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Heavy rainfall in Kochi accompanied by two typhoons

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1. Introduction

One of major disturbances causing heavy rainfall in Japan is typhoon. For 10 days from August 1, 2014 heavy rainfall continued in Kochi Prefecture (Fig.1). Its accumulated precipitation exceeded 2000 mm at the observation point in the mid portion of Kochi prefecture. The value corresponds to about 80% of mean annual precipitation of Kochi Prefecture as shown in Fig.2. Such heavy rainfall was caused by Typhoons 'Nakri' and 'Halong'. The heavy rainfall accompanied by tropical cyclones is apt to be affected by topography (Murata 2009, Smith et al. 2009). The present study aims to clarify the characteristics of precipitation systems in this rainfall event. We also compare this event with statistical feature of heavy rainfall in Kochi by typhoon for 27 years (Makigusa and Sassa 2013).

2. Analysis and data

We evaluated the change in precipitation system and the accumulated rainfall from the combined radar precipitation data of JMA. In order to classify precipitation system, we analyzed the data of the JMA Muroto C-band Doppler radar where locates in the cape Muroto and Asakura X-band polarimetric Doppler radar in Kochi University. We also used the initial value of meso-scale model (MSM) of JMA.

3. Results and discussion

About 70% of 114 typhoons caused heavy rainfall over 200mm/day in Kochi prefecture when typhoon's eye exists in the high-risk area from 26 to 35 N in latitude and from 126 to 134 E in longitude for 27 years from 1986 shown in Fig.3. Typhoon 'Halong' shown by a green line in this figure also passed through in this area and approached to Kochi prefecture. Although typhoon 'Nakri' shown by a red line passed through in the southwest portion of this area at the end of July, it did not cause heavy rainfall. When it moved northward outside of this area, heavy rainfall continued in Kochi prefecture for 3 days from 1 August. This is because of the motion of moist air

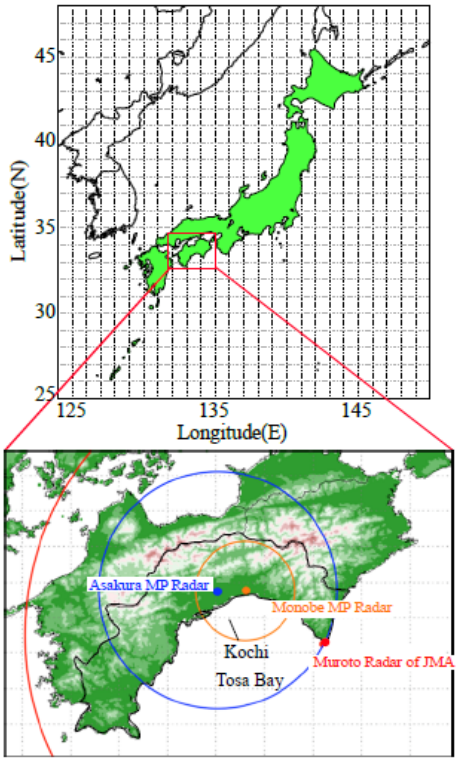

Fig.1 Map of Japan and Sikoku Island, red, blue and orange circles show the observation areas of radars.

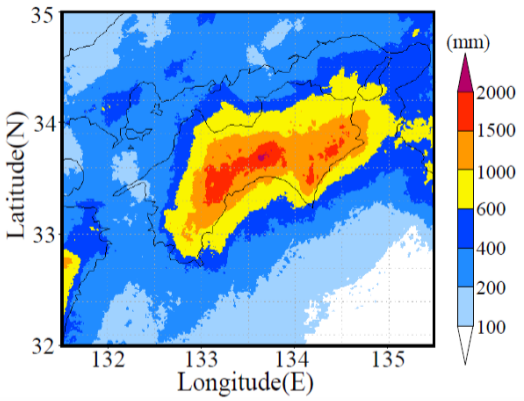

Fig.2 Accumulated rainfall for 1 – 10 August.

mass. Usually moist air concentrates around typhoon. But, a large amount of moist air mass flowed to Shikoku Island apart from Nakri due to the air flow accompanied by Pacific Ocean anticyclone located at the east side of Japan, as shown in Fig.4.

Accumulated rainfall by Nakri shown in Fig.5a was concentrated in central area of Kochi prefecture,

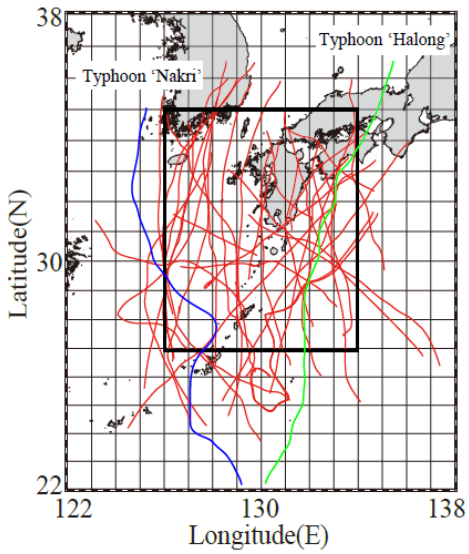

Fig.3 Tracks of typhoon Nakri (blue) and Halong(green), and typhoons (red) causing heavy rainfall over 200mm/day in Kochi for 27 years. Black flame shows its highrisk area. (Makigusa & Sassa 2013)

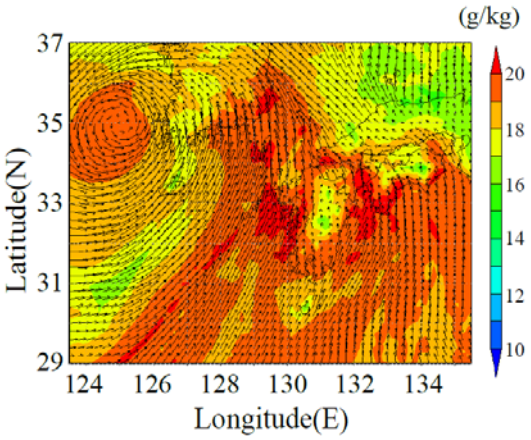

Fig.4 Distribution of water vapor and wind on the plane of 950hPa at 0900JST, 3 August.

whereas that by Halong in Fig.5b distributed in the west and east sides of Kochi prefecture.

Fig.6 shows temporal change of hourly precipitation and accumulated precipitation at Torigatayama in which accumulated precipitation exceeded 2000 mm up to 10 August. Two peaks of heavy rainfall were observed at this observation point. Amount of rainfall per hour exceeded 40 mm/h in both peaks. First peak continued for 3 days from 1 August due to the passage of typhoon 'Nakri', and the second peak continued for 3 days from 8 August by typhoon 'Halong'. When each peak appeared, we observed characteristic echoes by the JMA Muroto Doppler radar and Asakura radar in Kochi University as shown in Fig.7. Some rain bands over 40 dBZ in reflectivity, aligned parallel to the slope of mountains, were observed by both radars as shown in Fig. 7a when the first rainfall peak appeared. We call such precipitation system, 'streak on slope'. Convergence of wind was observed in the southern part of each rain band. Such orographic pattern appears due to southerly wind accompanied by typhoon when the eye of typhoon locates in the west or northwest side of Sikoku Island, e.g. the area shown in Fig.8a. In the second rainfall peak, strong echo's fixes on the southeast slope of Shikoku

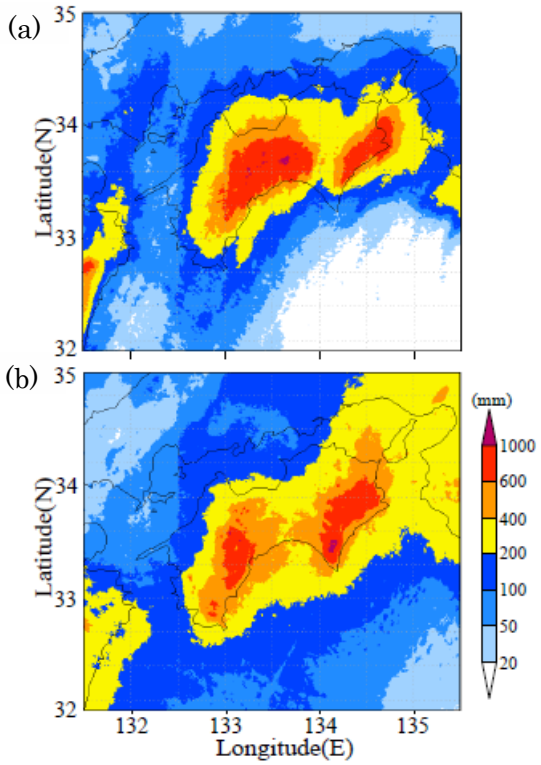

Fig.5 Accumulated rainfall by Nakri (a) for 1 - 3 August and Halong (b) for 7 -10 August.

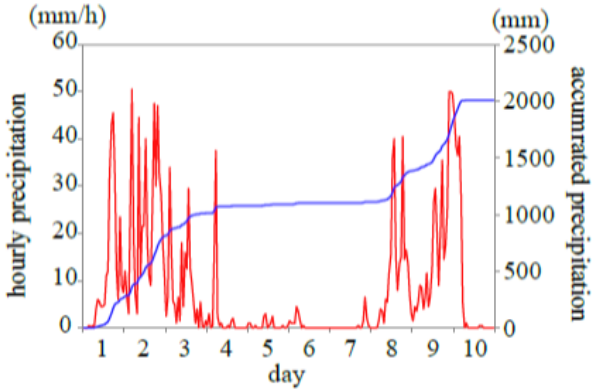

Fig.6 Temporal change of hourly precipitation and accumulated precipitation at Torigatayama.

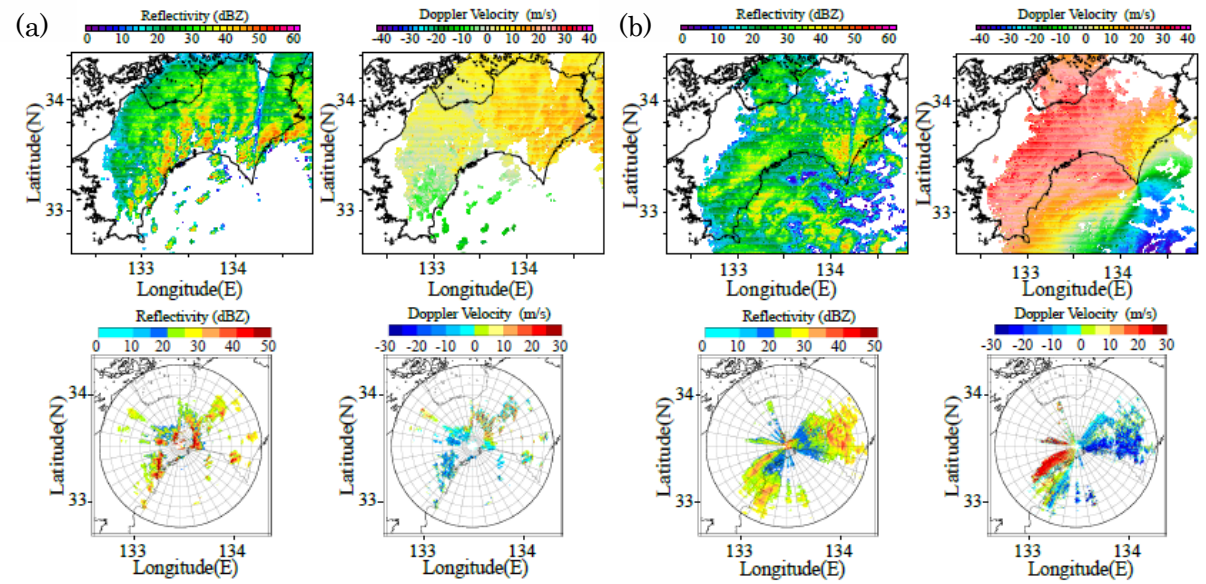

Fig.7 Reflectivity (left) and Doppler velocity (right) of Muroto radar (upper) and Asakura radar (lower). (a) Echo by Nakri at 1340JST, 2 August. (b) Echo by Halong at 1621JST, 9 August.

Mountains as shown in Fig.7b. We call it 'fixed echo'. It will appear when the strong southeast wind accompanied by typhoon goes up the southeast slope of Shikoku Mountains. Fixed echo type appears when the typhoon eye locates in the southwest side of Shikoku Island as shown in Fig.8b and strong rotating wind around typhoon continuously transports a plenty of water vapor to the southeast slope of Shikoku Mountains.

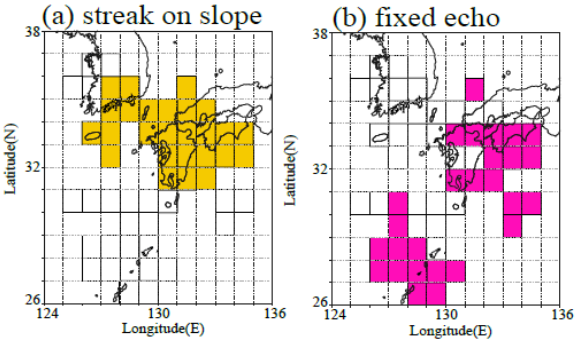

Fig.8 The location of typhoon's eye when the streak on slope (a) and fixed echo (b) systems appear in Kochi. (Makigusa and Sassa 2013)

4. Conclusions

Two typhoons 'Nakri' and 'Halong' caused heavy rainfall in different area and made different precipitation system. Typhoon 'Nakri' caused streak on slope type system and typhoon 'Halong' caused fixed echo type system due to their rotating wind. These precipitation systems can be predicted by typhoon location because they occurred due to orographic effect. Although the case of Halong was similarity with ordinary case which studied by Makigusa and Sassa (2013), that of Nakri was slightly different from ordinary case of typhoon. In this case, water vapor was conveyed apart from Nakri for long time.

Acknowledgments

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