Based Updraft Area and Its Verification Using Polarimetric Doppler Radar

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1. Introduction

The initial proposed method for the early detection of Guerilla-heavy rainfall (GHR) by using radar utilized a radar echo aloft called "baby-rain cell" inside a single cumulonimbus cloud [1]. Then, following studies analyzed the vertical vorticity in the baby-rain cell [2]. For earlier detection of GHR, the rapid scan observation (RSO) data of Himawari-8 is employed.

The Rapid Development Cumulus Area (RDCA) concept was introduced by utilizing the RSO data. RDCA is the development process of cumulus clouds that potentially expected to evolve into thunderstorm within one hour in 10km^2 area. The cloud development process informed by RSO data is used to generate RDCA index by adapting logistic regression model.

RDCA index ranging from 0.1 to 0.9 can represent cloud development which can be used to estimate the occurrence of a GHR earlier than precipitation radar observation. Previous research revealed that RDCA index can detect a GHR 20 minutes before radar detection [3].

As the RDCA index can also represent cloud development, which can provide us the indirect information of updraft, we verify the utilization of RDCA index by comparing its time series with radar-estimated vertical velocity of rain cell which also can give us the information of updraft. The vertical velocity as the indication of updraft can be estimated by using multiple Doppler radar analysis [4].

We found a good time correlation between RDCA index and vertical velocity estimation. This result provides us the opportunity to use the RDCA index to be operational data in areas without radar coverage such as Indonesia in order to know the development of cloud before the occurrence of GHR.

2. Data and Methodology

The RSO data of Himawari-8 satellite is used in this study. Seven bands of RSO data (band 03, 08, 10, 11, 13, 15 and, 16) are utilized to generate 13 RDCA parameters to represent the cloud development. By adapting logistic regression model, the RDCA parameters are used to generate the RDCA index, which has temporal and spatial resolutions, five minutes and 1km, respectively.

The Doppler information from two radars (Katsuragi and Rokko) of X-band polarimetric RAdar Information Network (XRAIN) in Kinki region is utilized as shown in Fig. 1. The Doppler radar cannot provide vertical velocity information. It can just provide horizontal wind speed and wind direction information. However, the vertical velocity of rain cell as the indication

of updraft can be estimated using multiple Doppler radar analysis by adapting the variational scheme which has already been proposed to predict the occurrence of GHR [2]. This variational scheme utilizes a minimized cost function as the sum of squared errors due to the discrepancies between observed and analyzed data. Then, it is optimized by using a limited memory Broyden-Fletcher-Goldfarb-Shanno (L-BFGS) method.

3. Result and Discussion

The comparison between time series of rain rate, RDCA index and vertical velocity of rain cell is shown in Fig. 2. Fig. 2b shows that the RDCA index is detected from 11:40 and it fluctuated before the rainfall was detected on the ground as it is shown by Fig. 2a. The RDCA index is increasing from 12:00 when rainfall is detected on the ground.

The vertical velocity estimation by multi Doppler analysis is shown by Fig. 2c. At 12:00, the increasing value of vertical velocity is detected above 2 km. The height of vertical velocity detection which is marked by the horizontal red line increase after 12:00, and its speed increase as well. The trend of the increasing of vertical velocity is similar with the increasing of RDCA index and rain rate.

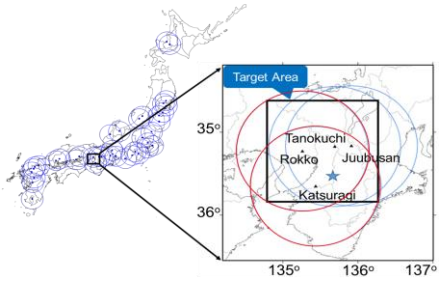

Figure 1. Red circle indicates the overlapping area of the two radar observations utilized. The analyzed rain cell is marked by a blue star.

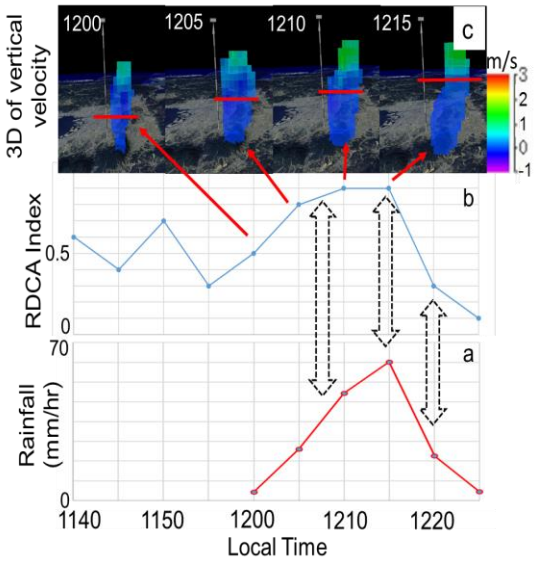

Figure 2. Comparison of a) rainfall detected on the ground, b) RDCA index, c) estimated vertical velocity of rain cell.

4. Conclusions

By using one case analysis we found that the comparison between time series of RDCA index and estimation of vertical velocity of rain cell shows a good time correlation. This result, opens the opportunity to use RDCA index in order to provide updraft information. We will investigate more cases of the comparison between RDCA index time series and estimated vertical velocity of rain cell to verify the RDCA index in predicting the occurrence of GHR.

References

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