

## Introduction

Kochi Prefecture, Japan has a hot spot of tornadoes and heavy rain frequently occur there. Recently, Ministry of Land, Infrastructure, Transport and Tourism (MLIT) dployed high resolution X-band radar Network, XRAIN. In addition to opperational Doppler radar network of Japan Meteorological Agency (JMA), this system provides useful information about storms. Unfortunately, XRAIN does not cover Kochi Prefecture and the other area of low population.

The present work aims to establish new compact radar network system to make up XRAIN.

## 2. Climatology of Kochi

32 tornadoes occurred in Kochi Prefecture from 1991 to 2015. This value is the third largest in Japan. Especially, the shoreline from Kochi city to Aki city is a hot spot of tornado as shown in FIg.1. In this area tornadoes occur every year. The probability of tornado occurrence is 32 per 10000km<sup>2</sup> per year. This value is more than 10 times of that of Oklahoma, U.S.

Heavy rain also frequently occurs in Kochi Prefecture. Fig. 2 shows the number of heavy rain more than 50 mm/h. Annual precipitation of Kochi Prefecture is 2500 mm whereas that of Japan is 1700 mm. The maximum daily precipitation in Japan is 851.5 mm at Yanase in Kochi Prefecture. Such heavy rain is caused by stationary linear rainband and stationary MCS on mountain regions. These storms were strongly affected by the topographical characteristics of Kochi. Warm Kuroshio current flows near Tosa Bay and warm moist air is supplied from it. The north boundary of Kochi Prefecture is Shikoku Mountains of 1500 m high.



Fig.1: Distribution of tornadoes observed from 1961 to 2015 in Japan illustrated by JMA

# **Compact Radar Network Observation Project in Kochi, Japan**

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Fig.2: Number of heavy rain more than 50 mm/h from 1980 to 2010



Fig.3: Typical precipitation system causing heavy rain in Kochi, Both system occured due to orgraphic effect and warm moist air conveyed by Typhoon.

This year is in Phase I. At this time we operate three polarimetric radars at Asakura, Monobe and Aki as shown by yellow circles in Fig.4. This area covers the hot spot of tornado. Asakura radar made by JRC has 80 km observation range and makes 10 PPI scans from 2 deg. to 30 deg. in elevation angles every 2.5 minutes. Monbe and Aki radars made by Furuno has 30 km observation range and makes 5 PPI scans from 3 deg. to 16 deg. in elevation angles every 1 minute. We also deplyed mesonet shown in Fig.5. Phase II will start nest year. Usa, Kuroshio and Shimizu radars will be set from next year.

# 3. Observation Plan



Fig.4:Compact radar network in Kochi Prefecture, Yellow circles denote observed areas and Red circles show our future

The present observation project are made by research group from Kochi University, Furuno Electric Co. Ltd. and National Institute of Information and Communications Technology (NICT).

Mission of Kochi University:

Observation and analysis, Developement of algorithm for radar Fig.6:Kochi tornado on 5 October network.

Mission of Furuno Electric Co. Ltd.:

Development of radar operation system to avoid radio wave interference. Most of radars must set to same frequency because available frequency band is very narrow in Japan.

Mission of NICT:

Development of internet data providing system.

We observed two tornadoes in 2014 (Poster session 1-A, 9) and one tornado in 2016. The latter one may be multiple vortex tornado as shown in Fig.6 and its parent storm was caught by Monobe radar as shown in Fig.7. Now we develop the vortex detection algorithm and radar network system. An example of radar network composed of Monobe and Aki radars is shown in Fig.8.



fimed by Mr. Nomura



Fig.8:An example of convective echos captured by Radar netwrok



Fig.5:Mesonet in Kochi Prefecture, Sensors were POTEKA made by Meisei Electric Co. Ltd. The data are provided from cloud system.

# Recent observation results



Fig.7:Parent storm of Kochi tornado caught by Monobe radar

Most tornadoes in Kochi Prefecture born in Tosa Bay and land (Sassa st al. ▲ mm/h 2011). If we catch the vortices in parent storm, developing upper from near sea surface, about 50% of them caused tornado damage. Therefore, we can issue tornado worning by using automatic vortex detection algorithm and our radar network. Scan rate is one minute and lead time is estimated as more than 10 minutes.

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