THE RELATIONSHIP BETWEEN TYPHOON AND PRECIPITATION PATTERNS OF HEAVY RAIN IN KOCHI, JAPAN Hitomi Makigusa¹, Koji Sassa²

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I. INTRODUCTION

Kochi prefecture occupies southern part of Shikoku Island and was known as the area where heavy rain frequently occurs in Japan. For example, the maximum value of daily precipitation in Japan, 851.5 mm/day, was observed at Yanase in Kochi Prefecture. Moreover, four observation points of Japan Meteorological Agency (JMA) in Kochi Prefecture are ranked in top 20 of heavy hourly rain in Japan. As Typhoon 201106 'Ma-on' yielded the maximum daily precipitation event (Blunden and Arndt 2012), Tropical cyclones, are major sources causing heavy rain in Kochi. The present study aims to categorize mesoscale convective systems yielding heavy rain and to investigate relationship between the locations of typhoons and the categorized convective systems.

II. ANALYSIS AND DATA

We picked up heavy rainfall events observed by any rain gauges at 29 JMA's observation points in Kochi Prefecture for 25 years from 1986 to 2010. The criterion of the event is over 50 mm/h in hourly precipitation. Then, we decided major synoptic disturbances yielding heavy rainfall events from meteorological charts of JMA near the time when the heavy rainfall events occurred. Totally, 588 events



(b) events associated with typhoon

FIG. 1: The number of heavy rainfall events in Kochi Prefecture



FIG. 2: Example patterns of convective system

occurred for 25 years as shown in Fig. 1a and 236 events were associated with 49 typhoons in Fig. 1b. We also categorized convection system causing heavy rainfall event to five types using radar echoes; spiral rainband, fixed echo, streak on slope, quasi-linear rainband and multi-cell types as shown in Fig. 2. The spiral rainband type is the convection system of typhoon itself. The fixed echo type is quasi-stationary convective system locked at certain area due to orographic effect. The streak on slope type is also a kind of orographic rainfall. The other two types are major convective systems that appear with extra tropical storms and Meiyu front. Because these convection systems sometimes cause heavy rainfall events at a number of points, the number of total convection systems caused by typhoons is 190. The tracks of typhoon's eye when the convective systems appeared were also checked from the typhoon best track data collected by JMA and the probability that heavy rainfall event occurs was evaluated at each area where typhoon's eye located.

III. RESULTS AND DISCUSSION

As shown in Fig. 1a, total heavy rainfall events occur mainly in the slant face of Shikoku Mountains. Top 3 points that many heavy rainfall events occur are Shigeto, Sakihama and Yanase. On the other hand, the events associated with typhoon are remarkable in the west part of slant face except for Yanase as shown in Fig. 1b. This is because the counter-clockwise wind circumstance inherent in typhoon carry hot and wet air mass from Pacific Ocean.

The dominant convective systems caused heavy rainfall are fixed echo type and streak on slope type. These two patterns occupied 71 % of total convective system as shown in Fig. 3a. Spiral rainband type was only 16 % of the total systems. Namely, heavy rainfall associated with typhoon is mainly caused by the convective system developed through the interaction between the counterclockwise wind circumstance and orographic effect. Similar



FIG. 3: Number of observed convection systems

result for hurricane was obtained by Smith et al. (2009). The major convective systems are different in top 3 points that many heavy rainfall events occurred. The fixed echo type is dominant at Yanase shown in Fig. 3b. Though Funato and Ikegawa locate closely with each other, major systems at Funato are spiral rainband type and fixed echo type (Fig. 3c) whereas major system at Ikegawa is streak on slope type (Fig. 3d).

The beat tracks of 49 typhoons are shown in Fig. 4. Even the typhoons that did not land on Shikoku Island caused heavy rainfall in Kochi. The location of typhoon eye when each convective system appeared is plotted in grid area of 1 degree of londitude and 1 degree of latitude in Fig.



FIG. 4: Best tracks of typhoons causing heavy rainfall in Kochi from 1986 to 2010



FIG. 5: The relation ship between typhoon location and convective systems

5. Each colors show dominant convective system. The number in mesh denotes number of convective system. When typhoon locates near Shikoku Island, major three patterns occur. The fixed echo type occurs when typhoon locates on far southern or southern-westerly sea from Shikoku Island. Especially, typhoon locates around Okinawa Island is apart more than 800 km from Shikoku Island. These cases may be similar to predecessor rain events (Galarneau et al. 2010). Typhoons locate between Kyushu Island and Korea Peninsula caused mainly streak on slope type systems. In this case, some narrow rainbands are generated parallel to the slope when wet southern wind due to counter-clockwise rotation around typhoon climb along the southern slope of Shikoku mountains as shown in Fig. 2c.



(a) events in west part of Kochi



(b)events in east part of Kochi

FIG. 6: Probability of heavy rainfall at each typhoon location

The locations of typhoon are different depending on the location that heavy rainfall events occurred. Then, we evaluated the probabilities of heavy rain events in the west part and the east part of Kochi Prefecture, separately. Fig. 6a shows the probability of heavy rainfall when typhoon exists in each mesh. The number of typhoon passing through each mesh for 25 years is indicated. The heavy rainfall dose not occur when typhoon locates in the north side of Shikoku Island. On the other hand, the typhoon passing the northwest of Okinawa Island has high risk of heavy rainfall. As shown in Fig. 4, most of typhoons approach Shikoku Island from southwest, passing through Okinawa Island. In such case, heavy rainfall in west Kochi probably continues for long time. For the case of rainfall at the east part of Kochi, the location of typhoon is quite different from another case as shown in Fig. 6b. In this case, the probability of heavy rainfall is higher when typhoon locates near the southern part of Korea Peninsula.

IV. CONCLUSIONS

The major convective systems yielding heavy rainfall associated with typhoon are fixed echo type and streak on slope type. Both the types are due to orographic effect. The probability of heavy rainfall risk is also obtained with respect to the location of typhoon.

As the future work, we will evaluated heavy rainfall risk due to typhoon in the future climate that global warming progresses.

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