ANALYSIS OF HEAVY RAIN IN HIROSHIMA BY 3D MP-X RAIN AND DOPPLER WIND

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1. INTRODUCTION

High temporal and specific spatial characteristics of rain event detected by multi-parameter radar at X-band wavelength (MP-X radar) play a key role for the early warning of heavy rain related disaster management. The promising Quantitative Precipitation Forecast (QPF) using MP-X radar is one of the solutions for mitigation of heavy rainfall related disasters. The target event was the one happened in August, 2014 which was formed by an intense, quasi-stationary convection rain band with "back-building" type from the continuous supply of the warm moist air from the southern Pacific Ocean (Tanaka et al. 2015). This record-breaking rain caused the mass landslide areas, a number of casualties and serious damage in the north of Hiroshima city. That's why the comprehensive analysis of high temporal and spatial resolution of 2D MP-X rain map, 5 min interval 3D composite X rain together with Doppler wind may certify for the applicability of the high accuracy QPF. This study is the preceding step of QPF using MP-X rain for data assimilation with the Weather Research and Forecasting (WRF) model.

2. DATA

The data of two MP-X radar preprocessed 2D composite rain map, original radar observation and Doppler velocity from Nogaibara and Ushioyama radars are provided by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Moreover, the Japan Meteorological Agency (JMA) operational conventional C-band radar data and in-situ station rainfall from Radar-AMeDAS (Automated Meteorological Data Acquisition System) and Hiroshima Prefectural government are used for quantitative evaluation of X-band rainfall.

3. METHODS

3.1 Three dimensional composite scheme of MP-X rain

The execution of 3D rain is mainly based on the modified Cressman interpolation, the standard method for areal composite rainfall map developed by MLIT. First, volume scan data of approximately 250 m resolution from each radar are transformed into the 3D Cartesian coordinates. But inhomogeneous radar cell density is apparent in each 3D grid with 500m in vertical and 1000m in horizontal resolution. By using the effective radius weighted function of horizontal and vertical direction in each radar, radar cell valued are interpolated to each grid. We just modify the effective radius in height compared to the original function. It should be noted that the oversampling may happen near the radar site and undersampling may occur near the edge of radar range 80 km. Total 12 PPI volume scan data with maximum 25 km in height above the radar is available for target event.

3.2 Processing of Doppler radial wind

For each volume scan data, Doppler radial wind data of the lowest elevation scan is available every minute and retrieval of the radial velocity algorithm is derived from COPLAN method. This method is based on the identical planes scanned by two radars with different elevation angles at the same time. In the meantime, the data are derived from the cylindrical coordinate with the polar axis connecting the two radars (Fukao et al. 2014). The wind data are analyzed in the cylindrical coordinates and then transformed into Cartesian coordinates by using the angle of rotation of the polar axis. The drawbacks may be the wind data can be derived only from the common coverage area by two radars neglecting the vertical wind component and not for the radial wind from one radar.

4. RESULTS AND DISCUSSION

To evaluate the quantitative accuracy of MP-X radar rain, the intensity received at total 29 ground stations is compared to MP-X rain and C-band radar rainfall in hourly and 10 minute interval time series. MP- X rain shows more reasonable agreement in time series data than C-band data at Mirihigashi station and a slight underestimation is found when the rain rate is over 100-120 mm/hour. The heavy rain band in a confined area along the valley of the mountainous area occurred within less than 20km peripheral circle from both of the radars and the signal extinction area appeared less than 60km observation range according to the snapshot view of 2D area composite map at 03:00 hr LST. MP-X rain shows better than C-band radar data in general even so the sensitivity of heavy rain attenuation, the restricted coverage and

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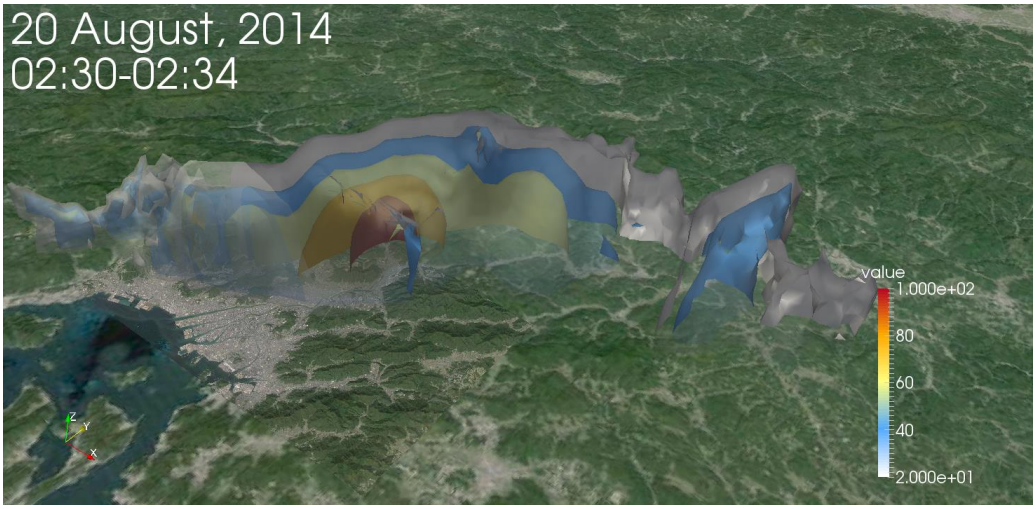

Fig 1. 3D structures of heavy rain cloud at 02:30-2:34 am on 20th August, 2014 over Hiroshima city

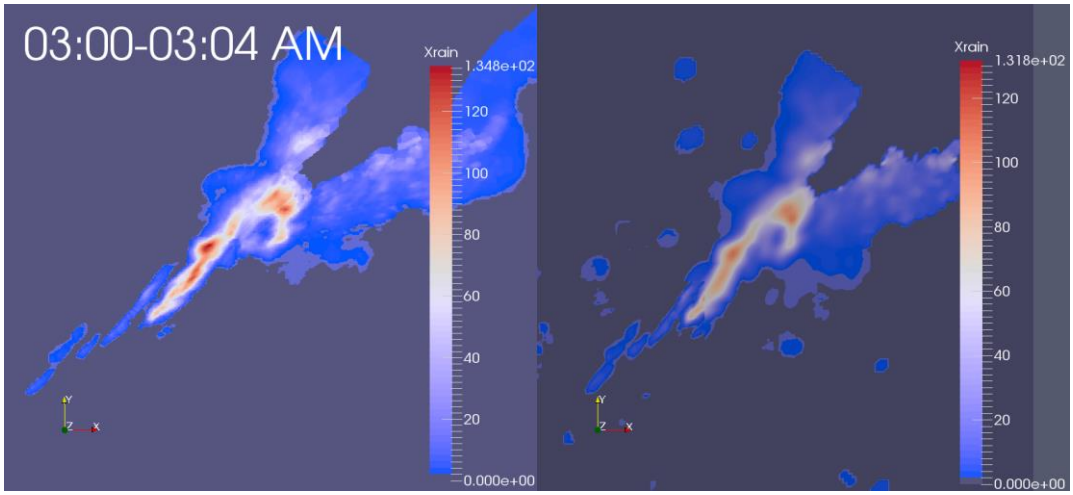

Fig.2 Comparison of 2D processed area rain (left) and extracted surface from 3D composite rain at 800 m height (right)

undervalued rain intensity are the main deficiency to be taken care of. The isometric 3D view of approximately 50km × 5km in the horizontal extent with 15 km in height and 20 mm/hour (gray) to intense core rain cloud of over 100 mm/hour (red) can be clearly seen in Fig. 1. The resulted 3D rain should be validated through RHI scan data but it is not available now. But the comparison of 2D processed area rain by MLIT and extracted rain surface form 3D composite rain at 800 m height is done for quantitative checking. There is a small difference in the specific shape and the maximum value in area rain map is 135 mm/hour and 3D rain is 130 mm/hour. This may be the reason of difference in projected rain from multiple PPI data of elevation angles less than 5 degrees in area rain map and limited to 5km in 3D grid. Doppler radial wind processing is now undergoing and the results will be discussed later.

5. CONCLUSION

The preliminary analysis shows the potential efficacy of MP-X rain such as high temporal and spatial resolution, good agreement with ground data and the availability of updates real time series data. It should be carefully handled the rain attenuation and the limited coverage range limitations. The development of 3D rain algorithm is successfully accomplished, but the detailed investigation and approval are still indispensable. After the radial wind to the horizontal wind direction and the velocity retrieval scheme had approved, combination of 3D rain and surface wind will improve the understanding of the convective heavy rain mechanism. In consequence, this kind of analysis support towards the high accuracy QPF coupling with MP-X rain and WRF.

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