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Investigation of Relationship between RDCA Index Using Himawari-8 Data and Radar Estimated Hydrometeor Type aloft Considering the Stage of Cumulus Cloud

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1. Introduction

Hydrometeorological disasters such as flash flood caused by localized heavy rainfall is one important issue in Japan recently, since the increasing number of the occurrence of it. In Japan the localized heavy rainfall is well known as Guerilla-heavy rainfall (GHR). The occurrence of GHR which has 30 minutes rainfall in an intensity of 50 mm/h in the short river in urban area in Japan has caused some tragedies and some people died, for example the flash flood which occurred in Toga River in Kobe in 2008. It is very important to investigate the initiation mechanism of GHR and to predict its occurrence to give time for people to evacuate and save their life. Nakakita et al (2010) have proposed a method of detection of baby-rain cell aloft by using radar as a very important signal before the occurrence of GHR. Nakakita et al (2016) identified vertical vorticity criterion in a baby-rain cell aloft to reduce fail prediction of GHR. In their case studies GHRs can be predicted 23.6 minutes on average before rainfall reached on the ground.

To predict occurrence of GHR in the earlier time, we utilized the Rapid Scan Observation (RSO) of Himawari-8 observation which provides cloud information of albedo and surface temperature. These information may help us predict GHR occurrence before a radar detect formation of a baby-rain cell. With these RSO observation, we used the regression model to predict the occurrence of GHR. The model we used is called Rapid Development Cumulus Area (RDCA) model, proposed by Satellite Meteorological Center (MSC) of Japan Meteorological Agency (JMA) and originally developed to predict lightning occurrence. As lighting occurrence can be reasonably related to development of a cloud which can form GHRs, we directly utilize RDCA to predict GHR in the study. The RDCA model can output an index ranging from 0.1 to 0.9, and represents the probability of the occurrence of GHR. Our previous work has proven that RDCA model can predict the occurrence of GHRs 20 minutes before baby-rain cells detected by radar.

To further improve the prediction accuracy of RDCA model, we would like to verify whether it can be used for revealing cloud stages. A hydrometeor classification methodology was proposed by Masuda and Nakakita (2016) to successfully classify the types of hydrometeor aloft into eight categories (rain, heavy rain, rain and hail, big drop, graupel, wet snow, dry snow, and ice crystal) by using polarimetric parameters observed by X-band polarimetric RAdar Information Network (XRAIN) and data of hydrometeor retrieved from a video sonde. Then, the information of classified hydrometeors aloft can be used to identify the life stages of a cumulus cloud (developing, mature early, mature late, and dissipating stages) in application of matching of rain rate.

In this study we investigated the relationship among RDCA index and hydrometeor types and cumulus stages estimated from polarimetric radar observation. The result is very important to investigate the capability of RDCA model for directly estimating cumulus life stages.

2. Data and Methodology

The RSO data of Himawari-8 satellite and XRAIN data are used in this study. Himawari-8, a Geostationary Meteorological Satellite, was launched by the JMA locating at about 36,000 km above the equator and 140º east in the space. It has fine spatial and temporal resolutions (0.5-2.0 km, 2.5 minutes) (Bessho et al, 2015) with 16 observation bands, including three visible bands, three near-infrared bands, and ten infrared bands. XRAIN is a weather radar network installed by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) since 2010 to fast detect localized heavy rainfall for the propose of disaster prevention. From the four X-band radars in our targeted Kinki Region, the reflectivity, Doppler velocity and four polarimetric parameters (Z_{hh}, K_{dp}, Φ_{dp}, ρ_{hv}) in the high spatial and temporal resolutions are used for our analysis.

Ten cases of GHR are used for case analysis. At the same time of the ten cases, all corresponding radar polarimetric parameters are also extracted to obtain the information of cumulus stage and hydrometeor type aloft by using the classification methodology (Masuda and Nakakita 2016). Finally, the resultant RDCA indices are compared with radar estimated cumulus life stages for verification.

3. Result and Discussion

Figure 1 is one example of the time series of rain rate, RDCA index, hydrometeor life stages and types aloft. The result show that RDCA model predicts the GHR occurred at 11:40 (Fig. 1b) or 20 minutes before rain detected at the surface (Fig. 1a). The RDCA indices fluctuates before the rain rate record. After 12:00 the tendencies of rain rate, RDCA index and development stage of cumulus (Fig. 1a, 1b, 1c, respectively) are in good agreement. The hydrometeor types estimated by radar are graupel and dry snow (Fig. 1d). After the stage of mature late, the rain rate and RDCA index start to drop. The hydrometeor type is dry snow. Finally, in the dissipation stage, the rain rate, RDCA index have similar tendency, and the hydrometeor type is ice crystal. Basically, RDCA model can reflect cumulus stages in this case.

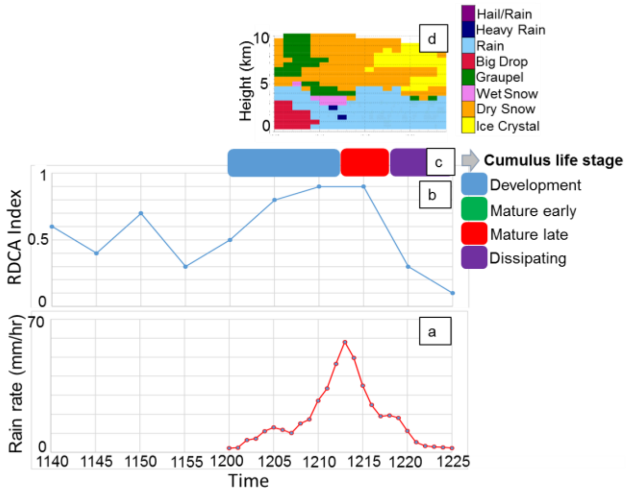

Figure 1. Comparison of time series of a) rain rate, b) RDCA index, c) cumulus life stages and hydrometeor types aloft.

4. Conclusions

The verification of RDCA model by comparing with rain rate and cumulus life stages shows the good correlation in the development and dissipation stages but poor one in the mature late stage. Correlation between RDCA index and estimated cumulus life stage is very important to verify the capability of RDCA model. Our results show Himawari-8 RSO data may be able to provide information of cumulus life stages directly.

References

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