Six Months of Preliminary Calibration Results of the PMR onboard the FY-3G Satellite

Honggang Yin[1], Jian Shang[1], Bosen Jiang[2], Lei Cao[2], Songyan Gu[1]
[1]National Satellite Meteorological Center, CMA
[2]Beijing Research Institute of Telemetry

1. INTRODUCTION

As the first spaceborne precipitation mission in China, the FengYun-3G (FY-3G) satellite was launched on 16 April 2023. The nominal orbital altitude of the FY-3G satellite is 407 km, and the nominal orbital inclination is 50°. There are 4 operational payloads on the platform, including the Precipitation Measurement Radar (PMR), the passive microwave imager MWRI-RM, the optical medium resolution spectral imager MERSI-RM, and the global navigation satellite system occultation sounder GNOS-R.

As the core instrument of the FY-3G satellite, the PMR is composed of a Ku-band radar and a Ka-band radar, and it adopts a planar slot waveguide active array antenna to conduct electronic scanning in the cross-track direction of orbit. The PMR uses variable pulse repetition frequency technology and four-frequency agility technology to achieve enough independent observing samples for all scanning angles. In the normal observation mode, the PMR can measure the rain echoes from -5 km under the sea level (i.e. the mirror image echoes) to 18 km height within the scanning angle range of ± 20.3°.Compared to the Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR) and NASA Global Precipitation Measurement (GPM) mission Dual-frequency Precipitation Radar (DPR), the PMR has larger swath width. It helps the PMR cover more precipitation events. In addition, the antenna peak sidelobe level of the PMR is lower than that of the TRMM PR and the GPM DPR. It helps the PMR to suppress the influence of ground clutter and reduce measurement error.

TABLE 1 THE COMPARISON OF PMR WITH PR AND DPR

Radar Systems	FY-3 RM PMR	TRMM PR	GPM DPR
Frequency band	dual-frequency (Ku, Ka)	single-frequency (Ku)	dual-frequency (Ku, Ka)
Swath width(km)	300	215(@350 km orbit altitude)	245(Ku), 125(Ka)
Horizontal resolution (km)(Naidr)	5	4.3(@350 km orbit altitude)	5.2
Range resolution(m)	250	250	250(Ku), 250/500(Ka)
Observation range(km)	18 ~ −5 ASL	15 ~ −5ASL	18 ~ −5ASL(Ku) 18 ~ −3ASL(Ka)
Minimum detectable precipitation rate(mm/h)	0.5(18 dBZ, Ku), 0.2(12 dBZ, Ka)	0.7(@350 km orbit altitude)	0.5(Ku), 0.2(Ka)
Dynamic range(dB)	≥70	≥70	≥70
Measurement accuracy(dB)	≤ ±1	≤ ±1	≤ ±1
Beam-matching accuracy(°)	≤0.1	/	≤0.14
Antenna peak sidelobe(dB)	≤ -30	≤ -25	≤ -25

2. INSTRUMENT STATUS

The PMR started observation soon after its launch, and the data preprocessing segment began normal operation at the end of July. The instrument status is very stable ever since it was powered on, Figure 1 shows the temperature variation of the Transmitter/Receiver (TR) modules. At 22:19 (UTC) on May 25th 2023, FY-3G flighted over the Typhoon Mawa, the NASA GPM core satellite also flighted over the same location after 7 hours. Figure 2 compares their measured radar reflectivity factors.

3. IN-ORBIT CALIBRATION

Calibration of the PMR consists of internal and external calibrations. The internal calibration is carried out one time every day. During the internal calibration phase, the transmitted signal from each element of the waveguide slotted array antenna can be received by the couplers over the array plane, so the relative amplitude and phase between each TR module can be monitored. The relative amplitude of transmitted signals from different TR modules on November 25th 2023 is shown in Figure 3.

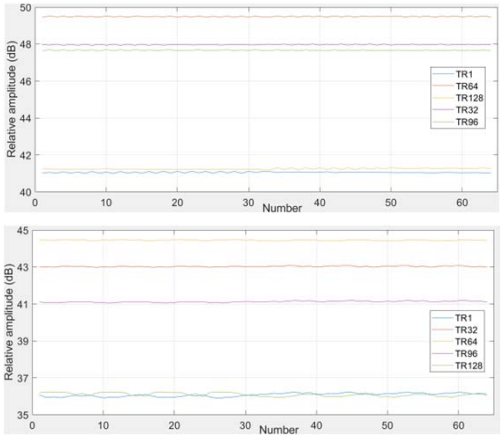

Figure 3. The relative amplitude of transmitted signal from different TR modules of the PMR achieved from the internal calibration

Since the internal calibration can't obtain information of the parameter changes of the whole radar, the external calibration is designed to absolutely calibrate the PMR. A radar active calibrator (ARC) is deployed under the satellite track during the external calibration. The ARC is able to operate in transmitting mode, receiving mode and transponding mode. Twenty-three external calibration experiments were conducted from August to September 2023.

4. CONCLUSION

The preliminary calibration results showed that, the PMR transmitting beamwidth and receiving beamwidth in both frequency bands on orbit changed by less than 3% compared to the ground test results. The maximum difference in transmitted/received beam direction between two bands is less than 0.02 degrees. Therefore, it can be concluded that the PMR has been working normally since its entry into orbit, and calibration parameters are reasonable.

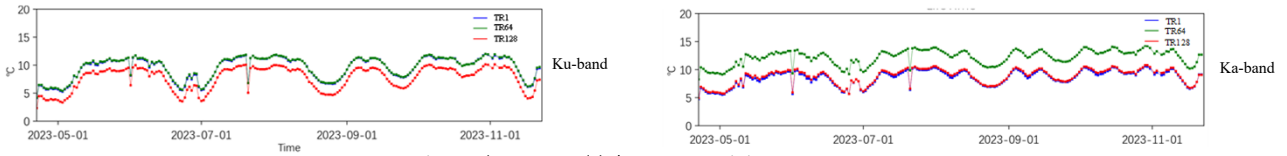

Figure 1. The PMR TR modules' temperature variation

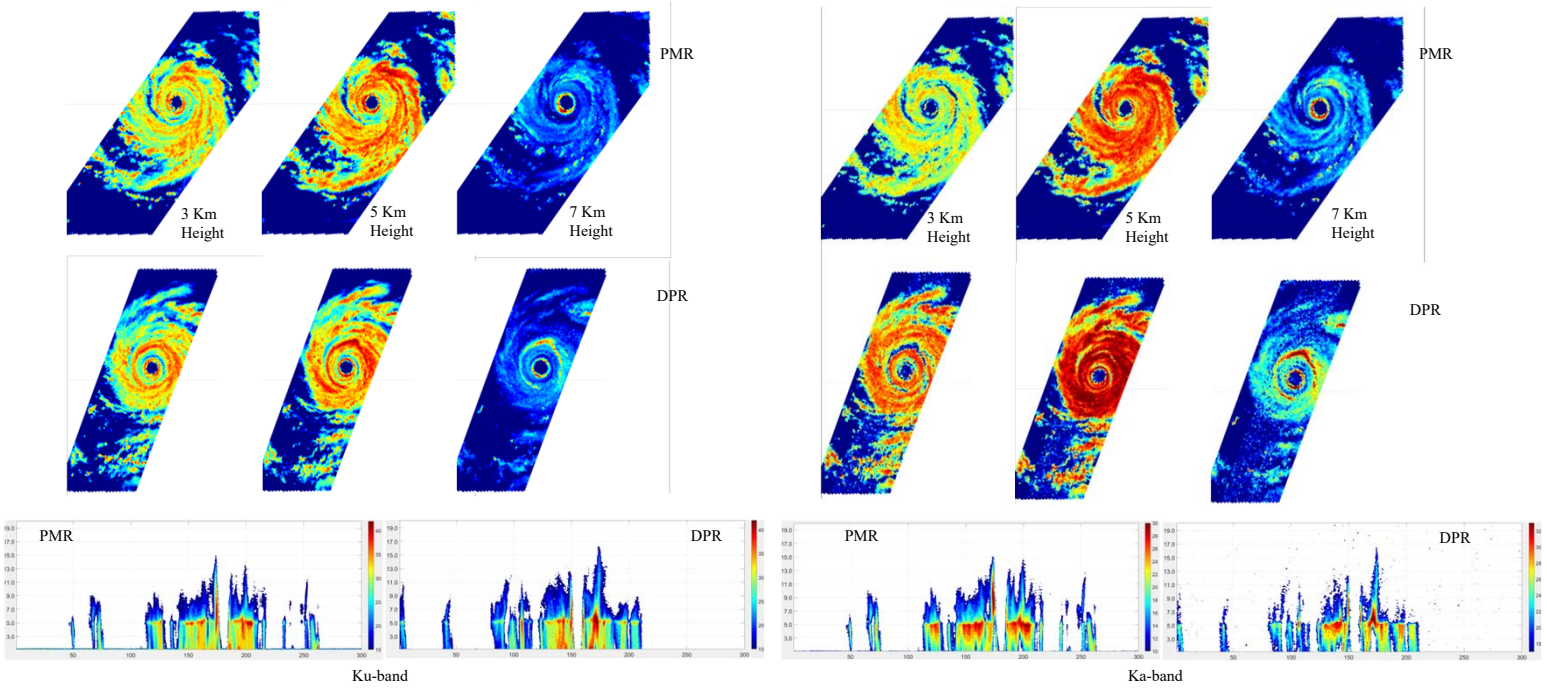

Figure 2. The horizontal and vertical sections of the measured radar reflectivity factors from the PMR and DPR for Typhoon Mawa 2023