P3.6 DEVELOPMENT OF A MULTIPARAMETER RADAR SYSTEM ON MOBILE PLATFOAM

Koyuru Iwanami [1]*, Ryohei Misumi [1], Masayuki Maki [1], Toshio Wakayama [2],
Kiyoyuki Hata [2] and Shinichiro Watanabe [2]

1: National Research Institute for Earth Science and Disaster Prevention, Tsukuba, Ibaraki, Japan
2: Mitsubishi Electric Corporation, Amagasaki, Hyogo, Japan

1. INTRODUCTION

It is important to observe cloud and precipitation systems during their whole life cycles from the initiation of cloud through formation and development of precipitation to dissipation of cloud and precipitation in order to study mechanisms and develop forecast methods of heavy rainfall and snowfall that causes disasters.

National Research Institute for Earth Science and Disaster Prevention (NIED) has investigated rainfall and snowfall clouds, especially that caused disasters, using X-band Doppler and polarimetric radars. But we could not observe non-precipitating clouds and measure simultaneously Doppler velocity and polarimetric parameters. So we have developed a multiparameter radar system with three frequencies of 9, 35 and 95 GHz on mobile platforms under contract with Mitsubishi Electric Corporation in order to observe cloud and precipitation systems through their whole life cycles. It will be useful for observation researches of not only cloud and precipitation systems but also cloud's affection to the redistribution of energy and water in the climate system.

We will introduce features of our developed multiparameter radar system in this paper.

2. FEATURES OF THE SYSTEM

The developed multiparameter radar system consists of an X-band radar subsystem for rain and snow observation and a dual-millimeter-wavelength (Ka- and W-band) radar subsystem mainly used for non-precipitation clouds observation. The data receiving facility is also provided for transmission of observation data by satellite communication in NIED.

Figure 1 shows the outside appearance of our developed radar system. Each subsystem is mounted on a truck of 4-tons, which we can drive with only normal auto-driving license in Japan, for field experiments. The antenna is mounted on the rear portion of flatbed and the radar control and data acquisition systems are contained in the container on the front portion of flatbed of each truck. The system can be easily transported to observation sites according to the meteorological situation.

FIG. 1. Photograph of developed multiparameter radar system. X-band (right) and Ka/W-band (left) radar subsystems are mounted on 4-ton trucks. The antenna on the top of container of X-band radar is used for satellite communication.

Main specifications of developed multiparameter radar system are listed in Table 1. Doppler measurements are available at all frequencies then information of wind field can be collected. The X-band and W-band radars have a function of dual-polarization. We can derive polarimetric parameters of Zhh, ZDR, ρhv, ΦDP and KDP. Unfortunately we cannot measure LDR because the antennas have complex structures and the isolation values between both polarizations are not enough to measure cross-polarization signals. The polarimetric function is expected to be used for discrimination of cloud and precipitation particle type and to improve accuracy of rain rate measurements.

The RVP7 and IRIS/Open by SIGMET are adopted as the radar signal processor and software for radar control and data analysis of each radar, respectively.

2.1 *Features of the X-band Radar*

The X-band multiparameter radar was developed for the main purpose of observations of local heavy rainfall that induced disasters such as shallow landslides

* *Corresponding author address:* Koyuru Iwanami, National Research Institute for Earth Science and Disaster Prevention, 3-1 Tennodai, Tsukuba, Ibaraki 305-0006 Japan; e-mail: iwanami@bosai.go.jp

TABLE 1. Specifications of developed radar system.

	X-band	Ka-band	W-band
Frequency	9.375 GHz	35.35 GHz	95.13 GHz
Antenna Type	Circular Parabola, 2.1 mϕ	Cassegrain, 2.1 mϕ	
Scan Range (Scan Rate): AZ	Full Circle (≤ 36 deg/s)	Full Circle (≤ 24 deg/s)	
EL	–2 to +92 deg (≤ 18 deg/s)	–2 to +182 deg (≤ 12 deg/s)	
Antenna Gain	41.6 dB	54.0 dB	58.7 dB
Beam Width	1.3 deg	0.3 deg	0.1 deg
Transmitter Tube	Magnetron	Magnetron	Klystron (EIA)
Peak Power	50 kW	100 kW	2.2 kW
Pulse Length	0.5 μs	0.5 μs	0.25 to 2.0 μs
Pulse Repetition Frequency	≤ 1,800 Hz	400/4,000 Hz	≤ 20 kHz
Polarization	H and V	H	H or V
Doppler Processing	PPP, FFT	PPP	PPP, FFT
Noise Figure	2.3 dB	3.5 dB	7.5 dB
Observation Range	80 km	30 km	30 km
Outputs	Z, V, W, ZDR, ρhv, ΦDP, KDP	Z, V, W	Z, V, W, ZDR, ρhv, ΦDP, KDP

and floods. It has polarimetric capability and then KDP (ΦDP) is observable that is useful for the correction of attenuation by rainfall and precise estimation of rain rate (Matrosov et al. 1999). It is also important to estimate and monitor rain rate accurately for disaster prevention.

Since the X-band radar subsystem and our institute has equipments for satellite communication (384 kbps), observed radar data can be instantly transmitted to our laboratory. This function enables for us to open the observed radar images to public via World Wide Web and further try to incorporate radar data into numerical models through data assimilation method in future. An example of RHI images is shown in Fig. 2.

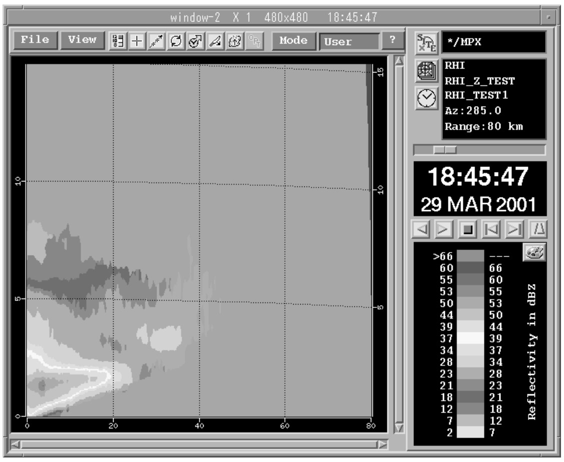

FIG. 2. An RHI image of reflectivity observed with the X-band radar.

2.2 *Features of the Ka/W-band Radars*

The major remarkable character of our developed Ka/W-band cloud radar subsystem is the adoption of a single Cassegrain antenna with 2.1 m diameter to make collocated measurements at both Ka- and W-band (Iwanami et al. 2000). This enables a measurement of liquid water contents in clouds by dual-wavelength method (Wakayama et al.; see P3.7).

W-band transmitter and receivers are mounted behind the main mirror, and a part of receiver for Ka-band near the antenna pedestal in order to minimize signal loss by wave-guide and derive better sensitivities. There are horn antennas at the center of main mirror and W-band circular horn is put between Ka-band horn array from the top and bottom.

Doppler measurements are available at both frequencies. Ka-band radar using a magnetron for the transmitter tube realizes Doppler velocity range of about ±8.5 m/s within the limitation of duty cycle of 0.05 % by the adoption of the double pulse operation.

Figure 3 shows the block diagram of the subsystem. The left-hand side shows a single antenna for common use, and upper part shows the Ka-band and lower part shows W-band radar in right-hand side. There are two receivers for vertical and horizontal polarization signals and polarimetric measurement is available at W-band.

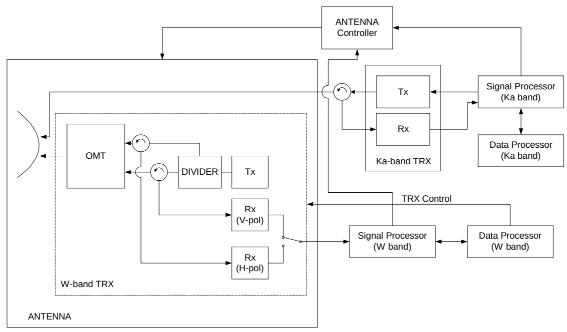

FIG. 3. Block diagram of the developed cloud radar subsystem.

Figure 4 shows the relationships between minimum detectable reflectivity dBZ and range km for 3 dB signal-to-noise ratio, given a 0.5 and 1.0 μs transmit pulse for Ka- and W-band. With one-second integration, Ka- and W-band minimum reflectivity is less than –29 dBZ and less than –27 dBZ at the range of 10 km. The numbers of pulse integration are 450 for Ka-band and 10-thousand for W-band.

Figure 5 indicates an example of time-height cross sections by vertically pointing measurement at Ka-band radar.

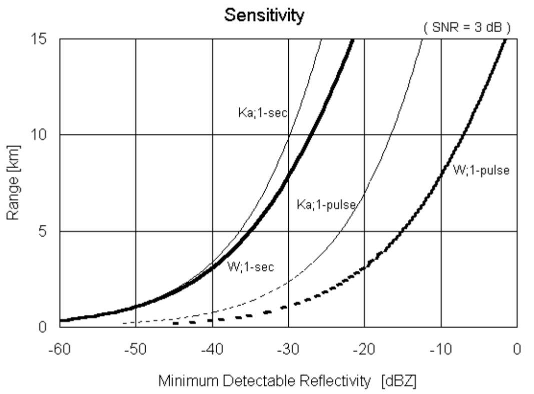

FIG. 4. Sensitivity of the developed cloud radar subsystem for 3 dB signal-to-noise ratio, given a 0.5 and 1.0 μs transmit pulse for Ka- and W-band. Thin and thick dashed lines show sensitivities at Ka- and W-band with single pulse. Thin and thick solid curves show sensitivities at Ka- and W-band with one-second integration, respectively.

3. RESEARCH THEMES AND OBSERVATION PLAN

We will study two research themes using our developed multiparameter radar system at first. First theme is on the methodology, we will study on the estimation methods of cloud and precipitation parameters such as liquid/ice water content, drop size distribution, rain rate and classification of particles using Doppler, polarimetric and dual-frequency techniques. The results of this study will become the basis of all the other our researches.

The second theme is the study of cloud formation and precipitation processes. We expect to observe a series of processes from the stage of water vapor convergence, cloud formation, precipitation to their dissipation using our developed radar system in combination with the other observation facilities. In addition, observation results should be compared with the results of numerical simulations by our developing cloud model that includes microphysical processes in detail. We hope to deeply understand cloud and precipitation systems by this study.

In order to study on the estimation methods of cloud and precipitation parameters and cloud formation and precipitation processes, we are planning several

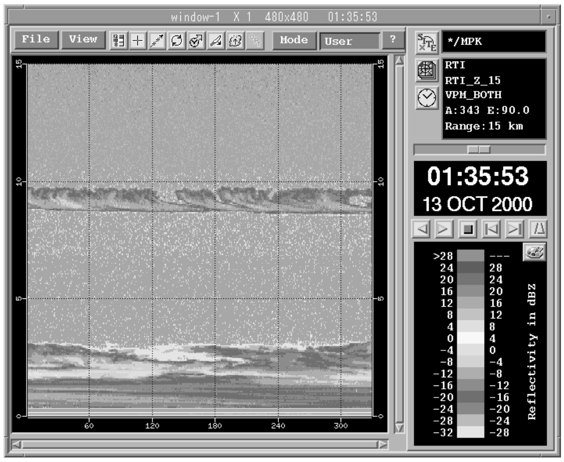

FIG. 5. Time-height cross section of reflectivity observed by Ka-band radar. Time duration is 330 seconds.

radar observations in combination with the other observations by a microwave radiometer, an instrumented aircraft, video sondes and fine GPS-network in cooperation with the other organizations. For example, we will make radar observation in the same period with water vapor tomography observation using fine GPS-network by GPS-meteorology group in autumn 2001 around Tsukuba city. Then we also try to make dual Doppler observation with Ka-band Doppler radar of Mitsubishi Electric Corporation.

In December 2001, we will carry out radar observation of snow clouds in combination with in-situ observation by an instrumented aircraft and video sondes in Niigata Prefecture, Japan. We will transport our cloud radar subsystem to the Palau Islands for the observation of clouds in the tropics in 2003.

4. CONCLUSIONS

National Research Institute for Earth Science and Disaster Prevention has developed a multiparameter radar system with three frequencies on mobile platform. Several cooperative observations are planned to retrieve cloud and precipitation parameters and understand cloud and precipitation processes.

REFERENCES

Iwanami, K., M. Maki, R. Misumi, S. Watanabe and K. Hata, 2000: The NIED dual-frequency cloud radar system under development. *Proc. 1st Internat'l Workshop on Spaceborne Cloud Profiling Radar*, 161-164.

Matrosov, S. Y., R. A. Kropfli, R. F. Reinking and B. E. Martner, 1999: Prospects for measuring rainfall using propagation differential phase in X- and Ka-radar bands. *J. Applied Meteor.*, **38**, 766-776.