263 *Application of Easily- and Visually-recognizable Meteorological Radar Products for Early Detection of Heavy Rainfall Occurrence*

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1. INTRODUCTION

In Japan, river and debris flow disasters have been frequently caused by heavy rainfall occurrence under the influence of the activity of a stationary front and associated inflow of a large amount of moisture into the front, as shown by Akiyama (1973) and Ninomiya (2000). Heavy rainfall and associated serious debris flow disasters occurred in 1999, and on August 20, 2014 in Hiroshima city located in the west of Japan. Many local residents were lost by the direct damage of debris flows. Such disasters have been caused by stationary heavy rainfall system such as back-building echoes shown by Fig.1. Detailed explanation of such stationary heavy rainfall systems are given by Blustein and Jain (1985), Kato and Goda (2001), and Kato (1998).

Currently, it is very difficult to predict numerically-based heavy rainfall and associated landslide accurately. This problem has led to the delay of evacuation of local residents. Therefore, the use of meteorological radar information is required for enhancing decision-making ability to urge the evacuation of local residents by local government staffs prior to the occurrence of the heavy rainfall disaster. It is also desirable that the local residents acquire the ability to determine the evacuation immediately after confirming radar information by themselves.

However, it is difficult for untrained local residents and local government staffs to easily recognize where heavy rainfall occurs locally for a couple of hours. This reason is that the image of radar echoes is equivalent to instant electromagnetic distribution measured per a couple of minutes, and the distribution of the radar echoes moves together with the movement of a synoptic system although sophisticated decision-maker may be able to recognize the possibility of heavy rainfall and associated disasters only by using instant radar information. In other words, easily- and visually-recognizable radar products which the untrained local residents and local government staffs are able to use are required for decision-making the evacuation from disastrous heavy rainfall.

Therefore, in this study, considering that the movement of radar echoes also may stop in a specific area if stationary front system becomes dominant, radar-based accumulated rainfall information is defined here. The rainfall product is derived by the integration of radar intensity measured every ten minutes during previous 1 hours. Using this product, it was investigated whether and how the radar-based accumulated rainfall

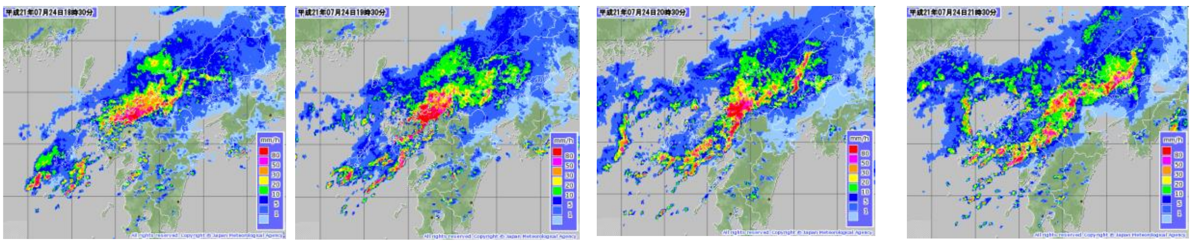

Fig.1 Back-building heavy rainfall system occurring in Northern Kyushu on

displayed at an interval of ten minutes can be applied for early detection of heavy rainfall occurrence.

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2. METHODOROGY

In Japan, spatial images of radar intensity can be easily checked via internet, television. Japan Meteorological Agency (JMA) provides 5 minutes-interval spatial radar images. These radar images are useful for confirming real-time distribution of radar intensity. However, it should be note that this shows an instant image of moving rainfall system. On the other hand, JMA also provides accumulated rainfall distribution, which can be constructed by the interpolated analysis using both of radar and ground rainfall data. However, this product is not real-time because the time interval is 30 minutes.

Therefore, in this study, radar-based accumulated rainfall distribution with 10 minutes-interval as shown in Fig. 2. The product shows previous 1 hour rainfall distribution, which can be easily calculated by the integration of rainfall distribution obtained from rainfall intensity with 10 minutes-interval. This product is not interpolated by ground rainfall networks for confirming whether the degree of rainfall accumulation can be visually and easily recognized by untrained end users.

In this study, differences between radar intensity distribution and accumulated rainfall distribution is investigated by focusing on visual features of these distributions.

3. RESULTS

3.1 Features of accumulated rainfall distribution depending on the speed of moving radar echoes

Fig.3 shows fast-moving strong radar echoes do not bring strong accumulated rainfall distribution because heavy rainfall system passes through a specific location during a short time. On the other hand, Fig.4 shows stationary or slow-moving strong radar echoes brings strong accumulated

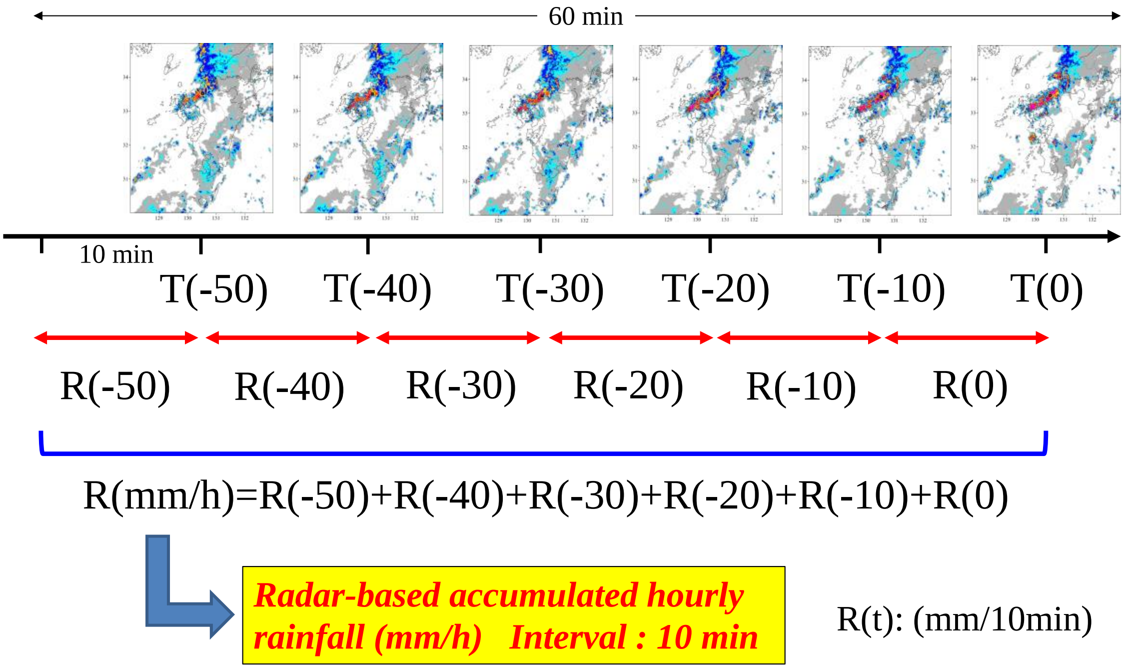

Fig.2 Calculation of accumulated radar-based rainfall distribution

rainfall distribution because the time duration exposed by heavy rainfall system is long at a specific location.

Untrained end users may recognize mistakenly fast-moving radar echoes as dangerous situation causing heavy rainfall and associated disasters such as debris flows and flood. On the other hand, the

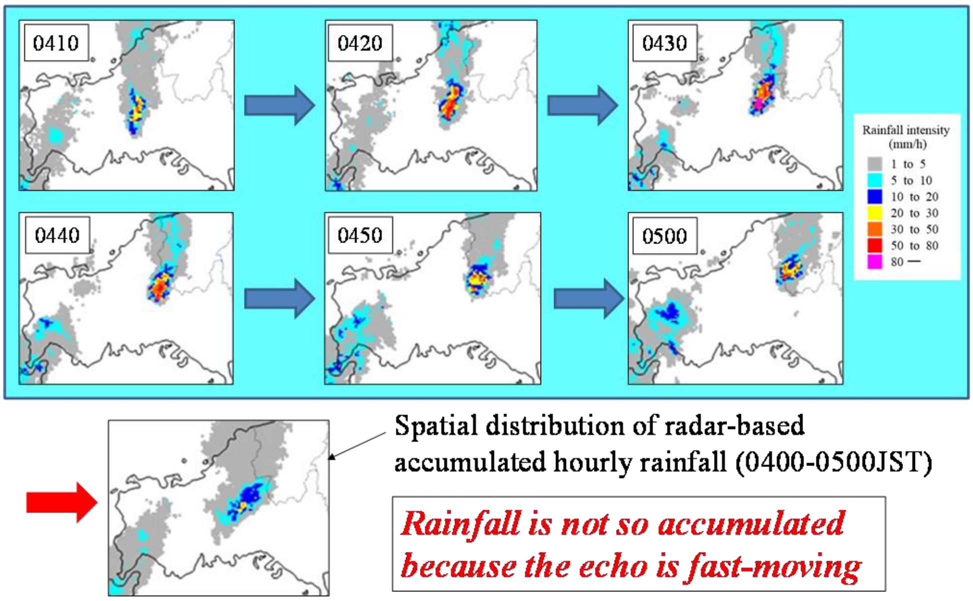

Fig.3 Accumulated rainfall distribution obtained from fast-moving echo with strong intensity

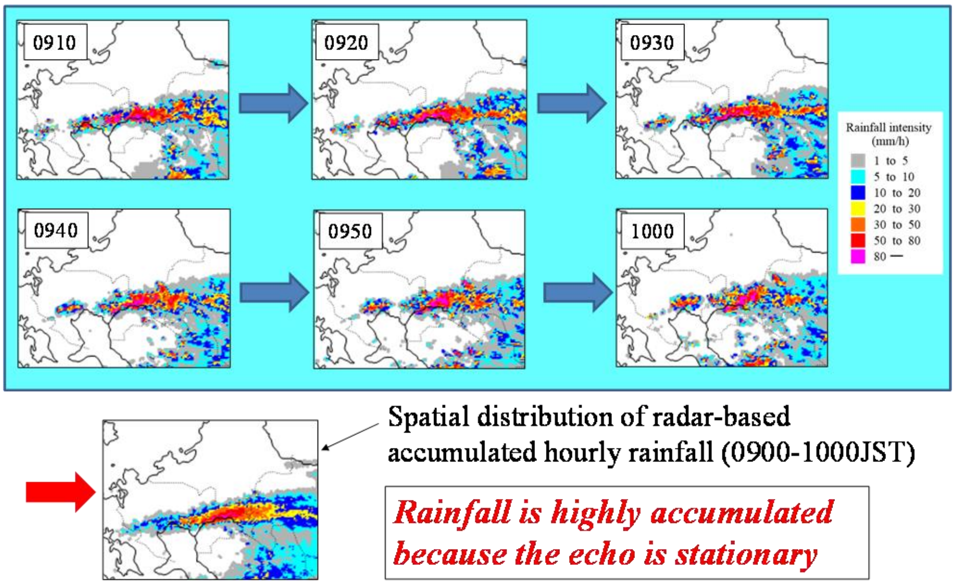

Fig.4 Accumulated rainfall distribution obtained from stationary or slow-moving echo with strong intensity

meteorological information of accumulated rainfall distribution can clearly provide location and area of heavy rainfall. Therefore, the accumulated rainfall distribution is very crucial for the identification of heavy rainfall and associated disaster situation.

3.2 *Visual Difference between radar intensity distribution and accumulated rainfall distribution*

As shown in Fig.5, we can clearly recognize difference between rainfall intensity distribution (upper images in this figure) and accumulated rainfall distribution (lower images). These radar intensity distributions consist of many rainfall cells although we can understand that the heavy rainfall activity is intensified in a limited area. However, it is difficult to easily identify heavy rainfall area. On the other hand, the accumulated rainfall distribution provides clear-cut information that heavy rainfall area concentrates in the limited area (one or two locations). Moreover, stationary it should be noted that the heavy rainfall system had already appeared prior to disaster. This signal can be seen in other cases.

3.3 *The movement of accumulated rainfall distribution*

Fig.6 shows radar intensity distribution (upper images) and accumulated rainfall distribution with 10 minutes-interval. The location of the triangle in the figure shows YAGI area attacked by serious debris flows (74 persons died). Since the heavy rainfall system was stationary, both products are very similar each other. However, we can clearly recognize visually-understanding signal that the dangerous back-building type stationary heavy rainfall system approaches towards the disaster area, YAGI.

4. CONCLUSION REMARKS

Radar-based accumulated rainfall products could confirm that some of stationary heavy rainfall systems had already appeared prior to disaster occurrence, and clearly identify the

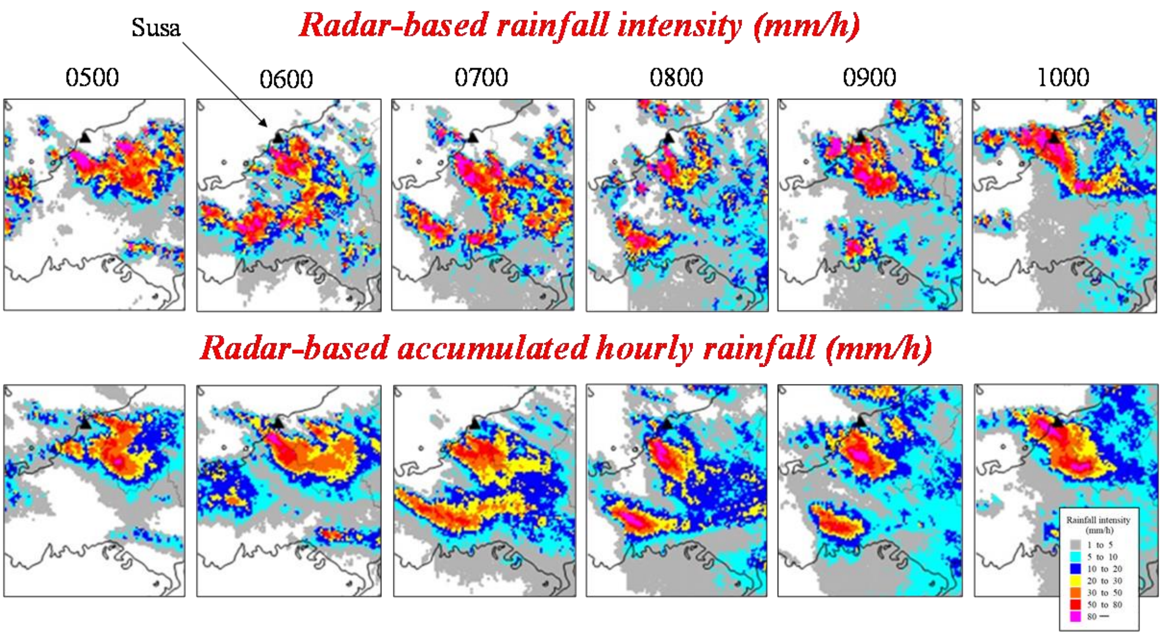

Fig.5 Difference between radar intensity and accumulated radar-based rainfall distribution

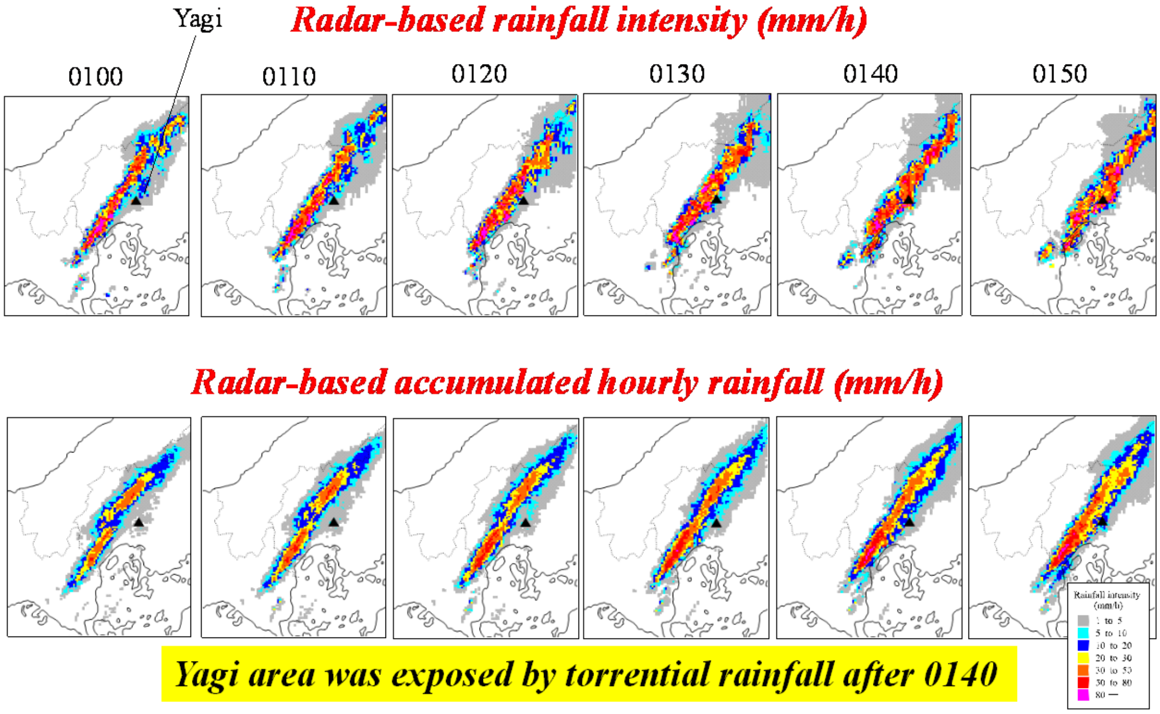

Fig.6 Movement of heavy rainfall area recognized visually by accumulated rainfall distribution

movement of heavy rainfall area. Moreover, accumulated area of rainfall could be visually and easily identified, compared with time-series (movie) of real-time radar-based rainfall intensity. Therefore, the accumulated rainfall distribution provides effective information for early detection of heavy rainfall causing disasters through the training of local residents and local government staffs who have no meteorologically-technical knowledge.

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