Study on Imaging with Scanning Airborne W-band Millimeter Wave Radiometer

De-Cai Kong, Yong-Hoon Kim, Jing Li, Sheng-Wei Zhang, Mao-Hua Sun, He-Guang Liu, Jing-Shan Jiang
National Microwave Remote Sensing Laboratory
Kwangju Institute of Science and Technology, Korea
P.O.BOX 8701, 100080, Beijing, P.R. China.
E-mail: kdc@nmrs.ac.cn

Abstract: The paper introduces a research on the W-band Millimeter Wave Radiometer(RADW92) through an airborne experiment. Microwave remote sensing images of part of the Yellow River and the WeiHe River are offered. Analysis of factors influencing the image qualities as well as the resolutions to them are also included. The RADW92 is the first generation of Millimeter Wave Radiometer in China, which works with operating frequency 92 GHz, the bandwidth 2 GHz, the integration time 60ms, the system sensitivity 0.6k and the linearity better than 0.999. Cassegrain Antenna is designed for imaging by conically scanning. The result of the experiment suggested that RADW92 had been adequate for space use.

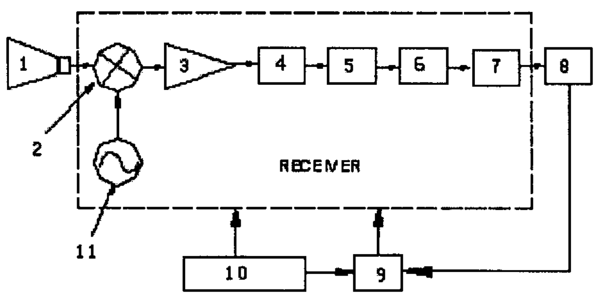
Key words: W-band, Millimeter Wave Radiometer, Conically Scanning, Airborne Experiment.

I Introduction

The Versatile Modular Microwave Remote Sensor(VMMRS) is a payload system with high function density developed by National Microwave Remote Sensing Laboratory(NMRS Lab) sponsored by the National 863-2 Program for the purpose of obtaining the microwave emission imagery of the earth's ocean, land, ice, clouds and precipitation. The VMMRS consists of a dual-band microwave altimeter , a microwave scatterometer and a microwave radiometer modularity. The W-band Millimeter Wave Radiometer (RADW92) is one of the channels of the radiometric modularity of the VMMRS. The operating frequency of RADW92 is 92GHz, which is in the region of the atmosphere window. The design of the RADW92 was based on several observational objectives: heavy precipitation over land, sea ice type, snow cover, water in clouds, integrated water volume of atmosphere, and etc.

1. RADW92 profile

The RADW92 is a total power microwave radiometer system with modular design and highly integrated level, which can provide higher spatial resolution, better system sensitivity and better linearity. The radiometer system consists of antenna, mixer, IF amplifier, detector, DC amplifier, integrator, data processing unit, rotator unit, power supply and etc. It is a dual-channel single sideband superheterodyne receiver with a common local oscillator and the local frequency is 92GHz[1], as shown in Fig. 1. The key function



1 —— antenna 2 —— mixer 3 ——IF amplifier 4 —— detector
5 —— vedio amplifier 6 —— integrator 7 —— A/D
8 —— data process unit 9 ——rotator 10—— power supply

Fig. 1 RADW92 system schematic diagram

Table 1 Key function parameters

Parameter	Value
Operating frequency	92GHz
Bandwidth	2GHz
Integration time	60ms
Sensitivity	0.6k
Linearity	0.999
Antenna	Cassegrain antenna
Diameter of antenna	120mm
3dB beamwidth	1.8°
Main-lob efficiency	>0.90
Noise figure of front-end	8.7dB

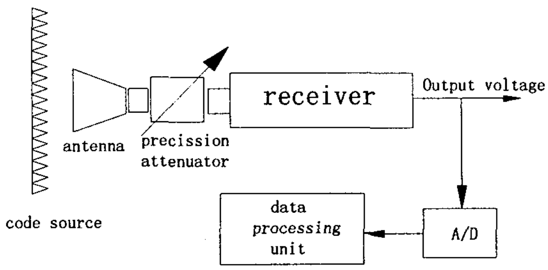


Fig. 2 Schematic diagram RADW92 calibration

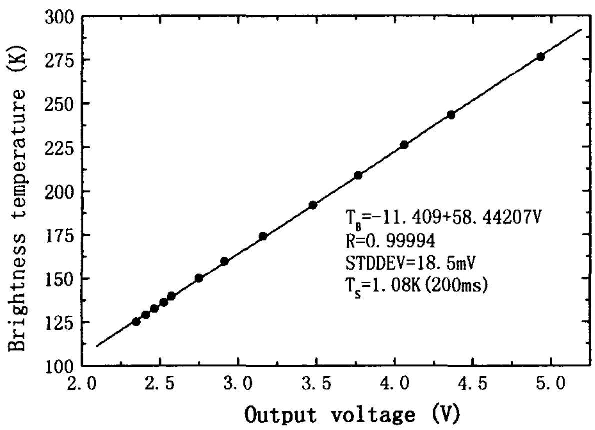


Fig. 3 Linearity of RADW92

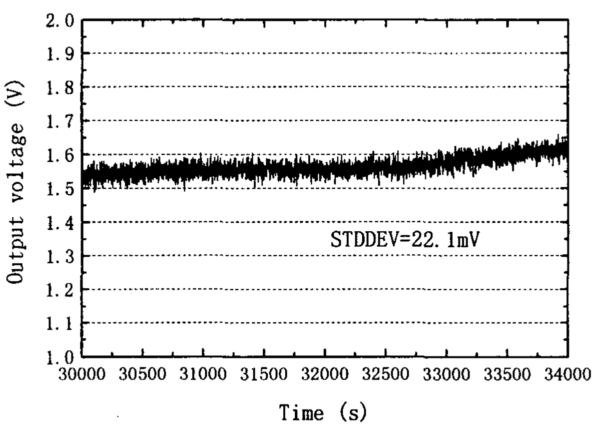


Fig. 4 Stability of RADW92 (during 1 hour)

parameters of the receiver are shown in the table 1.

2.Calibration[2]

The most important facilities used for calibration include precision attenuator and cold source full of liquid nitrogen. The calibration method is shown in Fig. 2. A set of input and output values of the receiver can be obtained by adjusting the decrement of the precision attenuator. Linearity and Stability of RADW92 are shown respectively in Fig. 3 and Fig. 4.

II Airborne experiment

1. Flight reference

During the April of 2002, the RADW92 was flown on the helicopter near Xi'an, where there are two rivers called Yellow River and WeiHe River. The purpose of the experiment is to get the radiometric imagery of the two rivers. The flight data are followed below:

Scanning mode: conically scanning

Observational angle: $\theta = 45°$

Flight altitude: $H = 1000m$

Spatial resolution:

Cross-track:

$$FP_C = 1424.2 \times tg(1.8°) = 44.5m$$

Along-track:

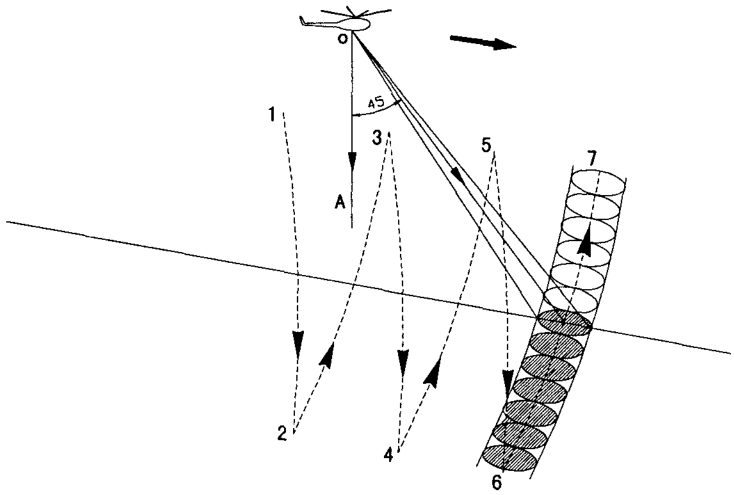


Fig. 5 Schematic diagram of imaging with scanning airborne RADW92

$$FP_A = FP_C / \cos 45° = 63.0m$$

Pixels per scanning line: $N = 31$
Azimuth range: $\alpha = \pm 27.9°$
Swath: $SW = 2 \times 1000 \times \sin 27.9° = 935.9m$

Duration of processing for one pixel: $T_d = 86ms$

Duration of scanning throughout one track:

$$T = T_d \times 31 = 86 \times 31 = 2666ms$$

Angular scanning velocity: $\omega = 20° / s$
Flight velocity:

$$V = 63.0m / 2666ms = 80km / h$$

2. Experiment result and analysis

Fig. 6 is the radiometric imagery of part of the

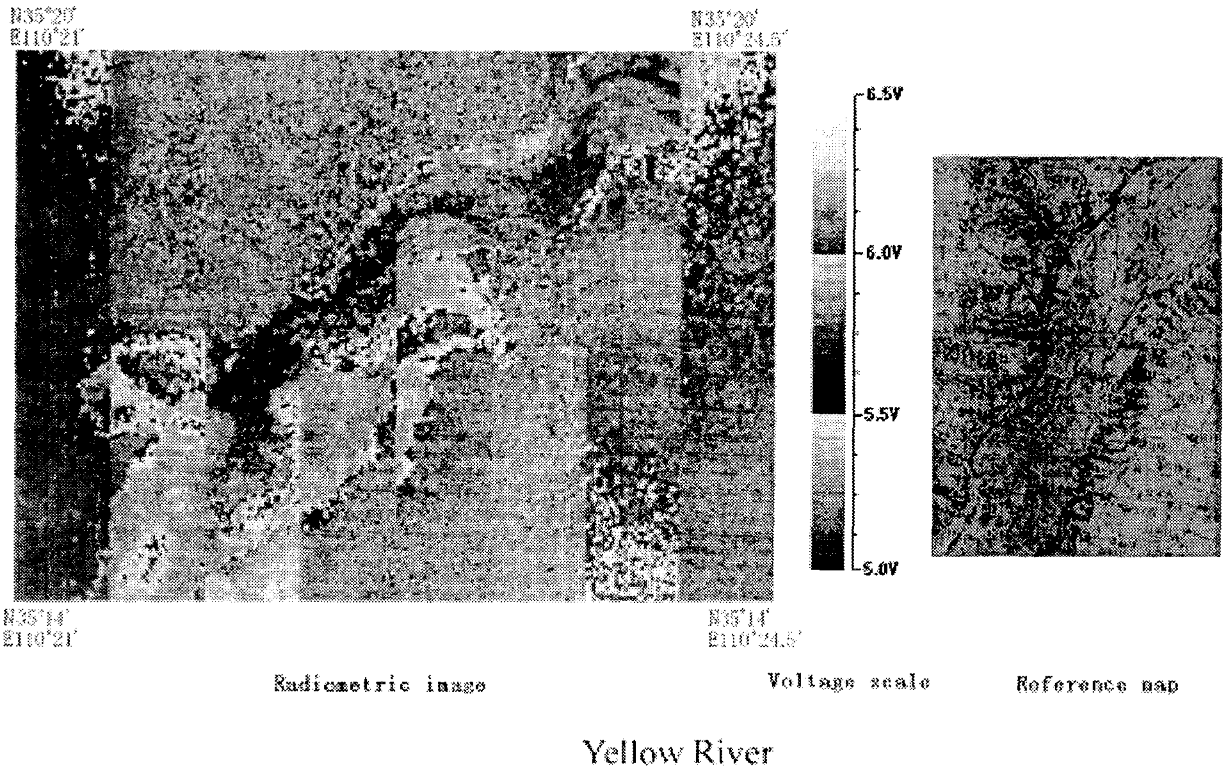


Fig. 6 Microwave emission image of the Yellow River

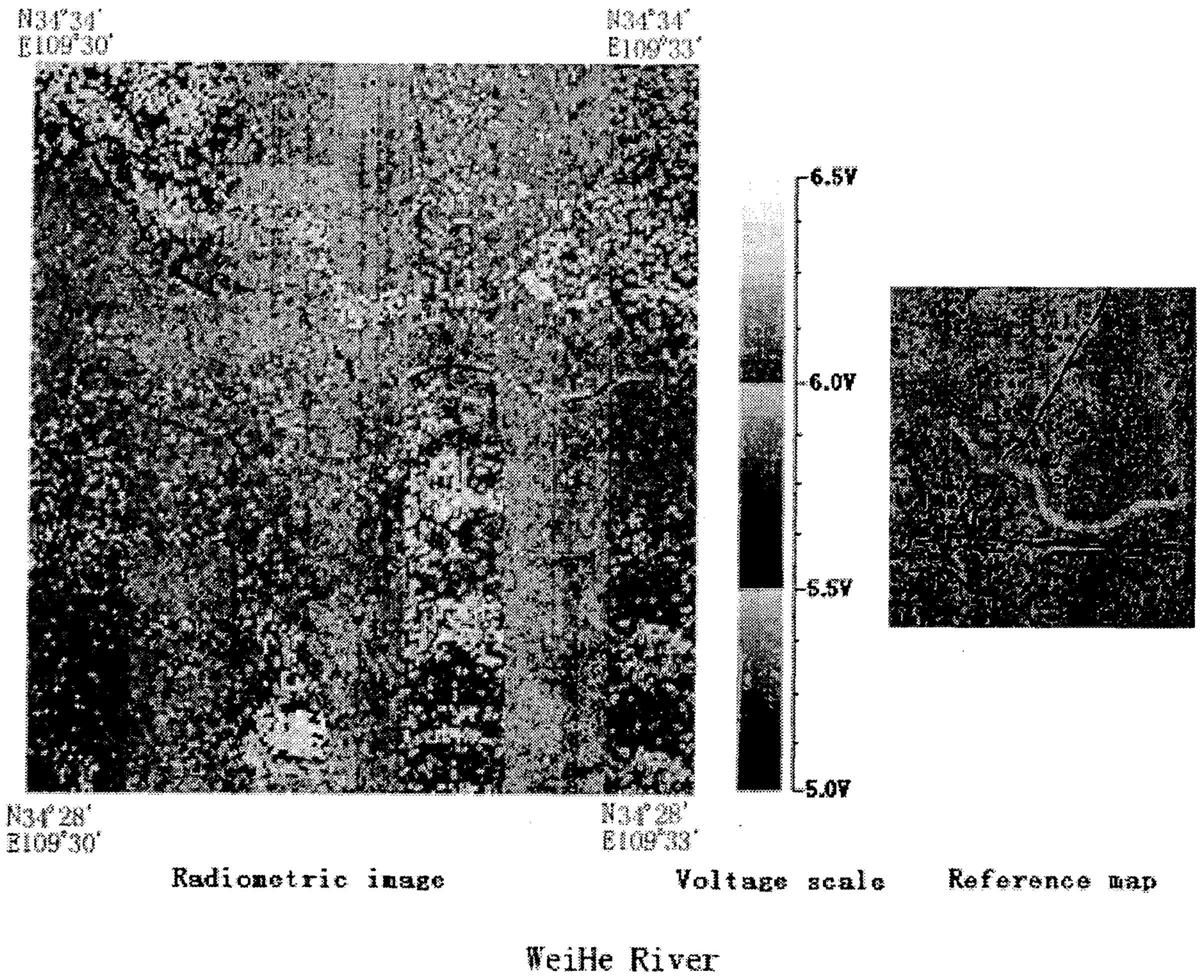


Fig. 7 Microwave emission image of the WeiHe River

Yellow River. The large green part in the image is the Yellow River and the other parts are exposed soil or vegetation. The shoal area can be distinguished from other part of the river. The image of the WeiHe River is shown in Fig. 7. The WeiHe River is narrower, which is about 30 to 120 meters wide. So it looks like a green curve in the image. At the bottom of the image, there is a reservoir. The other parts around the WeiHei River are exposed soil or vegetation.

The two images are both original results without any correction. Compared to reference map, it can be found that although both rivers in the images have the identical trends with the reference maps, the geometrical form of both rivers has distortion to some extent. Many reasons can result in the distortion including scanning track approximation, longitude and latitude approximation, flight altitude and velocity approximation, attitude approximation, and etc.

Scanning track approximation. In order to simplify the data processing, it is assumed that the image band are a series of same curvature scanning arcs, which align in same direction in turn, among which there is no gap or overlap. But the truth is that each scanned track is the result of synthesis of uniform circular motion and uniform linear motion, as curve 1-2, 2-3, 3-4 shown in Fig. 5. So the distortion is unavoidable under this condition. But it can be corrected by adding geometrical corrective function to the imaging algorithm.

Errors introduced by platform. The errors of longitude, latitude, flight altitude, flight velocity and attitude are all introduced by the experiment platform. They can lead to the change of observational field, view angle and spatial resolution, which are usually inevitable. So the effective way to avoid them is to match the observational data with platform reference.

Ⅲ Conclusion

Through the airborne experiment, the microwave emission images of the Yellow River and the WeiHe River have been obtained. The spatial resolution of the receiver is 60 meters, and the system sensitivity is better than 1k. Moreover, we find that the accuracy of the platform's parameters has great influence on image qualities. The algorithm of software is also an important factor that affects image qualities. According to that, the observed data for spaceborne imaging should be matched with the parameters of the imaging platform for the geometrical correction.

Ⅳ References

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